



PRACTICAL PHYSIOLOGY

Part 2

Federal State Budgetary Educational Institution of Higher Education
«Academician E.A. Vagner perm state medical university»
of the Ministry of Healthcare of the Russian Federation

PRACTICAL PHYSIOLOGY

Part 2

Tutorial textbook

*Approved by the Academic Council of FSBEI HE
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of the Ministry of Healthcare of the Russian Federation*

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The textbook “Practical Physiology” is a manual for practical work. In the presented 2nd part of the manual, options for laboratory work are described that introduce students to a number of modern theoretical and practical problems of physiology and experimental medicine.

The second part of the manual includes topics: central nervous system, autonomic nervous system, somatic nervous system, endocrine system, sensory systems, digestion, energy balance, psychophysiology of behavior, adaptation, physiology of work and sports, the basics of individual health.

Control materials are included in the manual. Test tasks are designed for independent work of students. The manual includes exam questions for the entire course of physiology.

The textbook is intended for medical students.

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Министерства здравоохранения Российской Федерации

ПРАКТИЧЕСКАЯ ФИЗИОЛОГИЯ

Часть 2

*Руководство к практическим занятиям
по нормальной физиологии*

*Утверждено ученым советом ФГБОУ ВО ПГМУ
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«Практическая физиология» является пособием для практической работы. В представленной 2-й части пособия описаны варианты лабораторных работ, знакомящие студентов с рядом современных теоретических и практических проблем физиологии и экспериментальной медицины.

Вторая часть пособия включает темы: центральная нервная система, вегетативная нервная система, соматическая нервная система, эндокринная система, сенсорные системы, пищеварение, энергетический баланс, психофизиология поведения, адаптация, физиология труда и спорта, основы индивидуального здоровья.

Контрольные материалы включены в работу. Тестовые задания предназначены для самостоятельной работы студентов. В пособие включены экзаменационные вопросы по всему курсу физиологии.

Пособие предназначено для студентов медицинских вузов.

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INTRODUCTION

The 2nd part of the textbook «Practical Physiology» presents a number of modern methodological ways to perform laboratory works on physiology, which are included in the curriculum of a higher medical school. Each seminar introduces students to the principles of operation, capabilities and rules of using different medical devices.

The presented part of the manual describes the most important research methods, especially those that are important for clinical work; presents some options of new laboratory works that introduce students to a number of modern theoretical and practical problems of physiology, i.e. practical works to study the CNS and its integrative function, sensory and endocrine systems, digestion, energy balance, adaptation, physiology of work, sport and health care. At the same time, the most methodologically valuable laboratory works are presented in the classic way.

The manual introduces new units containing program materials for the entire course of physiology (test tasks). These materials are intended for independent individual work of students, but can also be used for group (on- or off-line) knowledge control conducted by the teacher. The manual includes exam questions, as well as practical skills. The tutorial is intended for students of medical universities.

RULES FOR LABORATORY EXPERIMENTS

Normal physiology is an experimental science gaining its knowledge through observations on living animals, organ preparations and tissue cultures. Observations during medical procedures on humans also contribute to this knowledge. Experiments done in laboratories should comply with the existing laws and regulations that are based on bioethical principles. Bioethics is an interdisciplinary science dealing with ethical issues concerning both biological experiments and medical procedures. It is related to natural and social sciences as well.

1.1. Basic regulations during a practical

1.1.1. Protection of life

The following regulations have to be observed:

- it is forbidden to touch electric equipment or sockets with a wet hand;
- it is forbidden to put one's hand inside any equipment;
- a functional error has to be announced immediately to the head of the practical. Cut off the current with the automatic main fuse.
- equipment should be only used as described in the lab notes or explained by the supervisor. Any other operation, turning of knobs, flipping of switches, etc. should be avoided as it might lead to malfunctioning or impairment of the equipment.
- all electric sockets are situated on laboratory benches. Protect them from fluid. Any spillage should be mopped up immediately.

– accidents which occur in spite of all preventive measures should be reported immediately to the supervisor. He/she is responsible for taking the necessary steps.

1.1.2. Protection of health

– laboratory coats are obligatory
– hands must be washed during breaks or at the end of the experiment. Soap, warm water and disinfectants (Sterogenol and Neomagnol solutions) are available in the laboratory. Use only designated wash basins.

– eating, drinking and smoking in the laboratory area are prohibited.

– before or during the experiment always ask the assistants or experimental supervisor for any necessary first-aid material. The suitable disinfectant and antiseptic, finger stalls and hand protection are always available. Working with an untreated open wound may lead to infection and is therefore prohibited.

– poisonous and caustic chemicals are used in experimental work. They should not be put into the mouth or eyes. Certain chemicals (for example, pyridine) and drugs (such as histamine and adrenaline) can be absorbed through the skin: they should be handled with the utmost care.

1.1.3. Other safety regulations

In case of fire in the building, fire alarm will go on. Elevators will be stopped, and the building should be evacuated through the nearest staircase on foot.

1.2. Rules of experiments on humans

Human experiments and observation can only be carried out on volunteers after obtaining their informed consent. Subjects should be aware of the circumstances and possible outcomes of the experiment.

Experiments that might lead to permanent physical or psychological harm of the subjects are prohibited.

Safety precautions should be entirely followed during experiments.

ABBREVIATIONS

ACh	— acetylcholine
ANS	— autonomic nervous system
AP	— action potential
BMI	— body mass index
BMR	— basal metabolic rate
BP	— blood pressure
CD4	— T helper cell
CD8	— T suppressor cell
CNS	— central nervous system
CN	— cranial nerves
CSF	— cerebrospinal fluid
CVS	— cardiovascular system
DB	— diastolic blood pressure
ECG	— electrocardiogram
EMG	— electromyogram
EPSP	— excitatory postsynaptic potential
FSH	— follicle stimulating hormone
g	— gram
GA	— general anesthetic
GI	— gastrointestinal
GIT	— gastrointestinal tract
GnRH	— gonadotrophin-releasing hormone
GO	— gastro-oesophageal
GP	— graded potential
GSA	— general somatic afferent
GSE	— general somatic efferent

GVA	— general visceral afferent
GVE	— general visceral efferent
Hb	— haemoglobin
HDL	— high-density lipoprotein
HRV	— heart rate variability or cardiointervalography
HT	— hypertension
IgE	— immunoglobulin E
IgG	— immunoglobulin G
IgM	— immunoglobulin M
INR	— international normalised ratio
IPSP	— inhibitory postsynaptic potential
IS	— Infrasound
kg	— kilogram
LA	— local anaesthetic
LDL	— low-density lipoprotein
LH	— luteinising hormone
LHRH	— luteinising hormone releasing hormone
m	— meter
mane	— in morning
MP	— membrane potential
NE	— noradrenaline (norepinephrine)
nocte	— at night
NR	— normal range
NSAIDs	— non-steroidal anti-inflammatory drugs
P	— the mass of the body in kg
PNS	— peripheral nervous system
SBP	— systolic blood pressure
T3	— tri-iodothyronine
T3	— triiodothyronine
T4	— tetra iodothyronine
T4	— thyroxine

TEA	— thermic effect of activity
TEF	— thermic effect of feeding
TDEE	— total daily energy expenditure
TM	— tympanic membrane
TSH	— thyroid-stimulating hormone
TSH	— thyroid-stimulating hormone
US	— ultrasound
UV	— ultraviolet
WBC	— white blood cells
WCC	— white cell count
WHO	— World Health Organization

PRACTICUM

THEME I. GENERAL PHYSIOLOGY OF THE CENTRAL NERVOUS SYSTEM

Terms

Receptive field of a reflex – a set of receptors from which a given reflex is evoked.

Reflex – a stereotyped reaction to the action of external and internal stimuli

Reflex arc – a neural circuit that provides a reflex

Stimulus – a factor affecting the receptive field of a reflex.

Practical Class 1. Reflex. Organization of the Nervous System, Sensory Receptors. Reflex Principle of the Central Nervous System

Goal: to study the organization of the nervous system, reflex principle of the central nervous system

Introduction

Excitation in the CNS is carried out due to the activity of excitatory synapses. The excitatory mediator interacts with chemoreceptors of the postsynaptic membrane. As a result, an EPSP,

excitatory postsynaptic potential, associated with an increase in the permeability of mainly sodium ions (possibly calcium), occurs on the postsynaptic membrane. At the same time, the outgoing current of potassium somewhat reduces the depolarization caused by sodium. Under the influence of the summation of EPSP, an action potential develops in the axon hillock.

Manifestation of neuronal activity. Spontaneous activity is the automatic excitation of neurons (automaticity) without receiving of signals. The evoked activity occurs in response to information received from receptors. As a result, the activity of previously silent neurons or a change in the activity of already working neurons occurs.

Reflex is stereotyped reaction to the action of external and internal stimuli, which is carried out by the central nervous system (evoked activity). Reflex arc is a neural circuit that provides a reflex. The myotatic reflex (monosynaptic, only 1 synapse in the CNS), also known as the stretch reflex, is the contraction of muscle resulting from muscle stretching. Examples are patellar and Achilles reflexes, which are of clinical significance. Polysynaptic reflexes have 2 or more synapses in the CNS.

Examples are pupillary reflexes, which also have clinical significance.

Questions for discussion

1. Central and peripheral nervous systems.
2. Excitation in the central nervous system (CNS).
3. Reflex theory.
4. Types of reflexes.
5. Reflex arc, parts of the arc.
6. Functions of individual components of the reflex arc.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020.

2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 14th ed; WB Saunders, 2. 2012-2022.

Practical works

1. Receptive fields of reflexes.
2. Knee-jerk and Achilles reflexes.
3. The time of the motor reflex of the right and left hands to sound.

Practical work 1.

Receptive fields of reflexes

(blinking, pupillary, swallowing, etc.)

Objective: to study the receptive fields of reflexes

Equipment and materials: Weber's hair, cotton wool, 5 % solution of citric acid, distilled water.

Progress: For the blinking reflex, touch the eyelashes of the upper eyelid with cotton wool; for the pupillary reflex, close one eye with your hand or press on it, observe the reaction of the pupil of the other eye. For the sneezing reflex, irritate the mucous membrane of the lower nasal passage with a cotton swab. The swallowing reflex – irritate the root of the tongue using a piece of food or water.

Thought experiment. What method can you suggest to induce lacrimation? Describe it in the conclusions.

Results. Fill in Table 1.1, specify the receptive field and the stimulus that affects it.

Table 1.1

Receptive Fields of Reflexes

Reflex	The Receptive Field, Stimulus	Reflex Response
Pupillary reflex		Narrowing of the pupillae
Pupillary reflex		Dilatation of the papillae
Blink reflex		Blinking
Reflex tear secretion		Tear secretion
Sneeze		Sneezing
Swallow		Swallowing

Conclusions. Make conclusions about the localization, irritants and role of the receptive field for triggering unconditioned reflexes.

Practical work 2. Knee-Jerk and Achilles Reflexes

Objective: to study the knee-jerk and Achilles reflexes

Equipment and materials: neurological hammer

Progress: The knee-jerk is triggered in two ways:

A: A volunteer sits cross-legged. By hitting the tendon of the quadriceps muscle of the femur with a hammer, we stretch this muscle, which leads to its reflex contraction and extension of the lower leg. Instead of the hammer you can use the edge of your palm for this purpose.

B. A volunteer sits on a chair, stretching his legs bent at the knees in front of him, placing the front part of the legs on the same line. Trigger the knee reflex, as described above, on the right and left leg. Compare the value of the reflex of the right and left legs.

To trigger the Achilles reflex, a volunteer must kneel on a chair. By hitting the Achilles tendon with a hammer, we cause it to stretch the calf muscle, which leads to its reflex contraction and bending of the back leg. Instead of the hammer you can use the edge of your palm for this purpose.

Results. Draw a scheme of the reflex arcs of these reflexes, indicate the localization of nerve centers.

Conclusions. Specify with which receptors these reflexes arise, which neurons participate in the formation of reflex arcs, the clinical significance of these reflexes.

Practical work 3. The Time of the Motor Reaction of the Right and Left Hands to Sound

Objective: to measure the reaction time, evaluate the asymmetry of the conduction of excitation on the right and left side.

The average reaction time of a person can be between 200–250 ms.

Equipment and materials: reaction time meter.

Progress: Verbal instruction: when a sound signal is heard, press the key. A volunteer puts his hand on the telegraph key. Using the reflex meter, the time of the motor reaction of the hand to the sound is recorded (give the signal 10 times for the right hand, then the same – for the left). Determine the average value of the reflex time for each hand.

Results. Average reaction time:

right hand –

left hand –

Conclusions. What determines the speed of impulse conduction through neural networks? Write your opinion, which right-hander will react faster? Why?

Tests

1. THE MECHANISM OF EXCITATION OF INITIALLY SENSITIVE RECEPTORS INCLUDES ...

- a) the emergence of the receptor potential
- b) the emergence of AP, emergence of GP, its distribution to the nerve center
- c) the emergence of the receptor potential, then the emergence of AP, its distribution on the axon to the nerve center

2. A COLLECTION OF NERVE CELLS THAT ORGANIZE A REFLEX OR REGULATE SPECIFIC PHYSIOLOGICAL FUNCTION IS ...

- a) a nerve cells net
- b) a nerve center
- c) a synapse

3. PERCEPTION OF STIMULUS, INITIAL FILTERING OF INFORMATION, ENCODING OF INFORMATION ARE ...

- a) neuron functions
- b) receptor functions
- c) CNS functions

4. THE PROCESS OF TRANSFORMATION OF THE RECEPTOR POTENTIAL IN A SERIES OF AP (AP GENERATION SERIES) IS CALLED ...

- a) encoding
- b) decoding
- c) intra-coding

5. PATELLAR REFLEX OR KNEE-JERK IS PERFORMED TO CHECK THE SPINAL SEGMENT OF ...

- a) C1-C4
- b) Th2-Th4
- c) L2-L4

6. LEAST SENSITIVE TO HYPOXIA ARE ...

- a) skin, muscle
- b) liver, kidney
- c) brain, heart, lung

7. A CHANNEL OPENS ON A POSTSYNAPTIC MEMBRANE THAT CAUSES A NEGATIVE ION TO ENTER THE CELL. WHAT TYPE OF GRADED POTENTIAL IS THIS?

- a) depolarizing
- b) repolarizing
- c) hyperpolarizing
- d) non-polarizing

8. CLASSIFICATIONS OF REFLEXES BY THE BIOLOGICAL SIGNIFICANCE

- a) food, protective, statokinetic, sexual, homeostatic
- b) monosynaptic and polysynaptic
- c) statokinetic, sexual, homeostatic, vegetative

9. BRIGHT LIGHT HITTING THE RETINA LEADS TO THE PARASYMPATHETIC RESPONSE, THROUGH THE ...

- a) vagus nerve
- b) oculomotor nerve
- c) trigeminus nerve

Report Topics

1. Clinical role of the knee jerk and Achilles reflex.
2. Neural ensembles in the CNS.

Practical Class 2.

Coordination of Reflex Activity. Excitation and Inhibition in the Central Nervous System

Goal: to study the peculiarities of the processes of excitation and inhibition in the central nervous system.

Introduction

Excitation in the CNS is characterized by generation of action potentials (impulses). The nature of excitation is determined by the rhythm, frequency, bursts of impulses.

Inhibition is an independent nervous process that is initiated by excitation and leads to inhibition different from excitation.

Questions for discussion

1. Neuron functional states.
2. Inhibition in the central nervous system.
3. Principles of interaction between nerve centers.
 - 3.1. Coordination of reflexes.
 - 3.2. Principle of dominant.
 - 3.3. Principle of feedback.
 - 3.4. Hierarchical principle.
 - 3.5. Common final path principle (Common field principle).

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2. 2012.

Practical works

1. Central (I.M. Sechenov) inhibition.
2. Peripheral inhibition.
3. Relief of the knee reflex.
4. Reciprocal inhibition of the motor reflex.

Practical work № 1. Central (I.M. Sechenov) inhibition

Equipment and materials: Luprasiflm program

Progress (with the program):

1. Apply an electrical stimulus on the frog's leg which is decerebrated, but its optical lobes are still attached to the body.
2. Observe the obtained reflex response.

3. Apply a few NaCl crystals (excitatory factor) on the optical lobes.

4. Apply a new electrical stimulus.

5. Observe the absence of the reflex response.

6. Clean the optical lobes.

7. Repeat the application of the electrical stimulus and note that the reflex response is present again.

Results. Write down what happens to the reflex response when the inhibitory neurons of the thalamus are stimulated.

Conclusions. Explain the absence of the reflex response

Practical work № 2. Peripheral inhibition

Equipment and materials: Luprasiflm program

Progress (with the program):

1. Visualize the heart of a decerebrated frog.

2. Open the abdominal cavity and pull out a segment of the intestine.

3. Observe the cardiac activity and determine the heart rate.

4. Apply electrical stimuli on the intestinal segment.

5. Continue applying the stimuli and observe how its activity is restored.

Results. Write down what happens to your heart rate

1) at rest

2) when the vagus afferent is stimulated

3) when the heart escapes from the influence of the vagus

Conclusions. Explain changes of the cardiac rhythm

Practical work № 3. Relief of the Knee Reflex

Equipment and materials: neurological hammer

Progress. Trigger the knee reflex by hitting the tendon of the quadriceps muscle of the thigh, note its intensity. To facilitate

the occurrence of this reflex, a patient should put his hands in a "lock" and move them aside. At the same time, the experimenter causes a knee reflex on the same leg as the first time. Pay attention to the change in the expression of the reflex.

Results. Write down the value of the reflex in the initial state and after stress relief.

Conclusions. Explain the reason for the of knee reflex relief. Explain the mechanism of relief.

Practical Work № 4.

Reciprocal Inhibition of the Motor Reflex

Equipment and materials: reflexometer, wrist expander

Progress. Carry out a 10-times study of the time of the motor reaction to sound for the right hand. Calculate the average value. Do the same with simultaneous dynamic work with the left hand. Calculate the average value.

Results. Consider how reciprocal inhibition will affect the reflex time. Will it increase (slower reflex) or decrease (faster reflex)? Draw a diagram of reciprocal inhibition in nerve centers.

Conclusions. Characterize reciprocal inhibition.

Practical work № 5. Post-Tetanic Changes in the Motor Reflex Time

Equipment and materials: reflexometer, wrist expander.

Progress. Carry out a 10- times study of the time of the motor reaction to sound for the right hand. Calculate the average value. With the same hand, do dynamic work by using an expander for 1 minute. Immediately after work, determine the time of the motor reaction to the sound (five values). Calculate the average value.

Results. Post-tetanic changes are associated with changes in the release of neurotransmitters in synapses. Tetanus is a muscle

contraction with a high frequency of stimulation. At first, due to the release of additional receptors of the postsynaptic membrane, post-tetanic potentiation is observed (improvement of impulse conduction, AP). Then fatigue sets in, the mediator is exhausted and we see deterioration in the conduction of the impulse.

Think about the effect of post-tetanic potentiation on the reflex time? How does post-tetanic depression affect the reflex time?

Conclusions. Explain the reason of changes in the reflex time.

Tests

1. PRESYNAPTIC INHIBITION

- a) axo-dendritic synapse
- b) axo-somatic synapse
- c) axo-axonal synapse

2. TWO MAIN PROCESSES OBSERVED IN THE NEURAL NETWORK ARE ...

- a) excitation and inhibition.
- b) excitation and non-excitation
- c) excitation and non-inhibition

3. RECIPROCAL INTERACTION: WHEN ONE NEURON IS EXCITED, THE OTHER NEURON WILL BE ...

- a) inhibited
- b) excited
- c) normal

4. INHIBITION IS AN INDEPENDENT PROCESS THAT STOPS...

- a) the propagation of excitation.
- b) the propagation of polarization.
- c) the propagation of hyperpolarization.

5. TYPES OF POSTSYNAPTIC INHIBITION ARE ...

- a) reversal, direct
- b) reversal, direct, lateral
- c) reversal, direct, feedback

6. THE CREATOR OF THE DOCTRINE OF THE DOMINANT IS...

- a) ukhtomsky
- b) sherrington
- c) sechenov

Sensory Systems

Terms

Accommodation – the ability of the eye to change the focal length of the lens by changing the curvature of the eye lens. Adequate stimulus – a stimulus, caused by the irritants specific for this receptor. Threshold is minimal for adequate irritants.

Analyzer – the term created by the Russian scientist Ivan Pavlov which refers to the sensory system and indicates its active role in signal analysis.

Anesthesia – total or partial loss of sensibility, especially to touch.

Astigmatism – a condition in which an irregular shaped cornea or lens prevents light from focusing properly on the retina.

Blind spot – a small part of the visual field of each eye, corresponding to the position of the optic disc, where there are no photoreceptors.

Deuteranopia – green color blindness.

Focus – a point at which light rays pass through a convex lens.

Hyperopia (farsightedness) – the condition in which images focus behind the retina.

Macula lutea – a yellow oval spot at the center of the retina, the fovea centralis, the center of the macula lutea.

Myopia (nearsightedness) – the condition in which images focus in front of the retina.

Pain – a person's psycho-physiological emotional state, which occurs when super-strong stimuli act.

Protanopia – red-green color blindness.

Receptor – a structure that perceives information.

Refraction – the change in direction of a wave passing from one medium to another.

Saccades – rapid, ballistic movements of the eyes that abruptly change the point of fixation.

Tritanopia – blue-yellow color blindness.

Practical Class 3. Vision

Goal: to study the concepts of sensory systems, the visual system.

Introduction

Sensory systems detect stimuli (analyzers) and convert them into neural signals that can be interpreted by the nervous system. The sensory System includes: receptors, afferent pathway, CNS integration – the cerebral cortex. In receptors, information is converted into an electrical impulse. The afferent pathway includes several neurons, the thalamus, and carries information. The analysis and synthesis of information takes place in the cortex.

Visual Sensory System

The stimulus is light. Light is electromagnetic radiation in a certain part of the electromagnetic spectrum. The organ of vision is the eye. The retina contains two types of photoreceptors: rods and cones. Rods are responsible for providing vision in the dark, cones are responsible for color vision. There are three kinds

of cones that react to red, green and blue light. The pupil is an opening in the iris. It provides a clear vision by regulating the flow of light onto the retina.

The visual pathway: efferent fibers of the ganglion cells form the optic nerve, then a part of the fibers goes to the superior tubercles of the quadrigemina, and another part goes to the thalamus (lateral geniculate bodies) and further to the visual cortex (occipital lobe (fields 17,18,19)).

Questions for discussion

1. Sensory systems.
2. The structure of the visual sensory system.
3. Visual neurophysiology.
4. Optical system of the eye.
5. Visual disturbances.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 24th ed; McGraw-Hill Companies, Inc., 2012.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 14th ed; WB Saunders, 2020.
3. Medical physiology: principles for clinical medicine / edited by Rodney A. Rhoades, David R. Bell. — 4th ed. 2013.
4. Physiology / Linda S. Costanzo. 6 th ed. 2018.

Practical works

1. Measuring of the visual acuity.
2. Measuring of the visual field.
3. Campimetry. Identifying the location and size of the blind spot.
5. Studying of color vision.

Practical Virtual Work 1. Measuring of Visual Acuity

The visual acuity is understood as the ability of the eye to distinguish separately two luminous points from a corner of view equal to the angular minute.

Equipment and materials: special D.A. Sivtsev's eye charts for determining visual acuity, pointer, eye shield.

Progress: The study is conducted for each student. A volunteer sits on a chair 5 m from the table. The study is carried out separately for each eye, the other is covered with a special shield. A pointer shows the volunteer some letters of the eye chart, he calls them. The testing begins with the top line and, going down, finds the lowest line where the person sees all the letters clearly and correctly. In each line there is an indication of the corresponding visual acuity and distance from which the normal eye should see the letters. The visual acuity is calculated by the formula: V (visus) = d / D , where V is the visual acuity, d is the distance of the subject from the table, D is the distance from which the normal eye should clearly see this line. The visual acuity for the other eye is measured in the same way.

Results: Record the visual acuity of each eye in the protocol and health certificate.

Conclusion: Compare the visual acuity with the normal values.

Practical Virtual Work 2. Measuring of Visual Field

The visual field is the space visible to the human eye when fixing a glance at one point.

Equipment and materials: Forster perimeter, stamps of different colors, compasses, ruler, colored pencils, eye shield, blank for perimetry data.

The boundaries of the visual field are highlighted in white: outside - 100 degrees, inside and up - 60 degrees, down - 65 degrees. The boundaries of the visual field are highlighted in green: outside - 30 degrees, inside and up - 20 degrees, down - 25 degrees. The magnitude of the visual field varies from person to person and depends on the anatomical features and functional state of the retina.

Progress: Measuring of the visual field is carried out with the Forster perimeter. A volunteer sits with his back to the light, his chin in the recess of the tripod. To measure the visual field of the left eye the chin is placed on the right side of the stand. The height of the stand is adjusted so that the upper end of the tripod is at the lower edge of the eye socket. The volunteer fixes a white circle in the center of the perimeter arc with one eye and covers the other eye with a shield. Set the arc of the perimeter in the horizontal position and start measuring. To do this, slowly rotate the white mark on the inner surface of the perimeter arc from 90 degrees to 0 and ask the volunteer to indicate the moment when the mark becomes visible. The boundary is marked in degrees along the arc of the perimeter. To master the technique, you can limit yourself to determining only the horizontal and vertical meridians. In the same way, the boundaries of color vision are determined by replacing the white mark with a color (green) one.

Results: Record the result of the study into the Table 3.1. Draw a perimeter image for each of the colors for each eye on a special standard blank along the vertical and horizontal meridians.

Conclusion: Compare the magnitude of the visual field for both colors with the normal values. Explain the differences in the visual field for white and green colors.

Table 3.1

Borders of the Visual Fields in Degrees

The Visual Field in Degrees	White	Green
from above	60	30–35
from below	65	30–35
outside	100	40
inside	60	30–35

***Practical Virtual Work 3.
Campimetry. Identifying the Location
and Size of the Blind Spot***

The blind spot is the exit point of the optic nerve from the retina, there are no receptors here.

Equipment and materials: campimeter, black pointer with a white mark, ruler, pins. *Progress:* campimeter is a board with a black matte surface 1.5×1.5 m with a white mark in the center. A volunteer is located at a distance of 1 m from the campimeter to detect a blind spot. One eye should be covered with a shield, the other fixes the white point of the campimeter. The area of the blind spot is found when a black pointer with a white mark moves on the surface of the campimeter. Find the area of the campimeter on which the white mark of the pointer is not visible. Mark its boundaries with pins. The blind spot is in the temporal half of the visual field at 15° from the fixation point along the horizontal meridian and $2\text{--}3^\circ$ below the vertical meridian. Its dimensions are 9×12 cm (on the plane of the campimeter). The volunteer's blind spot is found and diameter is measured. Make recalculations

for real sizes, taking into account the focal length of the eye equal to 17 mm.

Results. Write down the coordinates and sizes of the blind spot, apply them to the scheme of circles and radii used for perimetry.

Conclusions. Explain what the blind spot is.

Practical Virtual Work 4. Studying of Color Vision

Objective: to learn to diagnose color perception disorders.

Equipment and materials: E.B. Rabkin's polychromatic tables, shield for closing the eyes.

Progress. A volunteer is sitting with his back to the light. He is consistently shown 25 colored tables from a distance of 1 m from the volunteer's eyes. The exposure time of each table is 5 seconds. Each table consists of circles of the main and additional colors. The circles of the main color form a number or a figure, and the additional one – the background of the table. The volunteer is asked what is depicted on them when presenting the tables. The first two tables are control ones, they are seen by people with both normal and impaired color perception. The remaining tables are correctly perceived by trichromats – people with normal color perception. If there is a violation of color perception, there are errors in the perception of the tables, and in some tables the hidden numbers and figures differ. The study is carried out separately for each eye.

Results. Indicate all correctly interpreted tables.

Conclusions. Estimate the color perception of the volunteer. Is it normal? Are there violations (the type of violation of color perception is determined by the annotations to the tables)?

Tests

1. OPTIC CHIASM IS ...
 - a) the efferent fibers of the ganglion cells
 - b) the temporal parts of the retina
 - c) the medial parts of the retina

2. BRIGHTNESS IS A SUBJECTIVE CHARACTERISTIC OF...
 - a) visual acuity
 - b) intensity
 - c) color vision

3. BRIGHTNESS UNITS ARE...
 - a) nm
 - b) Hz
 - c) Bel, decibel (dB)

4. CONES PROVIDE...
 - a) polychromatic vision
 - b) black-white vision
 - c) accommodation

5. LIGHT IS CHARACTERIZED BY...
 - a) wavelength
 - b) volume
 - c) duration

6. WITH A LACK OF RETINAL (OR VITAMIN A), THERE IS A VIOLATION CALLED ...
 - a) myopia
 - b) astigmatism
 - d) twilight vision (night blindness)

7. SENSORY SYSTEM INCLUDES...
 - a) afferent pathway
 - b) receptors
 - c) sound
 - d) CNS integration
 - e) emotions

8. THE TRACTUS OPTICUS PROJECTS ONTO THE CORPUS GENICULATUM LATERALE INSIDE THE...

- a) hypothalamus b) frontal lobe c) thalamus

9. THE FREQUENCY OF OSCILLATION OF THE VISIBLE PART OF THE SPECTRUM IS...

- a) 10^{15} Hz b) 110^{15} Hz c) 100^{15} Hz

10. THE FOVEA CENTRALIS, THE CENTER OF THE MACULA LUTEA CONSISTS OF ONLY...

- a) rods b) bilateral cells c) cones

11. WAVELENGTH OF LIGHT. THE VISIBLE PART OF THE SPECTRUM IS IN THE RANGE OF...

- a) 400–700 m b) 400–700 nm c) 400–700 sm

12. LIGHT IS ELECTROMAGNETIC RADIATION WITHIN THE CERTAIN PORTION OF THE ELECTROMAGNETIC SPECTRUM.

- a) right b) wrong

13. THE OPTICAL SYSTEM OF THE EYE INCLUDES...

- a) vitreous body, cornea b) retina c) sclera

14. WHEN A ROD IS STIMULATED BY LIGHT...

- a) the plasma membrane of the rod cell becomes hyperpolarized.
b) the plasma membrane of the rod cell becomes depolarized.
c) more neurotransmitter is released by the rod cell

15. RAPID, BALLISTIC MOVEMENTS OF THE EYES THAT ABRUPTLY CHANGE THE POINT OF FIXATION.

- a) accommodation b) pupils constrict c) saccades

16. THE TOTAL REFRACTIVE POWER OF THE EYE IS...

- a) 14 dpt
- b) 14 nm
- c) 588 dpt
- d) 58,8 dpt

17. THE BLIND SPOT AND DAMAGED RETINA CAN BE INVESTIGATED WITH...

- a) perimetry
- b) colour vision test
- c) campimetry

18. COLOUR VISION. THE REMAINING TABLES ARE CORRECTLY PERCEIVED BY...

- a) people without normal color perception (protanopia).
- b) trichromates – people with normal color perception.
- c) people with astigmatism

19. PSYCHOLOGICAL CORRELATES OF INTENSITY ARE...

- a) 40–20 dB – color discrimination
- b) 60 dB -color discrimination
- c) 40–20 dB – the TV screen

20. THE VERTICAL NETWORK CONSISTS OF...

- a) photoreceptors
- b) bipolar cells
- c) ganglionic cells
- d) all answers are correct

Practical Class 4.
Hearing. The Sense of Hearing. Pain.
Nociceptive Sensation. Anti-Nociceptive System

Goal: to study the concepts of the auditory system, pain.

Introduction

The auditory system provides the perception of sound signals, verbal speech and musical works. The organ of hearing is the ear. A mechanical wave with a frequency of 16-20000 Hz and intensity of 0 to 140 dB is an adequate stimulus. The modern theory by Bekesy – the theory of "place" or "traveling wave" – explains the perception of sounds of different frequencies and strengths.

Pain is a signal of the destructive effect of irritants or the degree of oxygen starvation of tissues. Pain is perceived by the nociceptive system. Any receptors with excessive exposure give a feeling of pain, in addition, there are special pain receptors located in the skin and internal organs. The antinociceptive system performs the function of a "limiter" of pain excitation. The neurons of the antinociceptive system produce endogenous opioid substances (endorphins, dynorphins, enkephalins), which bind to the opiate receptors of the neurons of the nociceptive system and reduce the sensation of pain.

Questions for discussion

1. The structure of the auditory system. The ear is the organ of hearing.
2. Theories of sound. Modern Bekesy theory – the theory of "place" or "traveling wave".

3. Pain. Manifestations of pain. Types of pain.
4. Nociceptive system.
5. Antinociceptive system.

Books recommended

1. Essentials of anatomy and physiology/Valerie C. Scanlon, Tina Sanders. – 5th ed. 2006.
2. Ganong W. F. Review of Medical Physiology. 24th ed; McGraw-Hill Companies, Inc., 2012.
3. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 14th ed; WB Saunders, 2020.
4. Medical physiology: principles for clinical medicine / edited by Rodney A. Rhoades, David R. Bell. — 4th ed. 2013.
5. Physiology / Linda S. Costanzo. 6th ed. 2018.

Practical works

1. Measuring of hearing acuity by whisper and speech.
2. Comparison of bone and air conduction of sound.
3. Audiometry.
4. Studying of pain points.

***Practical Work 1.
Measuring of Hearing Acuity
by Whispering and Speaking***

Equipment and materials: 6 m long room

Progress. The study is conducted in a quiet room from a distance (diagonal) of at least 6 m. Each ear is examined separately. A volunteer turns his ear to the examiner, closing the other one. The volunteer should not see the examiner's face. The examiner whispers some words such as mother, porridge, horse, lamp or numbers. The volunteer must repeat the words correctly. With normal hearing

acuity, a whisper is heard from a distance of 6 m. If the subject does not perceive a whisper, the study is conducted by speaking.

Results. Record into the protocol and health certificate from what distance the whisper differs for each ear.

Conclusions. Make a conclusion about the hearing acuity of the volunteer.

Practical work 2.

Bone and Air Conduction of Sound.

Weber and Rinne Experiments

Objective: to study the method of diagnosing violations of air conduction of sound; to compare air and bone conduction of sound.

Air conduction: auricle → ear canal → tympanic membrane → auditory ossicles → membrane of the oval window → perilymph → endolymph → basal membrane → hair cells

Bone conduction: skull bones → perilymph → endolymph → basal membrane → hair cells

Equipment and materials: set of tuning forks, stopwatch, cotton wool.

Progress. A) Weber's test. The leg of the tuning fork is placed on the middle line of the head. The sound passes through the bone and is heard equally by both ears. If you put a cotton swab in one ear, the closed ear hears the sound better, because the sound energy from the closed ear will be less lost through the external auditory canal than from the open one. The same thing happens if there is a disease of the sound-conducting apparatus of one of the ears.

B) Rinne's test is based on the comparison of air and bone conduction of sound. The tuning fork is placed on the mastoid process. The heard sound gradually weakens and completely disappears. As soon as the sound becomes hard to be heard, move the tuning fork to the ear. The sound is heard again. Normally, a

tuning fork with a frequency of $V = 128$ Hz is heard through the air almost twice as long as through the bone, and is perceived correspondingly for 60 and 30 seconds, respectively. When the sound-conducting apparatus is damaged, the opposite phenomenon is observed. The sound of the tuning fork is heard through the bone and can't be heard in the outer ear canal.

Results. Specify the time intervals which characterize the air and bone conduction of sound.

Conclusions. Using the Weber test, a violation of air conduction of sound is determined. Compare the duration of bone and air conduction of sound (Rinne test)

Practical work 3.

Audiometry

Objective: to study the technique, to find out at what frequencies the sensitivity of auditory receptors is the greatest.

Equipment and materials: audiometer, telephone with headphones for air conduction, cotton wool, pencil, audiometric blanks, alcohol.

Progress. The audiometer is an instrument which allows you to estimate the sensitivity of the auditory analyzer by the minimum value of sound pressure on the tympanic membrane. An audiometer accurately doses the sound frequency in the range from 115 to 10 000 Hz and its volume. To characterize the condition of the volunteer's auditory analyzer, find the audibility thresholds for each frequency of sound vibrations, amplifying the sound from -10 to $+100$ dB separately for each ear. The threshold values depend on the frequency of sound and the condition of the hearing organ.

Results. Draw an audiogram of the found thresholds on a special blank. The lowest threshold values for frequencies from 1000 Hz to 4000 Hz.

Conclusions. Compare the thresholds of perception of sounds with different frequencies for each ear with the normal values. The maximum hearing acuity is achieved at speech frequencies.

Practical Work 4.
Study of Pain Points

Objective: to make sure that there are pain points

Equipment and materials: pins or wooden disposable toothpicks.

Progress. Draw a 10×10 mm square on the inner surface of the forearm. Touch the skin inside the square sequentially with the tip of a sterile pin, making 10 horizontal touches in 10 lines along the vertical line, i.e. passing each mm of the square. The pressures are of the same strength, 100 touches all in all. The time interval between touches is 1–2 s. Describe the sensations of the volunteer. When touching different points of the skin, the volunteer may experience sensations of touch or pain. Conduct the study on the volunteers of different genders.

Results. Write the results into the Table 4.1.

Table 4.1

Sensations

Volunteer	Sensations	
	Touch	Pain
Male		
Female		

Conclusions. Describe gender differences in the density of forearm skin nociceptors.

Tests

1. THE FREQUENCY OF AN ADEQUATE STIMULUS FOR THE HUMAN EAR MECHANICAL WAVE IS ...
a) 16–20 000 Hz b) 10–16 000 Hz c) 20–26 000 Hz
2. MUSCLE PAIN REFERS TO ...
a) somatic deep b) visceral c) somatic superficial
3. THE MEDIATOR OF THE NOCICEPTIVE SYSTEM IS ...
a) norepinephrine c) substance P
b) GABA d) Acetylcholine
4. THE RECEPTOR PART OF THE NOCICEPTIVE SYSTEM IS PRESENTED BY ...
a) mechano- and osmoreceptors
b) osmo- and chemoreceptors
c) mechano- and chemoreceptors
5. FROM THE INSIDE AND OUTSIDE OF THE HEAD, IMPULSES FROM PAIN RECEPTORS GO ALONG ...
a) VII pair of cranial nerves
b) VI pair of cranial nerves
c) V pair of cranial nerves
6. THE CORTICAL PART OF THE NOCICEPTIVE SYSTEM IS LOCATED IN THE ...
a) temporal gyrus c) precentral gyrus
b) postcentral gyrus d) occipital lobe
7. THE PHENOMENON OF DOUBLE PAIN IS EXPLAINED BY THE FACT THAT IMPULSES FROM PAIN RECEPTORS ARE CARRIED OUT ...
a) both answers are correct b) on type C fibers c) on type A fibers

8. THE ANTI-NOCICEPTIVE SYSTEM HAS ...
- a) three levels
 - b) two levels
 - c) one level
 - d) four levels
9. THE HYPOTHALAMUS BELONGS TO THE ANTI-NOCICEPTIVE SYSTEM
- a) the second level
 - b) the first level
 - c) the third level
 - d) the fourth level
10. MEDIATORS OF THE ANTI-NOCICEPTIVE SYSTEM
OPIATE RECEPTORS OF THE NOCICEPTIVE SYSTEM
- a) inhibit
 - b) activate
 - c) do not affect
11. THE ORGAN OF HEARING – THE EAR – INCLUDES THE FOLLOWING PARTS
- a) outer, middle, inner
 - b) external, tympanic membrane, auditory ossicles
 - c) middle, oval membrane, internal
12. NARCOSIS IS ...
- a) local anesthesia
 - b) general anesthesia
 - c) conductive anesthesia
13. AUDITORY RECEPTORS ARE LOCATED ON THE ...
- a) tectorial membrane
 - b) basilar membrane
 - c) oval window membrane
14. THE CONDUCTIVE PART OF THE AUDITORY SYSTEM INCLUDING NEURONS IS...
- a) the thalamus
 - b) the hypothalamus
 - c) both answers are correct

15. THE CORTEX OF THE AUDITORY SENSORY SYSTEM IS LOCATED IN THE ...

- a) occipital lobe
- b) superior temporal gyrus
- c) precentral gyrus
- d) postcentral gyrus

16. TYPES OF CODING IN THE MODERN THEORY OF SOUND PERCEPTION ARE...

- a) temporary
- b) both answers are correct
- c) spatial

17. UNDER THE ACTION OF SOUNDS WITH A FREQUENCY OF 20,000 HZ, RECEPTORS OF THE BASILAR MEMBRANE ARE MOST ACTIVE

- a) upper part
- b) middle part
- c) lower part

18. THE SUBCORTICAL PAIN CENTER IS THE ...

- a) thalamus
- b) hypothalamus
- c) cerebellum
- d) pale ball

19. NORMALLY, THE GREATEST HEARING ACUITY IS PRESENT AT FREQUENCIES OF ...

- a) 500–1000 Hz
- b) 3000–5000 Hz
- c) 1000–4000 Hz

20. WHEN PRESSING ON THE SKIN, A PERSON FEELS SHARP PAIN, WITH IRRITATION OF ...

- a) tactile receptors
- b) pain receptors
- c) both answers are correct

THEME II. SOMATIC SYSTEM

Terms

Static reflex – a reflex concerned with establishing and maintaining posture when the body is at rest.

Kinetic reflex – an involuntary movement in response to a stimulus and compensation for deviations of the body during acceleration or deceleration of rectilinear motion (lifting reflex), as well as for rotations (deviation of the head, body and eyes in the direction opposite to movement).

Nystagmus of the eye – moving the eyes with the speed of rotation of the body, but in the opposite direction, and their rapid return to the original position – ensures the preservation of the image of the outside world and thereby visual orientation.

Practical Class 5. The Motor System. The Role of CNS Parts in Regulation of Muscle Tone

Goal: to study the structural and functional organization of the sensory and motor parts of the motor system, tonic reflexes of the brain stem, the function of the vestibular analyzer.

Introduction

The somatic (motor) system consists of two parts: receptor and motor. The sensitive (receptor) part contains proprioceptors,

tactile receptors, vestibuloceptors. Proprioceptors are Golgi receptors, muscle spindle receptors, receptors of articular bags. Golgi receptors are located in tendons, they react to stretching and are stimulated by muscle contraction. The muscle spindle is a proprioceptor located deep within the muscle parallel to the extrafusal muscle fibers. It is encapsulated by connective tissue and includes intrafusal fibers. Muscle spindles are sensors of skeletal muscle stretching, they measure the muscle length and rate of stretching. The spindles are innervated by efferent nerve fibers, gamma-motor neurons. The gamma motor neurons are located in the ventral horn together with the alpha motor neurons and innervate the intrafusal fibers in the polar regions. There are two types of gamma motor neurons: dynamic and static. Dynamic neurons innervate the fibers of the dynamic bag, while static neurons innervate the static bag and chain fibers. Dynamic fibers increase the dynamic response in Ia spindle receptors, while static fibers increase the static response of both Ia and II spindle afferents. Gamma-motor neurons are responsible for controlling the sensitivity of the spindle. Tactile receptors are thermoreceptors (sensations of heat and cold), Meissner's corpuscles (sensations of touch), nociceptors (sensations of pain), Pacini corpuscles (sensations of pressure). Conductive pathways of sensory information are through Gault and Burdach columns from all receptors. Afferent neurons carry signals from sensory receptors to the nuclei of the spinal cord, from where the second-order neurons carry a message to the thalamus. Second-order neurons synapse with third-order neurons in the ventrobasal complex. These third-order neurons deliver the signals to the somato-sensory cortex of the brain into the Posterior Central Gyrus (Sensory homunculus).

Vestibular receptors as movements consist of rotations and displacements. The vestibular system comprises two components:

1) semicircular canals that indicate rotational movements; 2) otoliths that indicate linear accelerations. Receptors of semicircular canals react to angular acceleration. Otolith receptors respond to linear acceleration. The difference is that, unlike in semicircular canals, there are small crystals on the hair cells. These crystals are called otoliths or “ear stones”. Otolith organs detect acceleration, for instance, when you go up in an elevator, fall, or gather speed or brake in a car. In some situations, for example on a ship or airplane, different sensory organs (e.g. the eyes and the organ of balance) send contradictory messages to the brain. This can make us to feel unwell, dizzy or nauseous. A signal from the vestibular analyzer passes through the 8th pair of cranial nerves (vestibulocochlear nerve or auditory vestibular nerve) to the vestibular nuclei in the thalamus and to the cerebral cortex. All signals from receptors are processed with the cortex. The somatosensory cortex sends appropriate signals through motor neurons.

The motor part contains the spinal motor system, brain stem motor system, cerebellum, basal ganglia and cerebral motor cortex. The spinal motor system regulates movement coordination at the spinal cord level, including the most basic motor response to a stimulus – reflex. The brain stem, consisting of the medulla oblongata, pons and midbrain, is a kind of a coordinating unit of all motor control. Thanks to the reflexes of the brain stem, quick adaptation to changing environmental conditions is possible. Important motor nuclei of the brain stem are the red nucleus, vestibular nuclei (lateral vestibular nucleus = Deiters' nucleus; medial vestibular nucleus), parts of the reticular formation. Important efferent nerve pathways of the brain stem are rubrospinal tract, vestibulospinal tract, medial and lateral reticulospinal tract. The cerebellum is important for correcting posture in order to maintain balance, the cerebellar cortex calculates the best way to perform movement, plays an important role in speech and problem solving. The cerebellum

receives information from vestibular receptors and proprioceptors and modulates commands to motor neurons to compensate for changes in body position or muscle load.

Basal ganglia are a cluster of subcortical nuclei deep in the cerebral hemispheres containing caudate and lenticular nuclei (putamen, globus pallidus externus and internus), subthalamic nucleus and substantia nigra. The basal ganglia generate motor programs for slow movements and adapt speed. The basal ganglia have either a stimulating or inhibiting effect on motor functions. The motor cortex is the highest functional level in the hierarchy of motor control. It receives information from subordinated regions of the brain, processes it, and acts as a kind of “general” who gives the final command to perform the movement. The motor homunculus is located in the precentral gyrus of the frontal lobe of the motor cortex.

Questions for discussion

1. The importance of the somatic nervous system. Maintaining posture and balance, orientation and movement of the body in space, providing various types of working movements, communications.

2. The role of the associative zones of the cortex and limbic system in the formation of the idea of movements.

3. Somatosensory part of the somatic system. Structural and functional organization. Afferent synthesis (proprioceptive, tactile, vestibular signals). Ascending pathways of Goll and Burdach.

4. Motor part of the somatic system. Structural and functional features of the motor areas of the cortex (somatotopic organization, motor columns, neural organization). Realization of the idea of movements. Pyramid and extrapyramidal conducting pathways.

5. The role of basal ganglia in regulation of movements, nuclei of the posterior and middle brain, cerebellum, alpha and gamma motor neurons of the brain stem and spinal cord.
6. Tonic static and statokinetic reflexes of the brain stem
7. The structure and functions of the vestibular analyzer.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2. 2012

Practical works

1. Rotatory chair testing
2. Assessment of the integral function of the CNS to maintain the posture and balance.
3. Tonic effects of the brain stem on the time of motor reaction to sound.

Practical work 1. Rotatory Chair Testing

Objective: to study the function of the vestibular apparatus

Equipment and materials: Bárány chair, stopwatch, ruler.

Progress: The study is performed on two subjects - with good and poor tolerance of rotation. A student is sitting in the Bárány chair. Examine the state of the motor and vegetative spheres. Pay attention to the absence of eye nystagmus, check the coordination of movements (the character of movement in a straight line with eyes closed and arms outstretched, conduct a finger-nasal test, handwriting test). Mark the symmetry of the subject's pose. Record the pulse rate, assess the width of the pupils. Then the volunteer is rotated in

the Bárány chair 10 times in 20 seconds with the head bent to the chest. Immediately after stopping the chair indicate the position of the trunk, nystagmus of the eyes, measure the pulse rate. After disappearing of nystagmus conduct a finger-nasal test, a handwriting test, a straight line test, note the presence of dizziness, nausea, rotation of the surrounding space, etc.

Results. Fill in the Table 5.1, describe the reaction of the somatic and autonomic nervous system.

Table 5.1

Indicators	First volunteer		Second volunteer	
	Before rotation	After rotation	Before rotation	After rotation
Somatic Nervous System:				
1. Nystagmus of the eyes, sec				
2. Finger-nasal test				
3. Handwriting				
4. Moving in a straight line				
5. Pose in the chair				
Autonomic Nervous System:				
1. Width of the pupils, mm				
2. Pulse rate, per min				
3. Sensory reactions				

Conclusions. Compare the reaction of two subjects. Indicate which mechanisms provide autonomic-somatic, vestibular-autonomic and vestibular-sensory responses of the subjects to rotation.

Practical Work 2.
Assessment of the Integral Function of the CNS
to Maintain the Posture and Balance

Objective: to study the influence of the vestibular and visual analyzers on maintaining posture and balance.

Equipment and materials: stopwatch

Progress: Determine the time of maintaining the balance standing on one leg. A volunteer stands on one leg, the other leg is bent at the knee at an angle of 45° . Mark the time of the test from the very beginning until the appearance of swings or deviation of the leg from the initial position. Do the same with closed eyes. To assess the effect of the vestibular analyzer on controlling the posture and balance, estimate the balance on one leg after a 20-second rotation around the axis. Compare the results of the three stages of the study in different volunteers.

Results. Record the results into Table 5.2.

Table 5.2

Volunteer	Time of balance maintaining		
	Initial, sec	with closed eyes, sec	with closed eyes and irritation of the vestibular apparatus, sec

Conclusions. Determine the parts of the brain which are involved in maintaining the posture and balance, estimate the role of the vestibular analyzer and reverse afferentation from the visual system for the quality of maintaining the posture and balance.

Practical Work 3.
**Tonic Effects of the Brain Stem on the Time
of Motor Reaction to Sound**

Objective: to measure the time of motor reaction to sound.

Equipment and materials: reaction time meter.

Progress: Verbal instruction: when a sound signal is heard, press the key. A volunteer puts his hand on the telegraph key. The volunteer is sitting in front of the reflex meter, his head is tilted forward (chin rests on his chest), his hand freely reaches the telegraph key of the reflex meter. Determine the average time of motor reaction to sound from 10 attempts in this position. Then the volunteer tilts his head back (chin forward) and in this position the average time of 10 attempts is determined again. The study is carried out on several volunteers. Calculate the average value.

Results. Record the results into Table 5.3.

Table 5.3

Motor reaction with the head forward and backward

Volunteer	Motor reflex time	
	Head forward	Head backward

Conclusions. Compare the results obtained in two positions. Explain the reasons of differences, taking into account the tonic effects of the motor nuclei of the brain stem on the motor neurons of the spinal cord.

Tests

1. SUBSTANTIA NIGRA TO RED NUCLEUS PROVIDES INFLUENCE

- a) exciting b) no effect c) inhibitory

2. INTRAFUSAL MUSCULAR FIBERS INNERVATED BY MOTONEURONS

- a) Alpha
- b) Beta
- c) Gamma

3. EXTRAFUSAL MUSCULAR FIBERS INNERVATED BY MOTONEURONS

- a) Alpha
- b) Beta
- c) Gamma

4. EXTRAFUSAL MUSCULAR FIBERS PERFORM THE FOLLOWING FUNCTION:

- a) muscle contractions
- b) providing the sensitivity of the muscle spindle
- c) formation of muscle tone and its regulation

5. THE GOLGI APPARATUS IS LOCATED IN THE...

- a) nuclear bag of intrafusal fibers
- b) distal sections of intrafusal fibers
- c) tendons of muscles

6. EXCITATION OF GAMMA MOTONEURONS LEADS TO...

- a) reduction of white muscle fibers
- b) reduction of intrafusal muscle fibers
- c) relaxation of extrafusal muscle fibers
- d) reduction of extrafusal muscle fibers

7. EXCITATION OF ALPHA MOTONEURONS LEADS TO...

- a) Reduction of white muscle fibers
- b) Reduction of intrafusal muscle fibers
- c) Relaxation of extrafusal muscle fibers
- d) Reduction of extrafusal muscle fibers

8. REFLEXES THAT ENSURE THE CONSTANCY OF THE POSE DURING MOVEMENT are called...

- a) statokinetic c) somatic
- b) kinetic d) static

9. IN CASE OF CEREBELLUM PATHOLOGY WE DO NOT OBSERVE...

- a) violation of movement coordination
- b) violation of the knee reflex
- c) change in muscle tone
- d) autonomic disorders
- e) loss of consciousness

10. THE FUNCTION OF PRIMARY SOMATOSENSORY AREAS IN THE CEREBRAL CORTEX IS TO...

- a) perceive simple (elementary) sensations
- b) form sensations that unite their primary qualities

11. THE FUNCTION OF SECONDARY SOMATOSENSORY AREAS IN THE CEREBRAL CORTEX IS TO...

- a) perceive simple (elementary) sensations
- b) form sensations that unite their primary qualities

12. THE FUNCTION OF MUSCLE SPINDLE IS TO...

- a) prevent excessive muscle stretching
- b) prevent excessive muscle contraction
- c) both answers are correct

13. THE FUNCTION OF PONTINE RETICULAR NUCLEI IS TO...

- a) transfer excitatory signals downward through the special tract
- b) transfer inhibitory signals downward through the special tract

14. THE FUNCTION OF MEDULLARY RETICULAR NUCLEI IS TO...

- a) transfer excitatory signals downward through the special tract
- b) transfer inhibitory signals downward through the special tract

15. THE MUSCLE SPINDLE CONSISTS OF...

- a) extrafusal and intrafusal fibers
- b) only intrafusal fibers

16. GOLGI APPARATUS IS ACTIVATED DURING...

- a) muscle stretching
- b) muscle contraction
- c) both answers are correct

17. THE FUNCTION OF GOLGI APPARATUS IS TO...

- a) prevent excessive muscle stretching
- b) prevent excessive muscle contraction
- c) both answers are correct

18. THE «EXTRA PYRAMIDAL» SYSTEM PROVIDES...

- a) proper management of movements, maintenance of the muscular tone and posture
- b) improper management of movements, maintenance of the muscular tone and posture

19. THE «PYRAMIDAL» (CORTICOSPINAL) SYSTEM PROVIDES...

- a) proper management of movements, maintenance of the muscular tone and posture
- b) improper management of movements, maintenance of the muscular tone and posture

Report Topics

1. Physiology of the brain stem. Functions of cranial nerve nuclei.
2. Physiology of the reticular formation of the brain stem. Ascending and descending influences.
3. Physiology of the cerebellum: neural organization, afferent and efferent connections, cerebellar functions, symptoms of damage to the worm and hemispheres of the cerebellum.
4. Functions of basal nuclei. Afferent and efferent connections. Importance of planning and control of voluntary motor activity (skeleto-motor and oculo-motor circles) for the formation of purposeful behavior and cognitive activity of a person. Symptoms of irritation and damage to the nuclei.
5. Functions of the cerebral cortex: sensory, motor and associative zones of the cortex.

THEME III. NEURO-HUMORAL REGULATION

Terms

Autonomic nervous system – efferent division of the peripheral nervous system that innervates cardiac and smooth muscles as well as glands.

Sympathetic nervous system – “fight or flight” subdivision of the autonomic nervous system.

Parasympathetic nervous system – nerve fibers that release epinephrine when stimulated

Acetylcholine – primary neurotransmitter of the parasympathetic and sympathetic sudomotor nervous systems (sweat glands).

Cholinergic – nerve endings that release acetylcholine

Agonist (mimetic) – neurochemical or drug that binds to the receptor and initiates a physiological effect

Antagonist (blocker) – chemical that interferes with the physiological action of the agonist

Practical Class 6.

Physiology of the Autonomic Nervous System (ANS)

Goal: to study the principles of the autonomic nervous system functioning.

Introduction

The suprasegmental part of the autonomic nervous system contains the ergotropic system and trophotropic system. The

ergotropic system (ergon (greek) – action + tropos direction) regulates catabolic processes, providing adaptation to changing environmental conditions, physical and mental activity. These effects are mediated mainly by the sympathetic system (norepinephrine) and adrenal medulla (adrenaline = epinephrine). The trophotropic system (trophe (greek) nutrition + tropos, direction) regulates anabolism and maintains homeostasis during rest periods. These functions are mediated primarily through the parasympathetic system (acetylcholine).

Sympathetic and parasympathetic divisions typically function in opposition to each other. But this opposition is better termed complementary in nature rather than antagonistic. For an analogy, one may think of the sympathetic division as the accelerator and the parasympathetic division as the brake. The sympathetic division typically functions with actions requiring quick response. The parasympathetic division functions with actions that do not require immediate response. Consider the sympathetic part as "fight or flight" and the parasympathetic one as "rest and digest".

The central parts of the sympathetic nervous system are localized in the thoracolumbar part of the spinal cord (T1–L2/L3 levels). The central parts of the parasympathetic nervous system are localized in the craniosacral brain: cranial nerves CN III, VII, IX, X and sacral part of the spinal cord (S2–S4).

The parasympathetic nervous system uses only acetylcholine (ACh) as its neurotransmitter. ACh acts on two types of receptors: muscarinic and nicotinic cholinergic receptors. Most transmissions occur in two stages: when stimulated, the preganglionic nerve releases ACh into the ganglion, which acts on nicotinic receptors of the postganglionic nerve. The postganglionic nerve then releases ACh to stimulate the muscarinic receptors of the target organ.

In effector organs, sympathetic ganglionic neurons release noradrenaline (norepinephrine) to act on adrenergic receptors, with the exception of sweat glands and the adrenal medulla. In sweat glands, the neurotransmitter is acetylcholine, which acts on muscarinic receptors. In the adrenal cortex, there is no postsynaptic neuron. Instead, the presynaptic neuron releases acetylcholine to act on nicotinic receptors. Stimulation of the adrenal medulla releases adrenaline (epinephrine) into the bloodstream which will act on adrenoceptors, producing a widespread increase in sympathetic activity. In the parasympathetic system, ganglionic neurons use acetylcholine as a neurotransmitter to stimulate muscarinic receptors.

Questions for discussion

1. The functions of the autonomic nervous system (ANS) (regulation of the activity of internal organs and their blood supply, regulation of transport and metabolic support of various forms of activity of the body).

2. The scheme of implementation of the regulatory effect of the ANS through the suprasedgmental and segmental centers of the ANS. The concept of suprasedgmental and segmental centers of the ANS, their functions.

3. Sympathetic division of the autonomic nervous system. Localization of central parts. Postganglionic neurons, their mediators, the mechanism of excitation transmission in peripheral synapses. Adrenoreceptors of working organs and their blockers. Postganglionic neurons, their mediators, the mechanism of excitation transmission in peripheral synapses. Cholinergic receptors and their blockers.

4. Sympathetic ganglia. Mechanisms of excitation transmission in ganglia. Localization of central parts. Parasympathetic ganglia. Mechanisms of excitation transmission in them.

5. Parasympathetic division of the autonomic nervous system.
6. The relationship of the sympathetic and parasympathetic nervous systems (antagonism and synergism), peripheral effects.

Books recommended

1. Kérdö I. Ein aus Daten der Blutzirkulation kalkulierter Index zur Beurteilung der vegetativen Tonuslage // Acta neurovegetativa. – 1966. – Bd. 29. – № 2. – S. 250–268. (нем.) link.springer.com/article/10.1007/BF01269900
2. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020
3. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2. 2012

Practical works

1. Pupillary light reflex.
2. The study of dermographism.
3. Calculating Kerdo Index.
4. Heart rate variability (HRV).

Practical Work 1. Pupillary Light Reflex

Objective: to study the light reflex of the pupil.

Equipment and materials: light source (pen-flashlight), ruler.

Progress:

A. A volunteer looks over the experimenter`s shoulder. Measure the width of the right and left pupils in normal lightning, make sure that it is the same. Then study the reaction of the pupil to light. Light the eye with light. At the same time, the pupils of both eyes narrow. Measure the width of the pupil.

B. A volunteer looks over the experimenter`s shoulder. Measure the width of the pupil in normal lightning, write it into the

notebook. Close one eye with your hand. The width of the pupil increases. Measure the width of the pupil in this reaction, in mm.

Results. Fill in Table 6.1.

Table 6.1

Width Of The Pupil

Volunteer	Initial pupil width, mm	Pupil width, mm	
		Light	Darkness

Conclusions. Determine how the pupil width varies with light, which part of the ANS provides this reaction. How does the pupil width change with darkness, which part of the ANS provides this reaction? Tonic effects of which of the two systems (parasympathetic or sympathetic) predominate on the pupil muscles in usual conditions? Compare these effects in different volunteers.

Practical Work 2. The Study of Dermographism

Objective: to study physiological dermographism.

Equipment and materials: neurological metal rod, stopwatch.

Progress: Easily and quickly swipe the rod over the skin (i.e. write, apply a stroke). Observe the reaction of the skin at the site of irritation for 30 seconds. In a few seconds after irritation a white stripe appears in a healthy person (white reflex dermographism). Calculate the time of appearance and duration of white dermographism. A red stripe (red dermographism) appears after a strong and slow irritation. Determine the time of its appearance, duration and intensity. White dermographism is associated with a vasoconstrictive reaction, realized through the sympathetic system. Diffused and persistent red dermographism shows the

humoral effect (histamine, etc.) on the vascular tone. Physiological dermographism is a vasomotor reaction of the skin that occurs when it is mechanically irritated. Normally, when pressing on any area, it gets a temporary light colour, which then becomes more intense, compared with nearby areas. This phenomenon can be observed from 8 seconds to 30 minutes and should not be accompanied by itching and swelling.

Results. Fill the results into Table 6.2.

Table 6.2

Duration of Dermographism Reaction

Type of dermographism	Time of appearance	Width of the stripe	Duration, sec
White			
Red			

Conclusions. Make a conclusion about the causes of white and red dermographism. Explain the difference in time of appearance, duration and intensity.

Practical work 3.

Estimating the Tone of the ANS Divisions Regulating the Cardiovascular System at Rest

Objective: to measure which ANS division is active at the moment.

Equipment and materials: stopwatch, sphygmomanometer.

Progress: At rest (sitting) after 10 minutes of quiet staying in this position, determine the heart rate for 1 minute and measure blood pressure (BP). According to Kerdo index, determine the prevailing tonic effect of the ANS division on the cardiovascular system. Kerdo Index = $1 - (\text{diastolic blood pressure} / \text{heart rate})$.

The negative value of Kerdo index indicates the predominance of the parasympathetic system. The positive value indicates is the predominance of the sympathetic system.

Results. Fill the results into Table 6.3

Table 6.3.

Kerdo Index

Volunteer	Heart rate	Diastolic blood pressure	Kerdo index	Conclusion
Trained				
Untrained				
Male				
Female				

Conclusions. Estimation of Kerdo Index: amphotonia from -15 to $+15$, sympaticotonia from $+16$ to $+30$, increased sympathicotonia $\geq +31$, parasympathicotonia from -16 to -30 , increased parasympathicotonia ≤ -30 . Determine which part of the autonomous nervous system is active in the volunteer. How does training affect the tone of the autonomic nervous system? Compare Kerdo index in those who do and don't sport; in male and female.

Practical work 4.
Heart Rate Variability (HRV)

Objective: to study the principles of heart rate variability (HRV) analysis.

Equipment and materials: stopwatch, sphygmomanometer.

Progress: The values of RR cycles shown on the plates are presented in the table in accordance with the classes of statistical series.

Results. Fill the results into Table 6.4.

Table 6.4

Heart Rate Variability

Volunteer	Intervals R-R, sec										
	0,51-0,55	0,56-0,60	0,61-0,65	0,66-0,70	0,71-0,75	0,76-0,80	0,81-0,85	0,86-0,90	0,91-0,95	0,96-1,00	1,01-1,05
1											
2											
3											

Conclusions. On the basis of the obtained data, construct a variation curve (histogram of the distribution of the intervals R-R). On the ordinate axis, mark the number of intervals in the column. On the abscissa – R-R intervals according to the classes in the table. In equal influence of the sympathetic and parasympathetic systems on the heart rhythm, the curve is symmetrical (amphotonia). The left-sided asymmetry of the curve (the shift of the vertex to the left) indicates the predominance of the sympathetic system (sympathicotonia). Right-sided – parasympathetic (parasympathicotonia).

Conclusions. Determine the type of dominance of ANS divisions in three volunteers.

Tests

1. WHICH OF THE FOLLOWING STATEMENTS REFERS TO THE AUTONOMIC NERVOUS SYSTEM?

- The ANS innervates skeletal muscle
- ANS functions are consciously controlled
- The ANS controls unconscious movement of skeletal muscles
- Receptor molecules of the ANS may be muscarinic, nicotinic, or adrenergic

2. WHICH OF THE ORGANS LISTED BELOW IS NOT DIRECTLY INNERVATED BY THE AUTONOMIC NERVOUS SYSTEM?

- a) heart
- b) sweat glands
- c) smooth muscle
- d) skeletal muscle

3. IN THE SYMPATHETIC DIVISION OF THE ANS...

- a) an important characteristic is convergence of neurons
- b) preganglionic fibers are generally longer than postganglionic fibers
- c) the preganglionic cell body is located in the lateral horn of the spinal cord
- d) a single preganglionic fiber usually synapses with a single postganglionic fiber
- e) preganglionic fibers emerge from the cervical portion of the spinal cord

4. THE PARASYMPATHETIC NERVOUS SYSTEM IS CHARACTERIZED BY...

- a) the absence of preganglionic fibers
- b) the absence of postganglionic axons
- c) short postganglionic axons near the organs they innervate
- d) short preganglionic axons near the spinal cord

5. SYMPATHETIC STIMULATION OF THE POSTGANGLIONIC CELLS OF THE ADRENAL MEDULLA CAUSES THE RELEASE OF...

- a) acetylcholine and epinephrine
- b) norepinephrine and acetylcholine
- c) epinephrine and norepinephrine
- d) cortisol

6. THE VAGUS NERVE CARRIES PARASYMPATHETIC IMPULSES TO THE...

- a) salivary glands
- b) lacrimal glands
- c) parotid gland
- d) thoracic and abdominal viscera

7. WHICH OF THE FOLLOWING NEURONS IS MOST LIKELY TO BE ADRENERGIC?

- a) preganglionic sympathetic
- b) preganglionic parasympathetic
- c) postganglionic sympathetic
- d) postganglionic parasympathetic
- e) postganglionic somatic motor

8. THE MEMBRANES OF ALL POSTGANGLIONIC NEURONS IN AUTONOMIC GANGLIA HAVE...

- a) somatotrophic receptors
- b) muscarinic receptors
- c) adrenergic receptors
- d) nicotinic receptors

9. EFFECTOR CELLS THAT RESPOND TO ACETYLCHOLINE RELEASED FROM POSTGANGLIONIC NEURONS HAVE...

- a) somatotrophic receptors
- b) muscarinic receptors
- c) adrenergic receptors
- d) nicotinic receptors

10. THE TWO CLASSES OF ADRENERGIC RECEPTORS ARE...

- a) alpha and beta
- b) splanchnic and terminal
- c) muscarinic and nicotinic
- d) nicotinic and cholinergic

11. ADRENERGIC RECEPTORS...

- a) can be activated by the release of epinephrine
- b) have two structural forms - muscarinic and nicotinic
- c) when activated stimulate skeletal muscles to contract
- d) can be found in both the sympathetic and parasympathetic divisions
- e) are activated by the release of acetylcholine

12. WHEN ACETYLCHOLINE BINDS TO AUTONOMIC MUSCARINIC RECEPTORS...

- a) heart rate increases
- b) voluntary movements occur
- c) intestinal motility increases
- d) intestinal motility decreases

13. SYMPATHOMIMETIC AGENTS ACTIVATE...

- a) nicotinic receptors
- b) muscarinic receptors
- c) adrenergic receptors
- d) somatotrophic receptors
- e) cholinergic receptors

14. ATROPINE CAUSES THE PUPIL OF THE EYE TO DILATE BY BLOCKING THE EFFECT OF MUSCARINIC RECEPTORS. THIS MEANS ATROPINE IS A(N)...

- a) ganglionic blocking agent
- b) beta-adrenergic blocking agent
- c) alpha-adrenergic blocking agent
- d) parasympathetic blocking agent

15. WHICH OF THE FOLLOWING DRUGS WOULD BE THE BEST CHOICE TO USE IN CHRONIC ASTHMA TO DILATE THE BRONCHIOLES?

- a) a nicotinic agent
- b) a muscarinic agent
- c) alpha-adrenergic blocking agents
- d) beta-adrenergic stimulating agents
- e) ganglionic blocking agents

16. BETA-BLOCKERS (BETA-ADRENERGIC BLOCKING AGENTS) ARE FREQUENTLY USED TO...

- a) cause vasoconstriction
- b) block muscarinic receptors
- c) dilate the pupils of the eye
- d) prevent increases in heart rate
- e) prevent decreases in heart rate

17. WHICH OF THE FOLLOWING OCCURS WHEN THE PARASYMPATHETIC SYSTEM IS STIMULATED?

- a) increased blood pressure
- b) increased motility of the digestive tract
- c) increased metabolism
- d) increased heart rate
- e) decreased motility of the digestive tract

18. A MAN SEES A WOMAN; THE PUPILS OF HIS EYES DILATE. IT IS "LOVE AT FIRST SIGHT". What division of the ANS is involved?

- a) sympathetic division
- b) parasympathetic division
- c) somatic motor division

19. ACETYLCHOLINE WILL CAUSE THE PUPIL OF THE EYE TO CONSTRICT. A DRUG ACTS ON RECEPTORS FOR ACETYLCHOLINE TO CAUSE THE PUPILS OF THE EYE TO DILATE. NICOTINE DOES NOT BIND TO RECEPTORS IN SMOOTH MUSCLE CELLS OF THE IRIS. THEREFORE, THE DRUG WHICH CAUSES THE PUPILS TO DILATE IS A (AN)...

- a) nicotinic blocking agent
- b) muscarinic blocking agent
- c) nicotinic agent
- d) muscarinic agent
- e) adrenergic agent

Report Topics

1. Central parts of the autonomic nervous system. Limbic system.
2. Mechanisms of ANS regulation (agonists and antagonists)
3. Methods of ANS studying.

Practical Class 7. Endocrine System

Terms

Endocrine hormones (endocrines) – hormones released by glands or specialized cells into the circulating blood which influence the function of target cells at another location in the body.

Endocrine system – the system of endocrine glands, as well as diffusely distributed endocrine tissues and endocrine cells, which synthesize and secrete hormones to regulate body functions.

Type I diabetes – an autoimmune disease that leads to destruction of pancreatic β -cells and absolute insulin deficiency.

Type II diabetes – a disease characterized by a relative deficiency of insulin caused by a decrease in cell sensitivity to insulin or insulin secretion (or a combination of both).

Goal: to study the role of the endocrine system in maintaining homeostasis, as well as regulating the processes of growth, development and reproduction.

Introduction. The endocrine system is a complex of endocrine glands, as well as diffusely distributed endocrine tissues and endocrine cells that produce hormones. Hormones are chemical messengers that regulate most body functions, including homeostasis, growth, development, reproduction, as well as behavior (response to stress, emotion, mental activity). Hormones are released by endocrine cells into extracellular fluid and then diffuse into bloodstream, circulate with the blood and bind to specific receptors on/in target cells. There are three groups of hormones based on their chemical structure: steroids, amines and proteins.

– *Steroids* are derivatives of cholesterol and therefore can diffuse through plasma membrane (since they are formed by the lipid layer), so steroid hormone receptors are located inside target cells. Steroids: *cortisol* and *aldosterone* secreted by the adrenal cortex; *estrogen* and *progesterone* secreted by the ovaries and placenta; *testosterone* secreted by the testes.

– *Amines* are derivatives of the amino acid tyrosine.

Amines: *triiodothyronine* (T3) and *tetraiodothyronine* (T4) secreted by the thyroid; catecholamines – *epinephrine* and *norepinephrine* secreted by the adrenal medulla. Thyroid hormones T3 and T4 enter the cell by passive diffusion. Once in the cell, thyroid hormones penetrate into the nucleus, where they bind with nuclear receptors and can directly affect gene expression. Catecholamines receptors are surface.

– *Proteins and polypeptides* make up most of the hormones in the body including *hormones secreted* by the *anterior* and *posterior pituitary*, pancreas (*insulin* and *glucagon*), parathyroid gland (*parathyroid hormone*) and many others. Since proteins are

water soluble and can't cross plasma membrane so receptors for protein and peptide hormones are located on the cell surface and activation of the cell occurs with secondary messengers. Secondary messengers are effector molecules that can trigger various cascades of reactions inside the cell.

Report Topics

1. Autoregulation of hormone synthesis.
2. Hypothalamic-pituitary control of the thyroid, adrenal and gonadal glands.
3. Hormonal control of puberty and pregnancy.

Questions for discussion

1. Primary and secondary messengers.
2. Chemical structures of hormones.
3. Autoregulation of hormones synthesis.
4. Hypothalamic-pituitary control of the thyroid, adrenal and gonadal glands.
5. Hormonal control of puberty and pregnancy.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th Ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th Ed; WB Saunders, 2. 2012.

Practical works

1. Effect of insulin and aloxan on blood glucose levels.
2. Effect of thyroxine, thyroid stimulating hormone (TSH) and propyltiouracil on rat metabolism.

Practical work 1.
Effect of Insulin and Alloxan
on Blood Glucose Levels

Insulin is a peptide hormone which is synthesized by β -cells of the Langerhans' islets of the pancreas. The main metabolic action of insulin is to lower the level of glucose in the whole blood, by increasing the transfer of glucose through the plasmatic membrane of target cells, where it enhances: glycolysis; inclusion of glucose in the glycogen molecule (in the hepatic and muscular tissues); transformation of glucose into lipids and proteins, i.e. insulin increases the permeability of membranes for glucose so that cells absorb glucose from the blood and its content there decreases. There are violations of insulin secretion:

1. Destruction of β -cells leads to absolute insulin deficiency and is a key event in the pathogenesis of type I diabetes mellitus;

2. A decrease in the sensitivity of cells to insulin leads to relative insulin deficiency – plays an important role in the development of type II diabetes.

Objective: to demonstrate the effect of insulin on a healthy rat and a rat with insulin-dependent diabetes mellitus induced by alloxan administration (the substance which destroys the cells of Langerhans islets of the pancreas).

Equipment and materials: virtual practical work is carried out in a computer classroom.

Progress: Take a blood sample from the normal rat and then another blood sample from the rat with diabetes mellitus, before and after insulin administration. Measure the blood glucose level.

Results: Fill in Table 7.1.

Table 7.1

Glucose Level in Normal Rat, Rat with Diabetes Mellitus
Before and After Insulin Administration

Glucose level	mg/dl (conventional units)	mmol/l (SI units, mg/dl × 0.05)
Normal rat		
Rat with diabetes mellitus (after aloxan injection)		
Rat with diabetes mellitus after treat- ment (after sequential administration of aloxan and insulin)		

Conclusion. Make conclusions about the role of insulin therapy in type I diabetes.

Practical work 2.

***Effect of Thyroxine, Thyroid Stimulating Hormone (TSH)
and Propylthiouracil on Rat Metabolism***

Metabolism consists of all the exchanges of matter and energy between the organism and environment. Its value depends on the following:

- Species (the larger the animal, the lower the value of metabolism);
- Sex (the metabolism of a male is more intense than that of a female);
- Age (the older the animal, the lower the value of metabolism).

The main hormones which are responsible for regulation of metabolism are thyroid hormones (T3 and T4). They are synthesized by follicular cells of the thyroid gland, and their secretion is

enhanced by thyroid-stimulating hormone (TSH), which is synthesized by the anterior pituitary gland.

The intensity of exchanges between the organism and environment may be estimated by measuring the heat which comes out of the organism into the environment.

Direct calorimetry means measuring the heat which comes out of the organism into the environment per time unit. For this purpose a complex experimental device is necessary.

Indirect calorimetry makes it possible to evaluate metabolism by means of simpler methods, which do not use complex experimental devices. Such methods are: the method of nutritive balance and the method of respiratory exchanges. The method of respiratory exchanges is based on the principle that the intensity of metabolism is proportional to the amount of oxygen consumed by the organism per time unit.

Objective: to demonstrate the influence of T4, TSH and propyltiouracil on rat metabolism.

Equipment and materials: virtual practical work is carried out in a computer classroom. Metabolism is measured in a normal rat before and after administration of T4, TSH and propyltiouracil. *Propyltiouracil* is a substance which inhibits the synthesis of thyroid hormones.

Progress: During breathing, the animal absorbs oxygen and releases carbon dioxide. Carbon dioxide is absorbed by sodium. The volume of oxygen in the air decreases. Then we can determine the amount of oxygen absorbed.

1. Place an ordinary rat in the breathing room that is isolated from atmospheric air.

2. Wait for 60 seconds and notice how the level of the liquid decreases in the left side of the manometer, as oxygen from the

breathing room is consumed (at the same time, carbon dioxide which is produced by the rat is absorbed by sodium limestone).

3. After 60 seconds introduce air into the breathing room using the corresponding buttons until the level of liquid is equal on both sides of the manometer. This volume equals the volume of oxygen consumed by the animal during the experiment.

4. Repeat steps 1–2–3 after administering T4, TSH and propylthiouracil to the rat.

Results. Calculate the metabolic rate using the following formula and fill in Table 7.2.

$$\text{Metabolic rate} = \text{volume of consumed O}_2 \text{ (ml)} / \text{weight (kg)} / \text{time (hour)}$$

Table 7.2

**Oxygen Consumption and Metabolic Rate in a Normal Rat
After Administration of T4, TSH and Propylthiouracil**

	Normal rat	After T4 administration	After TSH administration	After propylthiouracil administration
Oxygen consumption (ml)				
Metabolic rate				

Conclusion. Make conclusions about the effect of T3 and T4 on the metabolism.

Tests

1. PROTEIN AND PEPTIDE HORMONE RECEPTORS ARE LOCATED...

- a) inside the cell (cytoplasmic and nuclear receptors)
- b) on the cell membrane (surface receptors)

2. NEUROENDOCRINE HORMONES ARE...

- a) peptides secreted by immune cells into the extracellular fluid and can function as autocrines, paracrines, or endocrines.
- b) secreted by neurons into the circulating blood and influence the function of target cells at another location in the body.
- c) released by glands or specialized cells into the circulating blood and influence the function of target cells at another location in the body

3. BY CHEMICAL STRUCTURE HORMONES CAN BE...

- a) proteins and polypeptides
- b) carbohydrates
- c) amines
- d) steroids

4. MAKE A MATCH

- | | |
|------------------------|---|
| 1. Steroid hormones... | a) are tyrosine derivatives formed by the action of enzymes in the cytoplasmic compartments of the glandular cells. |
| 2. Peptide hormones... | b) are usually synthesized from cholesterol (they are lipid soluble) and not stored, but can be rapidly mobilized for steroid synthesis after a stimulus. |
| 3. Amine hormones... | c) are synthesized by endoplasmic reticulum of the endocrine cells and stored in secretory vesicles until needed |

5. MAKE A MATCH

- | | |
|---|---|
| 1. Central endocrine glands are... | a) kidneys, thymus, pancreas and gonads. |
| 2. Peripheral endocrine glands are... | b) hypothalamus and pituitary. |
| 3. Organs that combine endocrine and non-endocrine functions are... | c) thyroid gland, parathyroid glands and adrenal glands |

6. ADRENAL CORTEX HORMONE THAT STIMULATES MASCULINIZATION IS...

- a) testosterone b) adrenaline c) corticosterone

7. HORMONES ARE SECRETED...

- a) through the ducts in the body cavity
b) directly to the blood or into the intercellular fluid and then into the blood
c) both options ("a" and "b") are correct

8. INSULIN IS A PEPTIDE HORMONE THAT IS PRODUCED BY...

- a) β -cells of the pancreatic islets of Langerhans
b) enteroendocrine cells of the stomach
c) parathyroid glands

9. THE PATHOGENESIS OF TYPE 1 DIABETES LINKS WITH ...

- a) violation of insulin secretion due destruction of β -cells of the pancreatic islets of Langerhans and absolute insulin deficiency
b) violation of the action of insulin on tissues/cells and relative insulin deficiency

Report Topics

1. Gastrointestinal hormones and regulation of energy homeostasis.

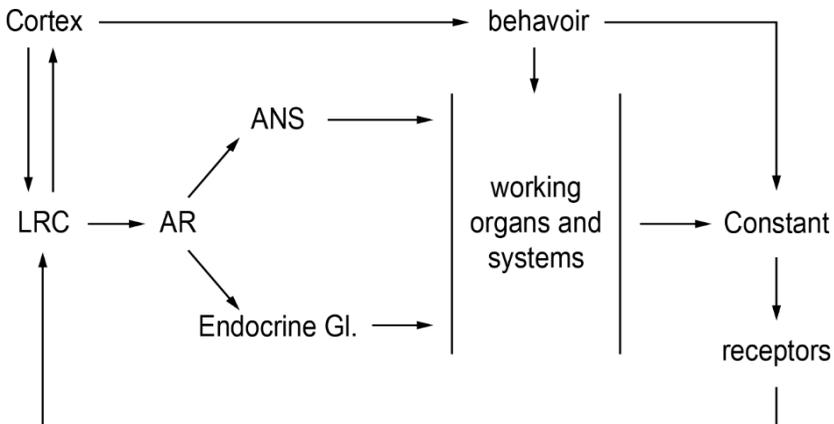
2. Hormonal control of puberty and reproduction.

Practical Class 8. Functional Systems

Goal: to study the regulations of homeostasis constants.

Introduction

The theory of functional systems was developed by the Russian scientist P. Anokhin. A functional system is a system of regulation of a certain constant of homeostasis, taking into account the role of nerve centers, direct and feedback connections between nerve centers and working organs and systems (Fig. 8.1).



*Fig. 8.1. Scheme of a functional system: AR – automatic regulation.
LRC – limbic-reticular complex (with hypothalamus)*

Questions for discussion

1. Anokhin's theory "Functional systems" (FS).
2. Components of a functional system.
3. Functional system of digestion.
4. Functional system of breathing.
5. Functional system of blood circulation (BP, BV).
6. FS maintaining osmotic pressure

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2. 2012.

Practical works

1. Orthostatic test.
2. Martine-Kushelevsky test.

Practical Work 1. Orthostatic Test

Objective: to demonstrate how changing the body position changes the heart rate and blood pressure. Students will compare the cardiovascular performance when a volunteer is at rest (in a horizontal position) and immediately after transition from the horizontal to vertical position and during the recovery period.

Equipment and materials: couch, stopwatch, sphygmomanometer, stethoscope.

Progress: Count the pulse (HR) twice after a 10-minute stay in the supine position, measure the blood pressure, the lowest of the two values is recorded into the table. Then, by the command, the volunteer takes a standing position. Immediately count the pulse in the first 15 seconds of orthostatics. According to these results, estimate the reaction of the heart to deposition of blood in the lower half of the body. Then, the heart rate is counted at the 3rd minute of staying in a vertical position, the blood pressure is determined at the end of the 3rd minute. The state of the mechanisms of orthostatic stability of the cardiovascular system is estimated according to the results of the 3rd minute.

Results. Record the results into Table 8.1.

Table 8.1

Survey conditions	Pulse Rate	BP syst.	BP diast.	BP pulse	Estimation of the results
Lying					
Standing, the first 15 sec					
Standing, 3-rd minute					

The tolerance of the sample is estimated by the Table 8.2 using the HR and BP data at the 3rd minute.

Table 8.2

Assessment of the tolerance of the orthostatic test

Indicators	Portability of the sample (3rd minute)		
	Good	Satisfied	Unsatisfied
HR/Pulse Rate	Acceleration no more than 11 strokes	Increase by 12–18 strokes.	Increase by 19 strokes and more
BP _{syst.}	Increases	Does not change	Decreases within 5–10 mm Hg.
BP _{diast.}	Decreases	Does not change	Increases
BP _{puls.}	Increases	Does not change	Decreases
ANS reaction	absent	Sweating	Sweating, tinnitus

Conclusions. assess the functional usefulness of reflex mechanisms of blood circulation regulation in the orthostatic test. What does “orthostatic shock” mean? List the components of a functional system.

Practical Work 2. Martine-Kushelevsky Test

Objective: to demonstrate how exercise changes the heart rate and what happens during the recovery period. Students will compare the cardiovascular performance when the volunteer is at rest and immediately after training and during the recovery period.

Equipment and materials: stopwatch.

Progress: Calculate the heart rate of a volunteer at rest (after 5 minutes of quiet sitting). The volunteer is asked to perform 20 squats (deep knee bends) in 30 seconds. The state of the mechanisms of regulation of transport supply of physical exertion is estimated by the results of the increase in the heart rate immediately after the exercise. The heart rate is counted for 15 seconds, converted to min. The state of the regulatory mechanisms in the recovery period is estimated by the results of squats at the 3rd min of the recovery period. The pulse is counted in the "sitting" position: before exertion, immediately after squats, at the end of the 2nd minute, at the end of the 3rd minute.

Results. Write the results into Table 8.3.

The increase of HR is calculated by the formula:

$$(HR_{\text{ex}} - HR_{\text{rest}}) \times 100 \% / HR_{\text{rest}},$$

where HR_{ex} – heart rate during exercise (measured immediately after exercise), HR_{rest} – heart rate after rest.

Conclusions. The results on the 1st minute tell us about the state of the mechanisms that adapt the cardiovascular system to exertion, on the 2nd and 3rd minutes – about the ability of the mechanisms of regulation of the cardiovascular system to recover after performing physical activity. Characterize the basic mechanisms that provide recovery after physical exertion in this volunteer, what are these mechanisms?

Table 8.3

Conditions of HR recording	HR	HR increase		Normal	Result assessment
		Absolute	%		
Sitting position Initial			100	60–80/min	
Immediately after exertion 1 minute				25% – excellent 26–50% – good 51–75% – satisfied >75% – unsatisfied	
At the end of the 2nd minute exertion 2 minute					
At the end of the 3rd minute exertion 3 minute				<5 beats – good 5–10 beats – satisfied >10 beats – unsatisfied	

Tests

1. ANGIOTENSIN II IMPLEMENTS ITS EFFECT THROUGH...

- a) vasoconstriction
- b) effect on glomerular filtration in the kidneys
- c) effect on reabsorption
- d) vasodilation

2. BLOOD PRESSURE HOMEOSTASIS IS REGULATED BY...

- a) baroreceptors c) volumoreceptors
- b) osmoreceptors d) chemoreceptors

3. EXTRINSIC CONTROLS REGULATE...

- a) local controls that are inherent in an organ
- b) regulatory mechanisms initiated outside an organ
- c) system aimed at stopping bleeding

4. THE FUNCTIONAL SYSTEM OF CO₂ AND O₂ IN THE BLOOD IS REGULATED BY...

- a) baroreceptors
- b) osmoreceptors
- c) volumereceptors
- d) chemoreceptors

5. THE FUNCTIONAL SYSTEM OF OSMOTIC PRESSURE IS REGULATED BY...

- a) baroreceptors
- b) osmoreceptors
- c) volumereceptors
- d) chemoreceptors

6. THE HORMONE THAT CAN INCREASE THE GLOMERULAR FILTRATION RATE IS...

- a) atrial natriuretic peptide
- b) renin
- c) angiotensin
- d) aldosterone

7. INTRINSIC CONTROLS REGULATE...

- a) local controls that are inherent in an organ
- b) regulatory mechanisms initiated outside an organ
- c) accomplished by nervous and endocrine systems

8. NEGATIVE FEEDBACK LOOP CHARACTERISTICS ARE THE FOLLOWING

- a) original stimulus reversed, most feedback systems in the body are negative, used for conditions that need frequent adjustment, causes effectors to counteract the influence that creates
- b) original stimulus intensified (Amplifies a response), increases deviation from a set point, anticipates internal changes and changes the set point, seen during normal childbirth

9. POSITIVE FEEDBACK LOOP CHARACTERISTICS ARE THE FOLLOWING

- a) original stimulus intensified (Amplifies a response), increases deviation from a set point, anticipates internal changes and changes the set point, seen during normal childbirth
- b) original stimulus reversed, most feedback systems in the body are negative, used for conditions that need frequent adjustment, causes effectors to counteract the influence that creates

10. RENIN-ANGIOTENSIN-ALDOSTERONE SYSTEM...
(CHOOSE THE TRUE STATEMENT)

- a) causes vasoconstriction and an increase in the volume of circulating blood
- b) causes vasodilatation and a decrease in pressure
- c) increases body temperature
- d) increases the number of red blood cells

11. THE THEORY OF FUNCTIONAL SYSTEMS WAS DEVELOPED BY...

- a) Anokhin
- b) Pavlov
- c) Sechenov
- d) Mechnikov

12. THE THERMOREGULATION MECHANISM IS IMPLEMENTED BY...

- a) sweat glands and muscle tremors
- b) regulating the volume of circulating blood
- c) increasing the number of red blood cells
- d) increasing the amount of warming fat

13. THE VOLUME OF CIRCULATING BLOOD IS REGULATED BY...

- a) baroreceptors c) volumoreceptors
- b) osmoreceptors d) chemoreceptors

14. WHAT IS HOMEOSTASIS?

- a) the system aimed at stopping bleeding
- b) the system for maintaining stable conditions in the internal environment
- c) the gas exchange system
- d) the system of higher nervous activity

THEME IV. BEHAVIOR

Terms

Analysis information – a distinction between acting stimuli.

Association cortices – the part of the parietal cortex that plays an important role in the production of planned movements.

Attention – selective orientation of human consciousness on certain objects and phenomena.

Balance of nervous processes – the relationship between excitation and inhibition.

Behavior – all the activities of an organism in the environment.

Conditioned reflex (temporary connection) – an individual reaction acquired during life through learning.

Consciousness – the state of being awake and aware of what is around you, able to think.

Dynamic stereotype – a sequence of conditioned reflexes developed for a strictly defined sequence of stimuli.

Electroencephalography (EEG) – an electrophysiological monitoring method to record electrical activity of the brain.

Emotion – subjective experience when changing external or internal environment.

Imprinting – a form of education in psychology and ethology, the "following reaction" of chicks or cubs of mammals after their parents and one after another.

Instinct – a chain of unconditioned reflexes.

Intelligence – the ability to learn, understand, and make judgments or have opinions that are based on reason.

Learning – a process to acquire new knowledge.

Mobility of nervous processes – the ability to quickly switch nervous processes.

Melatonin – “the sleep hormone”.

Memory – the process of capturing, storing and retrieving information.

Motivation to action – psycho-physiological process that controls human behavior.

Personality – the type of a person you are, shown by the way you behave, feel, and think.

Sensation – the ability to feel something physically, especially by touching, or a physical feeling that results from this ability.

Sleep – a periodic physiological state of loss of communication with the surrounding world.

Strength of the nervous processes – manifestation of the processes of excitation and inhibition.

Synthesis information – the recognition of an object, phenomenon or formation of an image.

Temperament (type of higher nervous activity) – a set of stable dynamic features of human mental processes: pace, rhythm, intensity.

Thinking – a cognitive mental process of reflecting the essential connections and relationships of objects and phenomena of the objective world.

Unconditioned reflex – inborn or dependent on physiological maturation rather than on learning.

Working memory – the operational component of short-term memory.

Practical Class 9.

Intellectual Functions of the Brain, Learning and Memory. EEG

Goal: to study the integrative function of the central nervous system, the mechanisms of intelligence, memory, learning.

Introduction

The cerebral cortex and the closest subcortical nuclei form the higher parts of the central nervous system. They form complex purposeful behavioral acts.

A very important role belongs to the frontal cortex: a) planning and organization of movements b) motor mechanisms c) regulation of speech, arbitrary complex forms of behavior, d) thinking processes.

Consciousness is a manifestation of human behavior. Attention, as a cognitive process in humans, manifests itself in a conscious state.

Memory plays an important role in studying the surrounding world, in learning. Thinking is the process of cognition and accumulation of information, operating this information with the help of memory.

Questions for discussion

1. Functions of the frontal cortex.
2. Electroencephalography – recording of brain electrical activity, EEG rhythms.
3. Physiological mechanisms of sleep. The role of suprachiasmatic nucleus. Melatonin.
4. Memory and learning. Types of memory and their neurophysiological mechanisms.
5. Consciousness, attention, thinking.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 24th ed; McGraw-Hill Companies, Inc., 2012.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 14th ed; WB Saunders, 2020.
3. Medical physiology: principles for clinical medicine / edited by Rodney A. Rhoades, David R. Bell. - 4th ed. 2013.
4. Physiology / Linda S. Costanzo. 6 th ed. 2018.

Practical works

1. Taking an electroencephalogram in a person. Its changes with an approximate reaction to photostimulation.
2. Identifying the predominant type of memory.

Practical Work 1.

***Taking an Electroencephalogram in a Person.
Its Changes with an Approximate Reaction
to Photostimulation***

Alpha rhythm 8–13 Hz. Alpha rhythm is associated with a relaxed state of wakefulness, rest. Alpha waves occur when we close our eyes and begin relaxing.

Beta rhythm 14–30 Hz. Beta waves are normally associated with higher cognitive processes and focusing attention, in a normal waking state, when we observe events with open eyes, or are focused on solving any current problems.

Theta rhythm 3–7 Hz. Theta waves appear when a calm, relaxed wakefulness turns into sleepiness.

Delta rhythm 0.5–3 Hz. Delta rhythm (slow waves) is associated with regenerative processes, especially during sleep, and low levels of activation.

Objective: to study how to evaluate an electroencephalogram.

Equipment and materials: electroencephalograms, rulers.

Progress: Specify the types of EEG waves recorded in different areas of the brain. Measure the frequency and amplitude of EEG waves recorded in the occipital region of the brain at rest, during and after photo stimulation (to analyze the EEG, students use a tablet with recordings from different areas of the brain).

Results: Present the results of measurements of the amplitude and frequency of EEG waves in the occipital region of the brain.

Conclusion: Specify the type of reaction to photo stimulation, frequency and amplitude characteristics of the main types (alpha, beta, theta, delta) of waves – the rhythms of the EEG. Assess the EEG method in the study of brain functions, behavior.

Practical Work 2.

Identifying the Predominant Type of Memory

Objective: to study to evaluate short-term memory.

Equipment and materials: four tables (each with 10 different words).

Progress: the work is conducted by the teacher.

1. The teacher reads aloud 10 words of Table No. 1 for 1 minute. Then, after 10 seconds, each student writes down the memorized words for 1 minute. Take a 3-minute break.

2. The students are shown Table No. 2 with 10 words for 1 minute. After a 10-second break each student writes down the learned words for 1 minute. Next, check the words memorized correctly. This is the way to test the visual memory. Take a 3-minute break.

3. The teacher reads the words of Table No. 3. The students listen to them for 1 minute, repeat in a whisper, “spell” in the air. After a 10-second break, students write down the words for 1 min.

Check the words memorized correctly. This is the way to test the auditory memory. Take a 3-minute break.

4. The students listen to the words of Table No. 4, watch them for 1 minute, repeat in a whisper, “spell” in the air. After a 10-second break, memorize the words for 1 minute. Check the words memorized correctly. This is the way to test the combined memory.

Results. Fill in Table 9.1

Table 9.1

Memory types

Memory type	Number of words to remember A	Number of memorized words B	Memory coefficient B/A
Auditory	10		
Visually	10		
Hearing-motor	10		
Combined	10		

Calculate the coefficients of different types of memory for students of the group.

Conclusions. Identify the predominant type (s) of memory for the student and students of the group.

Tests

1. ELECTROENCEPHALOGRAPHY (EEG). ALPHA RHYTHM IN EEG IS...

- a) 8–13 Hz b) 0.5–3 Hz c) 14–30 Hz

2. ELECTROENCEPHALOGRAPHY (EEG). BETA RHYTHM IN EEG IS...

- a) 8–13 Hz b) 14–30 Hz c) 0.5–3 Hz

3. ELECTROENCEPHALOGRAPHY (EEG). DELTA RHYTHMS IN EEG IS...

- a) 8–13 Hz b) 14–30 Hz c) 0.5–3 Hz

4. ELECTROENCEPHALOGRAPHY IS...

- a) recording of brain electrical activity
b) recording of heart electrical activity
c) recording of eye electrical activity

5. WHICH OF THE FOLLOWING DO/DOES NOT REFER TO THE FUNCTIONS OF THE CEREBRAL CORTEX?

- a) participation in language processing
b) definition of intelligence
c) identity definition
d) spontaneous regulation of breathing
e) sensory information processing

6. WHICH OF THE FOLLOWING DO/DOES NOT REFER TO THE FUNCTION OF THE FRONTAL LOBES?

- a) motor mechanisms of speech
b) regulation of complex behaviors
c) thought processes
d) organization of voluntary movements
e) visual signal processing

7. THE LEFT HEMISPHERE IS RESPONSIBLE FOR...

- a) logic and analysis, aptitude for music and visual arts
b) language abilities (controls speech, writing, reading), the ability to dream and fantasize
c) logic and analysis, numbers and mathematical symbols

8. THE RIGHT HEMISPHERE...

- a) specializes in processing information that is expressed in symbols and images, remembers facts, names, dates and their spelling.
- b) is responsible for the ability to identify music and visual arts, instantly creates an image of the object
- c) processes information that is expressed in symbols and images, remembers facts, names, dates and their spelling.

9. SPEECH IMPAIRMENT IS CAUSED BY...

- a) anesthesia
- b) aphasia
- c) tremor

10. WERNICKE'S AREA IS LOCATED IN THE...

- a) visual cortex and is responsible for recognizing words and sentences.
- b) motor cortex and is responsible for recognizing words and sentences.
- c) auditory cortex and is responsible for recognizing words and sentences.

11. BROCA'S AREA IS RESPONSIBLE FOR ARTICULATION, MUSCLE CONTRACTION AND MOVEMENT DURING SPEECH.

- a) right
- b) wrong

12. BROCA'S AREA AND WERNICKE'S AREA DON'T INTERCONNECT.

- a) right
- b) wrong

13. MEMORY IS A PROCESS OF...

- a) information capturing
- b) information storage
- c) information receiving
- d) all answers are correct

14. MECHANISM OF SHORT-TERM MEMORY

- a) circulation of impulses in neural networks
- b) synthesis of new proteins, resulting in an increase in the area of synaptic contacts
- c) change in the structure of protein ion channels and an increase in the sensitivity of neurons to impulses

15. MECHANISM OF LONG-TERM MEMORY

- a) circulation of impulses in neural networks
- b) synthesis of new proteins, resulting in an increase in the area of synaptic contacts
- c) change in the structure of protein ion channels and an increase in the sensitivity of neurons to impulses

16. CHARACTERISTIC OF SENSORY MEMORY (ULTRA-SHORT -TERM MEMORY)

- a) limited duration of short-term memory ~18 seconds, capacity 7 + 2 words or digits
- b) duration capacity – long, large
- c) both answers are wrong

17. THE WORKING MEMORY REFERS TO...

- a) sensory memory (ultra- short-term memory)
- b) short-term memory (primary memory)
- c) long-term memory

18. THE PROCESSES OF LONG-TERM MEMORY OCCUR UNDER THE INFLUENCE OF THE FOLLOWING NEURO-TRANSMITTER

- a) glutamate
- b) acetylcholine
- c) serotonin
- d) norepinephrine

19. THE CENTER OF ATTENTION IS LOCATED IN THE...

- a) thalamus
- b) hippocampus
- c) limbic system
- d) there is no special center

20. IN LEARNING MECHANISMS IT IS VERY IMPORTANT

- a) interaction of neurons with the help of axons
- b) interaction of neurons with the help of dendrites

Practical Class 10. Conditioned Reflexes

Goal: to study congenital and acquired forms of behavior, the theory of temperament, physiological mechanisms of sleep.

Introduction

The reflex principle of the work of the higher divisions of the central nervous system was suggested and justified by the Russian physiologist I.M. Sechenov (1863). Further, his ideas were developed by his student I.P. Pavlov (1849–1936). He created a new objective method of studying higher nervous activity—the method of conditioned reflexes. The formation of acquired behavioral programs is based on a conditioned reflex. The interaction of the organism with the external environment is determined by the innate and acquired properties of the nervous system: the strength of excitation and inhibition, their mobility and balance (the type of higher nervous activity – I. P. Pavlov).

Questions for discussion

1. Behavioral reactions, their meaning.
2. Characteristics of the conditioned reflex.

3. Inhibition of conditioned reflexes.
4. Dynamic stereotype.
5. The theory of temperaments.
6. Meaning and mechanisms of sleep.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 24th ed; McGraw-Hill Companies, Inc., 2012.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 14th ed; WB Saunders, 2020.
3. Medical physiology : principles for clinical medicine / edited by Rodney A. Rhoades, David R. Bell. — 4th ed. 2013.
4. Physiology / Linda S. Costanzo. 6 th ed. 2018.

Practical works

1. Differentiated inhibition in the cerebral cortex.
2. Studying typological features of the type of higher nervous activity using the Eysenck personality questionnaire.

Practical Work 1.

Differentiated Inhibition in the Cerebral Cortex

Objective: to study the technique of developing of a conditioned reflex and conditioned inhibition

Equipment and materials: installation for development of conditioned reflexes.

Progress: The technique allows us to develop a conditioned reflex to the green light. A volunteer sits in front of the reflexometer, presses on the head of the reflexometer key with his index finger. The volunteer is given a preliminary verbal instruction: "If you see a green light, raise your hand from the key head". After that, turn on the green light 10 times with breaks of 20–30 seconds.

Measure the motor reaction time. Then a new instruction is given: "If you see a green light, raise your hand from the key head. If you see a red light, do not remove your hand". Measure the reflex time for the green light after periodically switching on the red light.

Result. Note how the reflex time to the green light changed after the action of the red one not accompanied by a motor reaction.

Conclusion. Explain the reasons of changing in the time of the conditioned reflex to the green light after the action of the red one. What kind of inhibition in the cerebral cortex does differentiation inhibition refer to? What is its significance in human behavior?

Practical work 2.
***Studying Typological Features of the Type of
Higher Nervous Activity Using
Eysenck Personality Questionnaire***

Equipment and materials: Eysenck personal questionnaire, standard answers, indicators of standard rating scales (extra-introversion, anxiety) in points.

Progress: The work is carried out by the teacher. Each student briefly answers (only "yes" or "no") 57 questions of Eysenck questionnaire. The answers to the questions characterize sociability, communicability in activities and actions (extroversion) or isolation, determining internal motives (introversion) and anxiety in behavior. Neuroticism (emotional stability – emotional instability). According to the standard, the number of points for each rating scale is determined. Each correct answer gives 1 point. The final sum of points characterizes personality traits, approximate features (temperament) are estimated.

Sanguine = stable + extraverted

Phlegmatic = stable + introverted

Melancholic = unstable + introverted

Choleric = unstable + extraverted

Results. Answer “yes” or “no” to each of the 57 questions of Eysenck questionnaire. Calculate the number of points for each scale according to the standard. Identify the type of temperament.

Conclusion. To characterize the type of temperament (type of higher nervous activity) identified using Eysenck questionnaire.

Tests

1. IMPRINTING...

- a) has critical periods
- b) is capturing the image of the mother
- c) is a complex conditionally-unconditioned reaction

2. THE NEUROTRANSMITTER NOT INVOLVED IN ADDICTION IS...

- a) acetylcholine c) GABA
- b) serotonin d) Glutamate

3. INSTINCT IS...

- a) a chain of unconditioned reflexes
- b) a chain of conditioned reflexes
- c) capturing the image of the mother (parent)

4. THE CENTER OF THE ORIENTING REFLEX IS LOCATED IN THE...

- a) midbrain b) medulla oblongata c) limbic system

5. WHICH OF THE FOLLOWING CHARACTERISTICS DOES NOT REFER TO A CONDITIONED REFLEX?

- a) constant
- b) temporary
- c) acquired
- d) receptive field – any
- e) morphological basis – temporary connection

6. THE CONDITIONED REFLEX IS A (AN)...

- a) innate reaction
- b) acquired response
- c) center located in the spinal cord and the brain stem

7. POSITIVE EMOTIONS ARE PROVIDED BY THE...

- a) serotonergic system, endorphins
- b) adrenergic system
- c) dopamine system

8. NEGATIVE EMOTIONS ARE PROVIDED BY THE...

- a) serotonergic system, endorphins
- b) adrenergic system
- c) dopamine system

9. THE BASIS FOR MOTIVATION FORMATION IS...

- a) needs
- b) unconditioned reflexes
- c) conditioned reflexes

10. CHOOSE THE CORRECT CLASSIFICATION OF THE TYPES OF UNCONDITIONED INHIBITION OF CONDITIONED REFLEXES

- a) constant and variable
- b) permanent brake, fading brake, extreme braking
- c) deceleration, differential, conditional brake
- d) delayed braking, excessive braking.

11. UNCONDITIONED INHIBITION IN THE CORTEX REFERS TO...

- a) permanent braking
- b) differential inhibition
- c) delayed inhibition

12. WHICH OF THE FOLLOWING DOES NOT REFER TO CONDITIONED INHIBITION IN THE CORTEX?

- a) fading brake
- b) extinction
- c) differential inhibition
- d) disinhibition

13. ACCORDING TO I.P. PAVLOV CLASSIFICATION SANGUINE IS...

- a) strong, balanced, mobile
- b) strong, excitable
- c) strong, immobile

14. IVAN PAVLOV DIVIDED TEMPERAMENTS ACCORDING TO THE FOLLOWING PROPERTY (IES) OF NERVOUS PROCESSES...

- a) force
- b) equilibrium
- c) mobility
- d) all answers are correct

15. THE SLEEP HORMONE MELATONIN IS PRODUCED BY THE...

- a) pituitary
- b) pineal gland
- c) hypothalamus

16. FALLING ASLEEP IS CHARACTERIZED BY...

- a) theta waves on the EEG
- b) beta rhythm, spindles on the EEG
- c) delta waves on the EEG

17. THE BODY'S INTERNAL CLOCK IS THE...

- a) hypothalamus
- b) thalamus
- c) pituitary
- d) globus pallidus

18. THE MEANING OF SLEEP IS...

- a) memory stabilization
- b) getting new information
- c) formation of short-term memory

19. THE PARADOXICAL SLEEP PHASE IS CHARACTERIZED BY...

- a) lowering blood pressure
- b) decreasing heart rate
- c) irregular breathing

20. THE IMPRINTING CENTER IS LOCATED IN THE...

- a) thalamus
- b) hypothalamus
- c) cerebral cortex

THEME V. PHYSIOLOGY OF THE DIGESTIVE SYSTEM

Terms

Nutrition – the amount of nutrients and their ratio depending on the gender, age, body weight, as well as human working activity.

Hunger – a feeling in the whole body, an irresistible desire to eat any food.

Appetite – a desire to eat certain food.

Composition of bile – bile acids, bilirubin, fatty acids, cholesterol, salts, bicarbonates – pH 7.3–8.0.

Intestinal juice – contains water, salts, mucus, urinary and lactic acid, more than 20 enzymes – pH 7.0–8.6.

Component of the colon has pH 8.5–9.0, the dense part of which consists of mucous lumps in which enzymes from the small intestine are found.

Component of the large intestine – microflora, anaerobic bacteria predominate (90 %), the remaining 10 % are lactic acid bacteria and Escherichia coli.

The normal microflora of the colon includes: anaerobic bacteria (90 %), the remaining 10 % are lactic acid bacteria and Escherichia coli.

Auerbach's plexus – the outer plexus lying between the muscle layers, mainly controls motor activity.

Meusner's plexus – an internal plexus called the submucosal plexus, controls secretion and blood circulation.

Practical Class 11.
Secretory Functions of the Alimentary Tract.
Dietary Balance and Immunity (PLAB)

Goal: to study secretion and absorption in the gastrointestinal tract, the principles of dietary balances.

Introduction

Basic Mechanisms of Stimulation of the Alimentary Glands

1. Food contact with the epithelium — the function of enteric nervous stimuli.

2. Vegetative stimulation of secretion. Parasympathetic stimulation almost invariably increases the rates of alimentary gland secretion. Sympathetic stimulation usually reduces secretion.

3. Regulation of glandular secretion by hormones. In the stomach and intestine, several different gastrointestinal hormones help regulate the volume and character of secretions.

Secretion of Saliva. Saliva contains two major types of protein secretion:

(1) serous secretion containing ptyalin (α -amylase), which is the enzyme for digesting starches, and (2) mucus secretion containing mucin for lubrication and surface protection.

(2) parotid glands secrete an almost entirely serous type of secretion, while the submandibular and sublingual glands secrete both serous and mucus secretion.

(3) buccal glands secrete only mucus. Saliva has pH between 6.0 and 7.0, a favorable range for the digestive action of α -amylase.

Gastric Secretion. In the stomach there are glands in the gastric fundus (also called gastric glands), pyloric and mucous, which cover its entire surface. Gastric glands secrete hydrochloric acid, pepsinogen, internal factor and mucus. Pyloric glands

secrete mainly mucus, as well as the hormone - gastrin. Pepsin functions as an active proteolytic enzyme in a highly acidic medium (optimal pH from 1.8 to 3.5), it breaks down proteins to oligopeptides (Pepsin A -hydrolyzes egg albumin, muscle protein, Pepsin C – gastricin cleaves connective tissue protein – collagen, Pepsin B. Gastric secretion is said to occur in three “phases”: cephalic, gastric and intestinal.

Pancreatic Secretion. Pancreatic juice contains enzymes for digesting proteins, carbohydrates and fats. The main enzymes for fat digestion are (1) pancreatic lipase, which is able to hydrolyze neutral fat into fatty acids and monoglycerides; (2) cholesterol esterase, which causes hydrolysis of cholesterol esters; and (3) phospholipase, which breaks down fatty acids from phospholipids. The pH of the juice is 8.

Absorption

Absorption in the oral cavity is carried out mainly by the mucous membrane under the tongue, salts and water, medicinal substances can be absorbed.

Absorption in the stomach: water, salts, alcohol, glucose, vitamin C.

Absorption in the small intestine. Water is absorbed by osmosis (up to 9 liters). Mineral salts: Na, Ca, K, Fe, Mg, phosphates are absorbed by active transport. Carbohydrates broken down to monosaccharides and proteins broken down to amino acids are absorbed by active transport. Fat breaks down into glycerol and fatty acids which form chylomicrons with bile acids, which enter enterocytes, and they again synthesize fat, which is absorbed into the lymph.

Absorption in the colon: water, salt, vitamins.

Functional nutrition system maintains the level of nutrients in the blood, ensures proper metabolic processes.

The optimal ratio of nutrients (proteins, fats, carbohydrates) – the current formula is 1: 1.2: 4.6.

The optimal daily diet is 3–5 meals with an interval of 3–4 hours.

1 breakfast – 25 %, 2 breakfast – 15 %, lunch – 35 %, dinner – 25 % of the daily calorie content of food. Dinner – 3 hours before bedtime. The duration of a meal is at least 20 min, prolonged chewing of food slows down the hunger center.

Questions for discussion

1. Secretion of saliva, regulation of secretion. The composition of saliva of various salivary glands.

2. Digestion in the stomach, secretion. Regulation of this process.

3. Digestion in the small intestine. Gastric secretion and suction. Regulation of secretion.

4. The role of the liver in digestion. Composition of bile, regulation of bile secretion and removing. Pancreatic function. Its external secretion, regulation of secretion.

5. Absorption function in various parts of the digestive tract.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020.

2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2. 2012.

Practical works

1. Virtual work. Substrate specificity of saliva amylase.

2. Virtual work. The influence of pH on the action of pepsin.

3. Functional nutrition system.

4. Effects of micronutrient or phytonutrient deficiencies on immune responses (PLAB).

Practical Virtual Work 1.
Substrate Specificity of Saliva Amylase

Objective: to study the specificity of saliva amylase.

Equipment and materials: virtual work.

Progress: Saliva amylase is glycolytic enzyme whose characteristic substrates are starch and glycogen. It is most active at a temperature of 37–38 degrees and in a slightly alkaline medium, pH 7.5–8. Saliva amylase is mixed with three carbohydrates of different structures. To detect monosaccharides, the Trimer reaction is used, it proves that only starch is broken down.

Results. Mark "+" in the Table 11.1 which monosaccharide breaks down saliva amylase.

Table 11.1

Substrate Specificity of Saliva Amylase

		Monosaccharide
Starch	+ saliva amylase	
Sucrose	+ saliva amylase	
Cellulose	+ saliva amylase	

Conclusions. Make conclusions about amylase action.

Practical Virtual Work 2.
The Influence of pH on the Action of Pepsin

Objective: to study the action of pepsin.

Equipment and materials: virtual work.

Progress: Pepsin is proteolytic enzyme which is synthesized as inactive pepsinogen by the main cells of the gastric glands. Pepsinogen is converted into active pepsin when pH is below 5. This condition is provided by hydrochloric acid in the gastric liquid. Pepsin belongs to the group of endopeptidases.

It splits peptides into polipeptidic chains and is most efficient at pH of about 2. Ovalbumin is degraded by pepsin only with HCl.

Results. Mark "+" in the Table 11.2 which ovalbumin degraded.

Table 11.2

Action of Pepsin		
		Digestion
Ovalbumin	Pepsin + HCl	
Ovalbumin	Pepsin + H ₂ O	
Ovalbumin	H ₂ O + HCl	

Conclusions. Make conclusions about pepsin activity in an aggressive environment.

Practical Work 3.

Functional Nutrition System

Objective: to study the scheme of the functional nutrition system

Equipment and materials: scheme (Fig. 11.1).

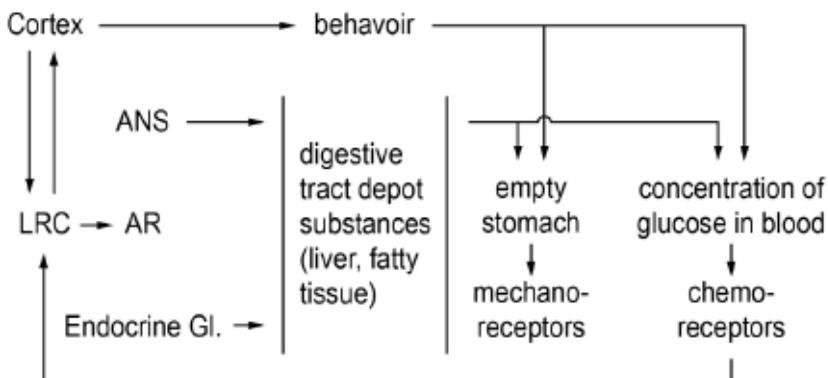


Fig. 11.1. Functional nutrition system:
AR – automatic regulation. LRC – limbic-reticular complex.

Practical Work 4.
Effects of Micronutrient or Phytonutrient Deficiencies
on Immune Responses (PLAB)

Objective: to study the table of the effect of micronutrient or phytonutrient deficiencies on immune responses

Equipment and materials: Table 11.3.

Progress: draw the table of the effect of micronutrient or phytonutrient deficiencies on immune responses

Table 11.3

Effects of Micronutrient or Phytonutrient
Deficiencies on Immune Responses (PLAB)

Micronutrient	Effects of deficiency
Vitamin A	<ul style="list-style-type: none"> • Loss of barrier function of mucosal epithelium Impaired neutrophil and macrophage function • Reducing the number of natural killer cells and their lytic activity • Immune response decrease
Vitamin D	<ul style="list-style-type: none"> • Reduced production of antibacterial peptides (endogenous antibiotics)
Vitamin E	<ul style="list-style-type: none"> • Violation of B-and T-cell immunity • Increased oxidative damage in the cell membranes of the immune system
Vitamin B6	<ul style="list-style-type: none"> • Decreased lymphocyte responsiveness • Violation of antibody synthesis
Vitamin C	<ul style="list-style-type: none"> • Reduced resistance to infections • Violation of T-cell proliferation
Zinc	<ul style="list-style-type: none"> • Disruption of T-cell maturation • Impaired lymphocyte responsiveness • Decrease in resistance to infection
Selenium	<ul style="list-style-type: none"> • Increased oxidative damage in the cell membranes of the immune system

Micronutrient	Effects of deficiency
	<ul style="list-style-type: none"> • Decreased cytokine synthesis • Decreased resistance to viruses • Reduced antibody synthesis
Caratinoids	<ul style="list-style-type: none"> • Dysfunction of phagocytes • Reduced activity of natural killer cells (EC)
Flavonoids	<ul style="list-style-type: none"> • Immunomodulatory effects

Tests

1. WHAT PHASE OF GASTRIC SECRETION IS PROVIDED WITH PARTICIPATION OF CONDITIONED REFLEXES?

- a) intestinal b) cephalic c) gastric

2. WHICH FACTOR IN GASTRIC JUICE ACTIVATES PEP-SINOGEN?

- a) hydrochloric acid b) internal factor c) mucus

3. THE JUICE OF THE LARGE INTESTINE CONTAINS...

- a) hydrochloric acid c) a large number of enzymes
b) bile acids d) mucus and salt

4. PARIETAL DIGESTION OCCURS IN THE...

- a) stomach b) colon c) small intestine

5. WHICH SUBSTANCE IS A PART OF BILE?

- a) lipase b) phosphoric acid ions c) cholesterol

6. CHOLECYSTOKININ INCREASES EXCRETION IN PAN-CREATIC JUICE

- a) bicarbonates b) mucus c) enzymes

Swallowing (Deglutition). Swallowing has three phases: oral (short, voluntary); pharyngeal (involuntary, fast); esophageal (involuntary, prolonged). The intake of liquid food lasts 1 sec, solid – 8–10 sec. Swallowing is a reflex act, the receptive field is the tongue root and pharyngeal mucosa (afferent fibers IX), the efferent fibers are trigeminal (V), sublingual (XII), glossopharyngeal (IX), vagal (X).

Motor function of the stomach. The motor function of the stomach is represented by three types: (1) storing a large amount of food until it can be processed in the stomach, duodenum and lower intestine; (2) mixing this food with gastric secretions until it forms a semi-fluid mixture called chyme; (3) slow emptying of chyme from the stomach into the small intestine at a rate suitable for proper digestion and absorption in the small intestine.

Movements of the small intestine. Mixing of contractions (segmentation contraction). They divide the intestine into separate segments, which look like a chain of sausages. Then the other transverse muscles contract, and the previous ones relax. The reduction frequency is about 9 per minute.

Propulsive movements. Peristalsis in the Small Intestine. Chyme moves through the small intestine with the help of peristaltic waves. These can occur in any part of the small intestine, and they move toward the anus at a speed of 0.5 to 2.0 cm/sec, faster in the proximal intestine and slower in the final part.

Movements of the large intestine. Slower and less frequent than those of the small intestine:

Mixing movements (haustral churning every 30 min), massaging movements (usually following meals) stimulated by distention of the stomach and duodenum) – gastrocolic reflex, duodenocolic reflex, peristaltic wave from the transverse colon through the rest of the large intestine.

The defecation reflex is involuntary. When pressure in the rectum reaches a certain value, the excitation from the receptors will go along the sensory neuron to the spinal cord (S2–S4). Next, the defecation reflex is formed (the internal rectal sphincter opens). The impulse also spreads through the spinal cord to the cortex (urge to defecate).

The act of defecation is voluntary. Its center is located in the cerebral cortex. When an impulse comes from the cortex to the spinal cord, the motor neurons that control the outer striated sphincter of the rectum are inhibited. The sphincter (external) opens and defecation occurs.

Questions for discussion

1. General principles of gastrointestinal motility.
2. Motor acts of the mouth: chewing, swallowing, their regulation.
3. Digestion in the stomach, movement. Regulation of this process.
4. Digestion in the small intestine. Movement, its regulation.
5. Movement of the colon, its regulation. CNS and PNS.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2. 2012.

Practical works

1. Analysis of a chewing gum in a person chewing food.
2. Analysis of an electromyogram (EMG) of the masticatory muscles.

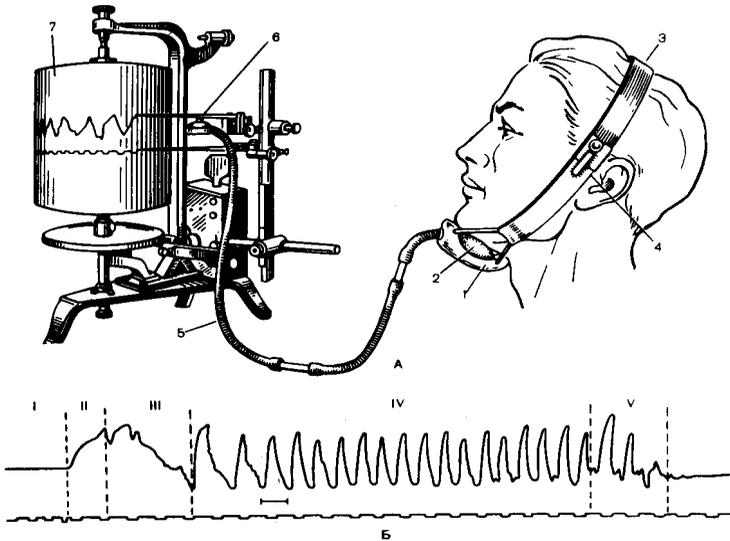
Practical Work 1. Analysis of a Chewing Gum in a Person Chewing Food

Objective: to study the process of a chewing act

Equipment and materials: chewing gum, food (bread or apple).

Progress: The sensor of the masticatiograph is fixed on the lower jaw of the volunteer, then connected to the recording device. Several cycles of chewing movements of the lower jaw are recorded (masticaciogram).

Results. Draw a masticatiogram in the workbook. Indicate the phases of chewing on it (Fig. 12.1). Calculate the number of chewing movements on the graph in phase 4 (the main phase of chewing).



*Fig. 12.1. Masticatiogram. Proper chewing consists of the following phases:
1 – rest phase (straight line), 2 – intake of food by the mouth (lift),
3 – indicative chewing phase, 4 – main phase of chewing,
5 – formation of the food lump and swallowing*

Conclusions. Write about the mechanism of the act of chewing.

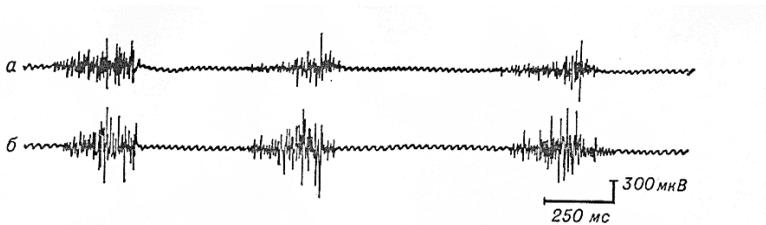
Practical Work 2.
Analysis of an Electromyogram (EMG)
of the Masticatory Muscles

Objective: to study the functions of the masticatory muscles.

Equipment and materials: electromyography, electrodes.

Progress: Electrodes are applied to the skin in the projection area of the main masticatory muscles on the left and right, an electromyogram is recorded.

Results. Draw electromyograms in the workbook (Fig. 12.2). Compare the EMG of the chewing muscles on the left and right; make a conclusion on which side there is more electrical activity, where there are more chewing movements.



*Fig. 12.2. Chewing muscle electromyography:
a – left, b – right when chewing bread on the right side*

Conclusions. What kind of muscle activity does their electrical activity when chewing?

Tests

1. THE INTESTINAL MOTOR ACTIVITY CONTROLS THE ENTERAL NERVOUS SYSTEM

- a) both answers are correct
- b) submucosal plexus
- c) intermuscular plexus

2. THE LONGEST SWALLOWING PHASE IS...
- a) esophageal
 - b) pharyngeal
 - c) oral
3. THE CENTER OF THE DEFECATION REFLEX IS IN THE...
- a) medulla oblongata
 - b) thoracic spinal cord
 - c) sacral part of the spinal cord
4. THE CONTRACTION OF SMOOTH MUSCLES IS CARRIED OUT WITH THE PARTICIPATION OF THE FOLLOWING PROTEINS
- a) calmodulin, actin, myosin
 - b) actin, myosin, tropomyosin
 - c) calmodulin, actin, troponin
5. IN GENERAL, THE ACTIVITY OF THE GASTROINTESTINAL TRACT IS REGULATED BY THE FOLLOWING PARASYMPATHETIC NERVE(S)
- a) vagus
 - b) glossopharyngeal nerve
 - c) pelvic nerve
6. WHICH MEDIATOR CONTROLS THE STOMACH AT THE ENDINGS OF PARASYMPATHETIC NERVES?
- a) erotonin
 - b) acetylcholine
 - c) norepinephrine
7. WHICH PAIRS OF CRANIAL NERVES REGULATE THE REFLEX ACT OF CHEWING?
- a) V, VII, XII
 - b) V, VII, IX
 - c) V, VII, X

8. GASTRIC MOTILITY ACTIVATES THE FOLLOWING HORMONES

- a) gastrin, motilin
- b) secretin, cholecystokinin
- c) gastrin, internal factor

9. THE CENTER OF THE DEFECATION ACT IS IN THE...

- a) cerebral cortex
- b) medulla oblongata
- c) lumbar spinal cord
- d) sacral part of the spinal cord

THEME VI. ENERGY AND METABOLIC RATE

Practical Class 13. Energy Balance

Goal: to study energy metabolism, energy balance and regulation of energy balance.

Introduction

Metabolism and energy are the basis of life. The main two processes ensuring the functioning and renewal of organs and systems are catabolism and anabolism. Catabolism leads to the breakdown of substances with the release of energy in the form of macroergic bonds and heat. Anabolism involves the formation of individual substances necessary for the body from monomers.

Energy metabolism indicators are measured using calorimetry methods, complete and incomplete gas analysis.

Conditions for measuring the basic metabolism: 1) the state of wakefulness in the morning; 2) 12–16 hours after meals; 3) the state of physical and mental rest; 4) at a comfortable temperature.

Based on these studies, Harris and Benedict tables were compiled, using which you can measure your basal metabolism, basal metabolic rate (BMR). Then you have to calculate the energy exchange per day.

Questions for discussion

1. Energy metabolism, interconnection of metabolism and energy.
2. Total daily energy expenditure (TDEE)
3. Energy sources and their calorific value

4. Calorimetry. Direct and indirect methods. Caloric equivalent (CE) of O₂ energy. Respiration quotient.
5. Energy balance in humans.
6. Regulation of energy balance.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th ed; McGraw-Hill Companies, Inc., 2001.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th ed; WB Saunders, 2008, 2012.

Practical works

1. Measuring the basal metabolic rate (BMR).
2. Measuring the deviation of the individual basal metabolic rate (BMR) from the normal values.
3. Studying the thermic effect of feeding (TEF, dynamic effect of food).
4. Calculating the total daily energy expenditure (TDEE).
5. Studying energy consumption by the method of indirect calorimetry.
6. Assessing human metabolism by the body mass index (BMI).

***Practical work 1. Measuring
the Basal Metabolic Rate (BMR)***

Equipment and materials: Harris and Benedict tables, weights, height meter.

Progress: Find numbers A and B in Table 13.1.

Results. The sum of numbers A and B shows the value of basal metabolic rate per day.

Conclusions. Give the definition of basal metabolism. What does basal metabolic rate depend on? What conditions are necessary to determine it by using instruments?

Table 13.1

Harris and Benedict Tables: A&B, for male and female

A

kg	kcal	kg	kcal	kg	kcal	kg	kcal	kg	kcal	kg	kcal
Male											
3	107	24	296	45	685	65	960	85	1235	105	1510
4	121	25	410	46	699	66	974	86	1249	106	1524
5	135	26	424	47	713	67	988	87	1263	107	1538
6	148	27	438	48	727	68	1002	88	1277	108	1552
7	162	28	452	49	740	69	1015	89	1290	109	1565
8	176	29	465	50	754	70	1029	90	1304	110	1579
9	190	30	479	51	768	71	1043	91	1318	111	1593
10	203	31	493	52	782	72	1057	92	1332	112	1607
11	217	32	507	53	795	73	1070	93	1345	113	1620
12	231	33	520	54	809	74	1084	94	1359	114	1634
13	245	34	534	55	823	75	1098	95	1373	115	1648
14	258	35	548	56	837	76	1112	96	1387	116	1662
15	272	36	562	57	850	77	1125	97	1400	117	1675
16	286	37	575	58	864	78	1139	98	1414	118	1688
17	300	38	589	59	878	79	1153	99	1428	119	1703
18	313	39	603	60	892	80	1167	100	1442	120	1717
19	327	40	617	61	905	81	1180	101	1455	121	1730
20	341	41	630	62	918	82	1194	102	1469	122	1744
21	355	42	644	63	933	83	1208	103	1483	123	1758
22	368	43	658	64	947	84	1222	104	1497	124	1772
23	382	44	672	-	-	-	-	-	-	-	-

A

Female											
kg	kcal	kg	kcal	kg	kcal	kg	kcal	kg	kcal	kg	kcal
3	683	24	885	45	1085	65	1277	85	1468	105	1659
4	693	25	894	46	1095	66	1286	86	1478	106	1669
5	702	26	904	47	1105	67	1296	87	1497	107	1678
6	712	27	913	48	1114	68	1305	88	1497	108	1688
7	721	28	923	49	1124	69	1315	89	1506	109	1698
8	731	29	932	50	1133	70	1325	90	1516	110	1707
9	741	30	942	51	1143	71	1334	91	1525	111	1717
10	751	31	952	52	1152	72	1344	92	1535	112	1726
11	760	32	961	53	1162	73	1353	93	1544	113	1730
12	770	33	971	54	1172	74	1363	94	1554	114	1745
13	779	34	980	55	1181	75	1372	95	1564	115	1755
14	789	35	990	56	1191	76	1382	96	1573	116	1764
15	798	36	999	57	1200	77	1391	97	1583	117	1774
16	808	37	1009	58	1210	78	1401	98	1592	118	1784
17	818	38	1019	59	1219	79	1411	99	1602	119	1793
18	827	39	1028	60	1229	80	1420	100	1611	120	1803
19	837	40	1038	61	1238	81	1430	101	1621	121	1812
20	846	41	1047	62	1248	82	1439	102	1631	122	1822
21	856	42	1057	63	1258	83	1449	103	1640	123	1831
22	865	43	1066	64	1267	84	1458	104	1650	124	1841
23	875	44	1076								

B

Cm/age	21	23	25	27	29	31	33	35	37	39	41	43	45
Male													
151	614	600	587	573	560	547	533	520	506	493	479	466	452
153	624	611	597	584	570	557	543	530	516	503	489	476	462
155	634	621	607	594	580	567	553	540	526	513	499	486	472
157	644	631	617	604	590	577	563	550	536	523	509	496	482
159	654	641	627	614	600	587	573	560	546	533	519	506	492
161	664	651	637	624	610	597	583	570	556	543	529	516	502
163	674	661	647	634	620	607	593	580	866	553	539	526	512
165	684	671	657	644	630	617	603	590	576	563	549	536	522
167	694	681	667	654	640	627	613	600	586	573	559	546	532
169	704	691	677	664	650	637	623	610	596	583	569	556	542
171	714	701	687	674	660	647	633	620	606	593	579	566	552
173	724	711	697	684	670	657	643	630	616	603	589	576	562
175	734	721	707	694	680	667	653	640	626	613	599	586	572
177	744	731	717	704	690	677	663	650	636	623	609	596	582
179	754	741	727	714	700	687	673	660	646	633	619	606	592
181	764	751	737	724	710	697	683	670	656	643	629	616	602
183	774	761	747	734	720	707	693	680	666	653	639	626	612
185	784	771	757	744	730	717	703	690	676	663	649	636	622
187	794	781	767	754	740	727	713	700	686	673	659	646	632
189	804	791	777	764	750	737	723	710	696	683	669	656	642
191	814	801	787	774	760	747	733	720	706	693	679	666	652
193	824	811	797	784	770	758	743	730	716	703	689	676	662
195	834	821	807	794	780	768	753	740	726	713	699	686	672
197	844	831	817	804	790	778	763	750	736	723	709	696	682
199	854	841	827	814	800	788	773	760	746	733	719	706	692

B

Cm/age	21	23	25	27	29	31	33	35	37	39	41	43	45
Female													
151	181	171	162	153	144	134	125	115	106	97	88	78	69
153	185	175	166	156	148	138	129	119	110	100	92	82	73
155	189	179	170	160	151	141	132	122	114	104	95	85	76
157	193	183	174	165	155	145	136	128	118	108	99	90	80
159	196	187	177	167	158	148	140	130	121	111	102	92	84
161	200	191	181	171	162	152	144	134	125	115	106	97	88
163	203	195	185	175	166	156	147	137	128	119	110	100	91
165	207	199	189	180	170	160	151	141	132	123	114	104	95
167	211	203	192	183	173	184	155	145	136	126	117	107	98
169	215	206	196	186	177	167	159	149	140	130	121	111	102
171	218	210	199	190	181	171	162	152	143	134	125	115	106
173	222	213	203	194	185	176	166	156	147	138	129	119	110
175	225	217	207	197	188	179	169	160	151	141	132	123	113
177	229	221	211	201	192	182	173	164	155	145	136	126	117
179	233	223	214	204	195	186	177	167	158	148	139	130	121
181	237	227	218	208	199	190	181	171	162	152	142	134	126
183	240	231	222	212	203	193	184	174	165	156	147	137	128
185	244	235	226	216	207	197	188	179	169	160	151	141	132
187	248	238	229	219	210	201	192	182	173	163	154	145	135
189	252	242	233	223	214	205	196	186	177	167	157	148	139
191	255	245	236	227	218	208	199	190	180	171	162	152	143
193	259	250	240	231	222	215	206	197	188	178	169	160	150
195	262	253	244	234	225	215	206	197	188	178	169	160	150
197	266	257	248	238	229	219	210	201	192	182	173	163	154
199	270	260	251	241	232	223	214	204	195	185	175	167	158

Practical Work 2.

Measuring the Deviation of the Individual Basal Metabolic Rate (BMR) from the Normal Values

Equipment and materials: tonometer, stopwatch.

Progress. Calculate the deviation of basal metabolism from the proper value according to Reid's formula:

Percentage of deviation = $0.75 \times (\text{pulse rate} + \text{pulse pressure} \times 0.74) - 72$.

Results. Record the results into a notebook. Normal deviation is $\pm 10\%$.

Calculate the deviation from the basal metabolic rate in kcal, for this, calculate your basal metabolic rate using the results of proper basal metabolism (work 1) and the percentage of your deviation.

Conclusions. Estimate the deviation. Why can the basic metabolism be judged by the activity of the circulatory system? How does transport support depend on metabolism?

Practical work 3.

Studying the Thermic Effect of Feeding (TEF)

Equipment and materials: results of 1, 2 works.

Progress. Calculate the specific dynamic effect of food, TEF – thermic effect of feeding. This is the consumption of energy for digestion (secretion, motility, absorption) and additional energy release after eating.

It usually amounts 15% of the basal metabolic rate with a mixed diet. When eating carbohydrates – 10% . When the diet mainly consists of proteins – 25% .

Results. Record the results into a notebook.

Conclusions. What is the thermic effect of feeding (TEF) of food? What determines TEF?

Practical Work 4.

Calculating the Total Daily Energy Expenditure (TDEE)

Equipment and materials: results of works 1–3.

Progress. Calculate the value of proper basal metabolism, the deviation by Reid's formula (in kcal), TDEE and working increment. The working increment for a student (TEA – thermic activity effect) during the semester is 1000 kcal.

$$\text{TDEE} = \text{BMR} + \text{TEF} + \text{TEA}$$

Results. Record the results into a notebook.

Conclusions. What is the total exchange per day? What does the daily energy expenditure depend on? How do we get energy? What should the energy intake correspond to? What is the energy balance?

Practical Work 5.

Studying Energy Consumption by the Method of Indirect Gas Analysis (Calorimetry)

Equipment and materials: spirometabolograph "Metatest-1", spirometabologram recorded in different conditions, compass, ruler.

The volume of absorbed oxygen is determined by the shift of the spirometabologram (Fig. 13.1). According to the calibration, a distance of 1 minute is measured (Fig. 13.2).

Calibrations are indicated on the spirometabologram form, usually 1 minute per 50 mm and 1 liter of oxygen per 1 cm.

Progress. 1. Find the deviation of the spirometabologram chart from the horizontal line in one minute. Calculate the amount of absorbed oxygen according to the calibration (make up the proportion). Exchange (energy consumption) per minute is calculated by formula 1:

$$\text{Exchange per minute} = \text{amount of O}_2 \text{ (l)} \times 4.86 \text{ (kcal/l)}.$$

2. Find the value of basal metabolism of a given subject (its parameters are indicated on a spirogram) according to Harris and Benedict tables. Calculate the basic metabolism per minute by formula 2:

$$\begin{aligned} \text{Basic exchange per minute} &= \\ &= \text{Basic exchange per day (kcal)} : 1440 \text{ (min.)} \end{aligned}$$

Results. Draw a spirometabologram, show on it the amount of oxygen consumed during the study. Write down the calculation results:

1. The volunteer's energy expenditure according to incomplete gas analysis data (spirometabologram and formula 1).
2. The main metabolism of the volunteer per a minute (according to Harris and Benedict tables and formula 2).

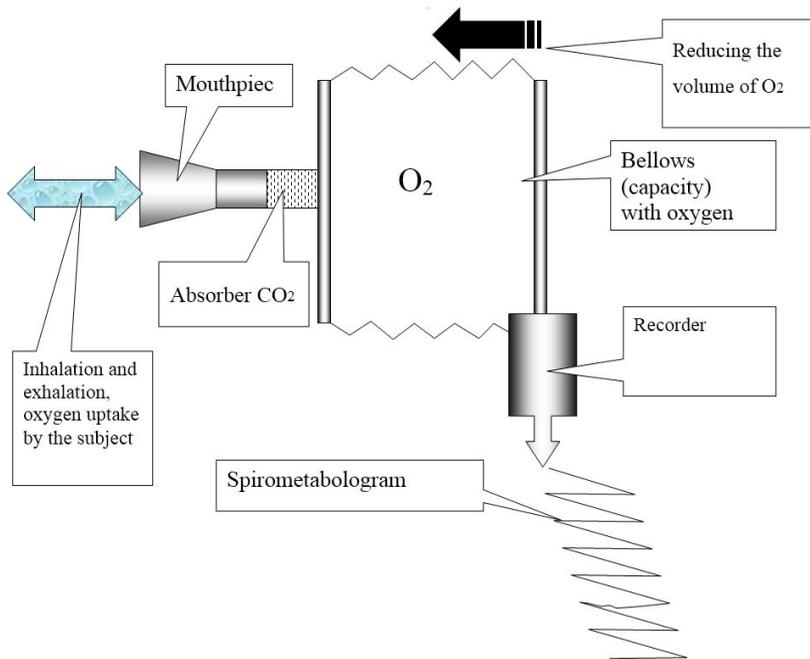


Fig. 13.1. Metatest device. Recording a spirometabologram

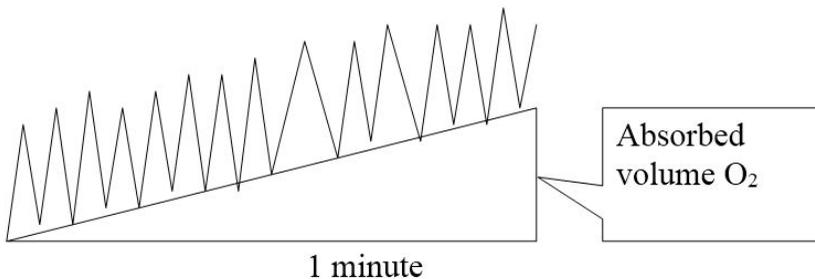


Fig. 13.2. Processing of the spirometabologram

Conclusions. 1. Describe the conditions under which the measurements are taken in the spirometabologram chart. Make a conclusion why there is (or is not) a deviation of the amount of energy consumption from the basic exchange.

2. Compare the obtained results analyzing spirograms recorded under different conditions.

3. What is the essence of the method of incomplete gas analysis?

Practical Work 6.
Assessing Human Metabolism by
the Body Mass Index (BMI)

BMI is still referred to the Quetelet index.

Equipment and materials: scales, height meter.

Progress. Measure your weight and height.

Calculate the body mass index (BMI) by the formula:

$$\text{BMI} = \frac{W}{H^2},$$

where W – body weight in kg, H – height in meters.

Results. Draw Table 13.2 in your copybook. Record your results into the table.

Table 13.2

Quetelet index (BMI)

Quetelet index (BMI)	Volunteer's index	Estimation of the body weight
Lower 18,5		Lack of body weight
Between 18,5 and 24,9		Normal body weight
20–23		Ideal body weight
25–29,9		Excess body weight
30 and more		Obesity

Conclusions. Estimate the body weight according to the Quetelet index (BMI). Ask the volunteer about the dynamics of body weight in the last month. Make a conclusion about his / her energy balance.

Tests

1. HOW TO CALCULATE THE BODY MASS INDEX?

- a) $BMI = \text{body weight (kg)} / \text{height}^2 \text{ (m)}$
- b) $BMI = \text{body weight (kg)} + \text{height}^2 \text{ (m)}$
- c) $BMI = \text{body weight (kg)} - \text{height}^2 \text{ (m)}$

2. WHEN YOU DIGEST FOOD AND ABSORB ITS NUTRIENTS, YOUR BODY USES ENERGY IN THE FORM OF CALORIES – ABOUT... (USUAL DIET).

- a) 1,5 %
- b) 15 % BMR
- c) 40 %

3. WHICH OF THE FOLLOWING FOODS HAS THE GREATEST ENERGY CONTENT?

- a) proteins
- b) fats
- c) carbohydrates

4. WOMEN`S BASAL METABOLIC RATE IS USUALLY...

- a) lower than in men
- b) the same as in men
- c) higher than in men

5. THE BASAL METABOLIC RATE IS MEASURED UNDER THE FOLLOWING STANDARD CONDITIONS

- a) complete physical and mental rest, sober stomach (2 h), indifferent temperature, early-morning hours;
- b) complete physical and mental rest, sober stomach (12 h), indifferent temperature, early-morning hours;
- c) complete physical and mental rest, sober stomach (12 h), indifferent temperature, early-morning hours; sleeping.

6. 1 CAL EQUALS...

- a) 4 187 joule
- b) 4,187 kjoule
- c) 4,187 joule

7. NUTRIENT PHYSIOLOGICAL CALORIFIC VALUE: LI-PIDS (FATS)

- a) 9 kcal/g
- b) 4 kcal/g
- c) 7 kcal/g

8. POSITIVE ENERGY BALANCE IS...

- a) intake = output
- b) intake < output
- c) intake > output

9. LEPTIN...

- a) "tells" the body that the brain does not need more food
- b) intensifies the feeling of hunger
- c) "tells" the body that the brain needs more food

10. WHEN THE ERGOTROPHIC SECTION (SNS) IS EXCITED...

- a) catabolism is activated
- b) cortex is activated
- c) anabolism is activated

11. NEGATIVE ENERGY BALANCE

- a) intake=output b) intake<output c) intake>output

12. NUTRIENT PHYSIOLOGICAL CALORIFIC VALUE
CARBOHYDRATES

- a) 9 kcal/g b) 4 kcal/g c) 7 kcal/g

13. INSULIN HAS THE EFFECT OF...

- a) lowering blood glucose
b) increasing blood glucose
c) both A&B

14. GHRELIN...

- a) "tells" the body that the brain does not need more food
b) intensifies the feeling of hunger
c) "tells" the body that the brain needs more food

15. WHEN THE TROPHOTROPIC SECTION OF THE ANS
(PSNS) IS EXCITED...

- a) catabolism is activated
b) cortex is activated
c) anabolism is activated

16. PROTEIN OPTIMUM

- a) 10 g per kg of body weight
b) 1 g per kg of body weight
c) 0.1 g per kg of body weight

17. TOTAL DAILY ENERGY EXPENDITURE (TDEE) INCLUDES

- a) basal metabolic rate (BMR), hyperthermic effect of activity (HEA), hypothermic effect of feeding (HEF)
- b) basal metabolic rate (BMR), thermic effect of activity (TEA), thermic effect of feeding (TEF)
- c) basal metabolic rate (BMR), thermic effect of activity (TEA)

18. MUTATIONS IN THE HUMAN MELANOCORTIN (MC) 4 RECEPTOR ARE ASSOCIATED WITH...

- a) obesity
- b) anorexia
- c) negative energy balance

19. NEGATIVE ENERGY BALANCE CAN LEAD TO A...

- a) decrease in metabolism and bone mass,
- b) reduction in thyroid hormones, testosterone levels
- c) A&B

20. The centre of metabolic regulation is in the...

- a) hypothalamus
- b) thalamus
- c) spinal cord

THEME VII. ADAPTATION

Terms

Adaptation – a set of reactions of the organism that support its functional stability (homeostasis) when environmental conditions change.

Distress develops when the body is unable to adapt to the action of the stressor. In this condition psycho-physiological disorders and diseases may develop.

Eustress or productive mobilization and adaptation if the organism have functional source.

Homeostasis – the constancy of the internal environment of the body.

Stressor – a factor causing the development of a stress response

Practical Class 14.

Stress. Adaptation. Adaptive Reactions

Goal: to study the factors of stress formation (general adaptation syndrome) and methods of its assessment.

Introduction. *Stress* is the body's reaction to unusual or extreme factors. These factors are called *stressors* and can be of various nature:

- Physical – high or low temperatures, noise over 85 dB, ionizing radiation, pressure;
- Chemical – intoxication, including anesthesia, hypoxia;

- Biological – infections, invasions;
- Physiological – trauma, surgery, blood loss, exercise, immobilization;
- Emotional – emotional stress, fear.

Moderate stress is accompanied by violations of homeostasis and its subsequent restoration. If stress is too excessive, the body is exhausted and there is pathogenetic basis for development of some disorders (mental, endocrine, cardiovascular, etc.). If there is a functional source in the body, then productive mobilization and adaptation occur, that is, stress is a reorganizing process, and ultimately increases our resistance level. This type of stress is called *eustress*. If stress is prolonged or intense, then the body doesn't have a resource for adaptation and, as a result, adaptive reactions break down, regulatory processes become desynchronized and *distress* develops.

In the evolutionary aspect, stress has had a positive effect (“fight-or-flight” decision making). The main morphological manifestations of stress were described by Hans Selye in the 1920s when studying the effect of stress on animals. They are called the «Selye triad» and include adrenal hypertrophy, involution of the thymus and lymph nodes (with lymphopenia) and acute gastrointestinal ulcers. The mechanism of stress formation is associated with increased levels of catecholamines (epinephrine, norepinephrine), glucocorticoids (cortisol, cortisone) and mineralocorticoids (aldosterone and corticosterone) as well as imbalances of other hormones.

But in the modern world, stress activation occurs mainly through psychosocial stimulation and may develop into a chronic condition (chronic stress). Symptoms of chronic stress include: irritability, anxiety, depression, headaches, insomnia, reproductive system dysfunction, eating disorders, immune system disorders.

The most common stress-associated diseases are:

- Cardiovascular system – hypertension, coronary heart disease and its complications – myocardial infarction and arrhythmias;
- Gastrointestinal tract – gastric and duodenal ulcer, ulcerative colitis;
- Mental disorders – anxiety, sleep disturbances, manic behavior, depression, provocation and exacerbation of some forms of schizophrenia;
- Immune system – immunosuppressive effect, exacerbation of non-infectious and autoimmune diseases, tumors.

According to Selye`'s research, the most commonly used indicators of stress are measuring of ACTH, corticosteroids and catecholamines in urine or plasma. There are non-specific methods for assessing the stress response:

- Electromyography that allows you to assess the effect of stress on the tone of striated muscles and degree of tension;
- Assessment of hemodynamic parameters reveals the effect of stress on the heart and blood vessels;
- Electro-cutaneous methods – by blood filling and humidity;
- Psychological methods – mental state testing.

Questions for discussion

1. Stress factors
2. Phases of stress. Stress hormones.
3. Differences between eustress and distress.
4. Symptoms of stress and stress-associated diseases.

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th Ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th Ed; WB Saunders, 2. 2012.

Practical work

1. Psychological diagnostics of stress (self-test).

Practical Work 1.

Psychological Diagnostics of Stress (Self-Test)

Psychodiagnostic techniques are designed to assess the individual characteristics of people, including the level of anxiety and stress. They should be interpreted by psychologists and take into account the person's condition (to obtain the correct result). Testing is a research method that allows you to get more objective results, compared to conversations, since tests and questionnaires use regulated protocols, therefore they are a formalized method. To assess the psychological state and stress, the following formalized methods are used: "Scale of psychological stress PSM-25", "Assessment of neuropsychological stress" (by T.A. Nemchin), method for determining the dominant state (by L.V. Kulikov), diagnosis of stress (by A.O. Prokhorov), questionnaire determining the tendency to stress developing (by T.A. Nemchin, Taylor), questionnaire "Fatigue-Monotony-Satiety Stress" and others. We suggest you take a test using the PSM-25 Psychological Stress Scale (Table 14.1).

Objective: to assess the level of stress using psycho diagnostic testing.

Progress: Assess your general condition. After each statement, write down the number from 1 to 8 that most clearly expresses your condition in the previous days (4–5 days). There are no wrong or erroneous answers. Points mean:

1 – never	5 – sometimes
2 – extremely rare	6 – often
3 – very rare	7 – very often
4 – rarely	8 – constantly

Table 14.1

#	Statements	Points
1	I'm tense and excited	1 2 3 4 5 6 7 8
2	I have a lump in my throat and / or I have a dry mouth	1 2 3 4 5 6 7 8
3	I'm overworked. I don't have enough time	1 2 3 4 5 6 7 8
4	I swallow food or forget to eat	1 2 3 4 5 6 7 8
5	I think over my ideas; I change my plans; my thoughts are constantly repeated	1 2 3 4 5 6 7 8
6	I feel lonely, isolated and misunderstood	1 2 3 4 5 6 7 8
7	I am suffering from physical ailment; I have a headache; The muscles of the neck are tense; Back pain; Stomach cramps	1 2 3 4 5 6 7 8
8	I'm absorbed in thoughts, exhausted, worried	1 2 3 4 5 6 7 8
9	I suddenly feel hot and cold	1 2 3 4 5 6 7 8
10	I forget about appointments or things to do or decide	1 2 3 4 5 6 7 8
11	I can easily cry	1 2 3 4 5 6 7 8
12	I feel tired	1 2 3 4 5 6 7 8
13	I grit my teeth tightly	1 2 3 4 5 6 7 8
14	I am not calm	1 2 3 4 5 6 7 8
15	I find it hard to breathe and / or I suddenly catch my breath	1 2 3 4 5 6 7 8
16	I have digestive or bowel problems (pain, colic, upset stomach or constipation)	1 2 3 4 5 6 7 8
17	I'm worried or confused	1 2 3 4 5 6 7 8
18	I'm easily frightened; Noise or rustling make me flinch	1 2 3 4 5 6 7 8
19	I need more than half an hour to fall asleep	1 2 3 4 5 6 7 8
20	I'm confused; My thoughts are confused; I lack focus, cannot focus	1 2 3 4 5 6 7 8
21	I look tired; bags or circles under the eyes	1 2 3 4 5 6 7 8
22	I feel weight on my shoulders	1 2 3 4 5 6 7 8
23	I am alarmed. I need to move constantly, I cannot stay in one place	1 2 3 4 5 6 7 8
24	I find it difficult to control my actions, emotions, mood or gestures	1 2 3 4 5 6 7 8
25	I'm stressed	1 2 3 4 5 6 7 8
<i>total score:</i>		

Results: Calculate the score for all questions. The higher it is, the higher your stress level. Your total score is ...

less than 95 points low stress level.

100–125 points average stress level.

more than 125 points high stress level.

Conclusion. Make conclusions about your stress level. The result should not be considered as a diagnosis, but only as information for reflection.

Tests

1. THE ACTIVATION OF THE CENTRAL STRESS-LIMITING SYSTEM OCCURS UNDER THE INFLUENCE OF ...

- a) epinephrine produced in the adrenal medulla
- b) β -endorphin produced in the pituitary gland
- c) heat shock proteins produced during hypoxia, ischemia, inflammatory processes, infections and others damages

2. THE FACTOR THAT CAUSES THE DEVELOPMENT OF A STRESS RESPONSE IS CALLED ...

- a) epinephrine
- b) anti-shock
- c) stressor

3. THE ALARM STAGE ("FIGHT OR FLIGHT") DOESN'T INCLUDES

- a) Increased heart rate and blood pressure
- b) Decreased breathing
- c) A flood of adrenaline throughout the body
- d) A sensation of well being followed by an emergency or risk

Report Topics

- 1. Diagnosis of shock. First aid for shock.

Practical Class 15.
Work and Sport Physiology: How the Body
Mobilizes its Powers

Goal: to study work, sport and performance physiology

Questions for discussion

1. Labor activity
2. Working conditions
3. Working dynamic stereotype
4. Sports and physical culture
5. Fatigue
6. Fighting with fatigue

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th Ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th Ed; WB Saunders, 2. 2012.

Introduction

1. Physical performance. The WHO (World Health Organization) recommended the Physical Working Capacity (PWC) test to determine the physical performance and fitness of a person.

Physical performance in the PWC170 sample is expressed in terms of the power of physical activity at which the heart rate reaches 170 beats/min. The choice of this heart rate value is based on the following two positions.

The first position is that the zone of adequate physiological functioning of the cardio-respiratory system is limited by the range of heart rate changes from 100–110 to 170–180 beats / min. Therefore, using this test, it is possible to establish the intensity of physical activity that “brings” the activity of the cardiovascular and entire cardio-respiratory system to optimal functioning.

The second position is based on the fact that the association between the heart rate and power of physical activity performed is linear in most healthy people up to a heart rate of 170 beats / min. At a higher heart rate, the linear nature of this association is violated.

2. A correction test (Anfimov's letter test) is carried out to determine mental performance. An individual result reflects attention, depends on mental fatigue. It is used to study fatigue during the day, week.

Practical works

1. Assessment of physical performance – PWC170 test.
2. Assessment of mental performance using a correction test.

Practical Work 1.

Assessment of Physical Performance – PWC170 Test

Objective: Physical performance in the PWC170 sample is expressed in terms of the power of physical activity at which the heart rate reaches 170 beats/min.

Equipment and materials: steps of 25 cm and 33 cm high, stopwatch.

Progress: First, a student goes up and down a step of 25 cm high. The load (climbing a step) is taken for 2 minutes with 30 lifts made. Each lift with the subsequent descent lasts 4 sec,

1 sec for the movement of each leg. After finishing the activity take the pulse for 1 minute. Rest – 2 minutes.

After that, do the same with the step of 33 cm high. After finishing the activity take the pulse for 1 minute.

Results. Calculate the work power based on the results of the first and second parts of the step-test using the formula:

$$\text{Work power (W)} = P \cdot H \cdot n + (P \cdot H \cdot n) : 3$$

where H – height of the step in m, n – number of lifts in 1 min, P – body mass in kg.

Calculate PWC_{170} using the formula:

$$PWC_{170} = W_1 + (W_2 - W_1) \cdot (170 - HR_1) / (HR_2 - HR_1),$$

where HR_1 or HR_2 is the pulse rate after the first or second lifts to the step.

Conclusions. Estimate the level of efficiency by the value of PWC_{170} .

The normal value of PWC_{170} for young untrained men is 850–1100 kg·m/min, for young untrained women – 450–850 kg·m/min. (The obtained results and their assessment are included in the health certificate).

Practical Work 2.

Assessment of Mental Performance

Using a Correction Test

Objective: to assess mental performance

Equipment and materials: Anfimov's alphabetic table

Progress: The task is to delete certain letters, looking through each line of the table. The whole group of students starts work simultaneously.

At the teacher's command, turn the alphabetic table - proof-reading text, turn upside down and carry out the task, marking in the text every minute of work by a vertical line by the instructor's command. The work lasts for 5 minutes.

Results. Calculate the total number of letters scanned for each minute and for the entire period of work. Calculate the number of errors for each minute and the entire period of work.

Conclusions. Estimate the volume and quality of mental work for the entire period according to the following criteria.

Volume: viewed more than 1000 letters – excellent, 800–1000 letters – good, 700–800 letters – satisfactory, less than 700 letters – bad.

Quality: 2 errors and less – excellent, 3–5 – good, 6–10 – satisfactory, 11 and more – bad. (The obtained results are written into the health certificate).

Make a conclusion about the number of scanned letters and errors per each minute of work. Explain the results.

Tests

1. FATIGUE IS A...

- a) temporary decline in performance, occurring after intensive or prolonged work
- b) constant decline in performance, occurring after intensive or prolonged work
- c) temporary decline in performance, occurring before intensive or prolonged work

2. IN THE PROCESS OF STRUCTURAL ADAPTATION TO WORK, THE NUMBER OF FUNCTIONING CAPILLARIES...

- a) increases
- b) decreases
- c) does not change

3. WORKING CAPACITY IS ...

- a) the ability to perform work for a certain time with a certain quality
- b) fatigue
- c) the ability to perform work for a certain time only

Practical Class 16. Health Care

Goal: to study the indicators of human health, maintenance and promotion of health.

Introduction

According to I.P. Pavlov's definition, a healthy organism is one whose components are balanced with each other and the environment.

Changes in these relationships are manifested in the form of shifts in emotional status, somatic, autonomic reactions, mental activity, and psycho-emotional state.

According to the WHO (World Health Organization, 1948), *“Health is a state of complete physical, mental, and social well-being but not just the absence of disease or ailment”*.

In 1986, the WHO made further clarifications:

“A resource for everyday life, not a goal of life. Health is a positive concept emphasizing social and personal resources, as well as physical capacities.”

This means that health is a resource to support the functioning of an individual in society as a whole, rather than an end in itself. A healthful lifestyle provides the means to lead a full life with meaning and purpose.

Health criteria are:

- well-being;
- work activity;
- family and household activities.

Questions for discussion

1. Physiological foundations of health and the concept of health
2. Characteristics of health factors and its risks
3. Principles for assessing individual health

Books recommended

1. Ganong W. F. Review of Medical Physiology. 20th Ed; McGraw-Hill Companies, Inc. 2012-2020.
2. Guyton A. C., Hall J. E. Textbook of Medical Physiology, 12th Ed; WB Saunders, 2. 2012.

Practical work

1. Registration of a health passport.

Practical Work 1.
Registration of a Health Passport

Equipment and materials: personal notebook(s) from the 1–2 semesters with results of your individual characteristics.

Progress. Fill in your health certificate with all personal indicators obtained during the study of practical physiology, make calculations using the given formulas (1st column of the table). Compare the results with the standard values (2nd column of the table). Write the total in the 3rd column of table. Analyze all the risk and anti-risk factors for health. Suggest a healthy lifestyle program for the following years.

Results. Fill in the health passport (Table 16.1) according to the scheme: name, age, height, weight.

Table 16.1

Health passport

Physiological indicators	Standard	Result estimation
1. Physical state		
1.1. Index of physical condition = $(700 - 3 \cdot \text{HR} - 2,5 \cdot \text{BP}_{\text{av}} - 2,7 \cdot \text{age} + 0,28 \cdot \text{weight}) / 350 - 2,6 \cdot \text{age} + 0,21 \cdot \text{height}$	less 0,375 – low, 0,375–0,525 – below the average, 0,526–0,675 – average, 0,676–0,825 – above the average, more 0,826 – high	
1.2. Vital Index = VCL / body weight in kg	65–70 MI / kg for male, 55–60 MI / kg for female	
1.3. Index of relative strength (RS) = $\text{RS} \cdot 100\% / \text{body weight in kg}$	45–50% – for female, 65–80% – for male	
2. Autonomic nervous system		
Kerdo index at rest	«–0,2» – «+0,2»	
3. Cardiovascular system		
3.1. HR	60–80/min	
3.2. BP _{syst.}	100–120 mm Hg	
3.3. BP _{diast.}	60–80 mm Hg	
3.4. BP _{puls.}	30–50 mm Hg	
3.5. BP _{aver}	75–95 mm Hg	
3.6. Martinet test		
– ΔHR	До 75%	
– Heart rate recovery time	3 min and less	
4. Respiratory system		
4.1. BR	10–18/ min	
4.2. VCL	±15% of PVCL	
4.3. Stange's trial	40–50 sec	
4.4. Gench's trial	20–30 sec	
5. Metabolism		
% of deviation of BM from PBM	± 10%	
BMI	Less 25 kg/m ²	
Index OT/OB	0,8 and less for female, 0,9 and less for male	
6. Analyzers		
6.1. Visual acuity:		
6.2. Right eye	1,0	

Physiological indicators	Standard	Result estimation
6.2. Left eye	1,0	
6.4. Hearing acuity:		
6.5. Right ear	By whisper from 6 meters and more	
6.5. Left ear	By whisper from 6 meters and more	
7. HNA		
7.1. Type of NA:		
– Ambivert	10–13 points	
– Extrovert	More 13 points	
– introvert	Less 10 points	
– anxiety	8–10 points	
– temperament		
- Type A		
- Type B		
7.2. Memory type:		
- visual short-term	MR = 0,7	
- auditory short-term	MR = 0,7	
7.3. Mental performance:		
- Workload	700-800 signs in 5 min	
- Quality of work	6-10 errors in 5 min	
- Level of attention	30–40 sec	
8. Health risk factors:	Risk indicators	
8.1. Smoking	Systematically	
8.2. Excess body weight	BMI more than 25 kg/m ²	
8.3. Hypodinamy	Constantly	
8.4. Salt consumption	More than 7–10 g/day	
8.5. Sugar consumption	More than 80 g/day	
8.6. Intake of fats	More than 80 g/day	
8.7. Intake of plant food	Less than 400 g/day	
8.8. Intake of alcohol	Systematically	
8.9. Violation of the work and rest regime	Systematically	
8.10. Disruption of sleep	Systematically	
8.11. Psychoemotional stresses	Systematically stress plankton, one-time severe stress	
8.12. Psychological type A		

Physiological indicators	Standard	Result estimation
8.13. Unfavorable heredity:		
- Hypertension in close relatives	+	
- Strokes, heart attacks, sudden death at the age of 55 years in close relatives	+	
- Diabetes in close relatives	+	
- Malignant tumors in close relatives	+	
9. Anti-risk factors:	Indicators of anti-risk	
9.1. Physical activity	Daily walking 2–3 km	
9.2. Rational nutrition	Constantly	
9.3. Safe food	Constantly	
9.4. Fruits, vegetables	400-500 g / day	
9.5. Cold quenching	Constantly	
9.6. Shaking with heat (sauna)	Weekly	
9.7. Psychological unloading (auto-training)	Weekly	
9.8. Plant adaptogens (ginseng, etc.)	Periodically, courses	
10. Chronic diseases		

Conclusions. Compare the results with the normal values. Make conclusions about your lifestyle, suggest a plan of reducing health risk factors and including health factors into your lifestyle.

Tests

1. THE STATE OF THE ENVIRONMENT: THE COMPOSITION OF AIR, WATER, UNFAVORABLE PRODUCTION CONDITIONS. HEALTH DEPENDS ON THESE FACTORS BY...

- a) 20 % b) 50 % c) 10 %

2. HEREDITY. ... OF DISEASES ARE GENETICALLY DETERMINED IN THE FORM OF DEFECTS IN INDIVIDUAL GENES, CHROMOSOMAL ABNORMALITIES, AND A PREDISPOSITION TO DISEASE.

- a) 20 % b) 50 % c) 10 %

3. THE WORK OF HEALTH AUTHORITIES DETERMINES HEALTH BY...

- a) 8–10 % b) 50–60 % c) 20–30 %

4. HEALTH (BY WHO DEFINITION) IS...

- a) the state of complete physical, mental, and social well-being
and not merely the absence of disease or infirmity
- b) the state of complete physical, mental, and social well-being
only
- c) the absence of disease or infirmity only

EXAMINATION QUESTIONS

Excitable Tissues

1. Excitable tissues. Transport processes across cell membrane. Diffusion and active transport (ion pumps). Types of ion channels.
2. Rest potential and graded potential. Ion mechanism. The role of the threshold.
3. Action potential (AP). Ion mechanism, properties.
4. Skeletal muscles. Types of muscular fibers (I, IIa, IIb), motor units. Contraction forms of the skeletal musculature. Explain the mechanism of muscular contraction (sliding filament theory).
5. Neuron. Classification of neurons. Structure and functions of neurons. Describe the mechanisms for excitation of the neuron and nerve fibers.
6. Synapse. Mechanisms of excitation in neurotransmission. Excitatory and inhibitory synapses. The properties of synapses.

Central Nervous System

7. Nerve centre. The most important physiological properties of nerve centers. Convergence (summation), divergence (irradiation, generalization, reciprocal interaction).
8. Reflex. Reflex arc, parts of the arc, types of reflexes.
9. Central inhibition. Pre-synaptic and post-synaptic inhibition. Coordination of reflexes. Reciprocal inhibition. The principles of dominant (A. A. Ukhtomsky), of feedback
10. Electroencephalography. The research method of electroencephalography, EEG rhythms.

11. Motor function of the spinal cord. The interaction of neurons in spinal segments and proprioceptors (muscle spindle, receptor Golgi, alpha- and gamma- motoneurons).

12. Somatic (motor) system. Cerebellum, basal ganglia, cortex functions.

Autonomic Nervous System

13. Sympathetic nervous system. Reflex arcs, the most important physiological effects, neurotransmitters and receptors of the sympathetic part of the ANS.

14. Parasympathetic nervous system. Reflex arcs, the most important physiological effects, neurotransmitters and receptors of the parasympathetic part of the ANS.

Humoral Regulation

15. Endocrine system. Classification of hormone chemical structure, the mechanisms of action of various hormones on target cells (membrane and nuclear reception). Role of second messengers.

16. Pituitary gland. Endocrine function of the hypothalamus and pituitary. Role of the hypothalamic-pituitary system in regulating the activity of peripheral endocrine glands.

17. Thyroid and parathyroid glands. Endocrine function of the thyroid and parathyroid glands, its regulation mechanisms, role of hormones of the thyroid and parathyroid glands.

18. Pancreas. Endocrine function of the pancreas, regulation mechanisms, role of hormones of the pancreas.

19. Adrenals. Endocrine function of adrenals, regulating mechanisms, role of cortical and medulla hormones.

20. The role of hormones in energy balance and body weight maintenance (insulin, contra-insular hormones, leptins, ghrelin).

21. Hormonal regulation of the reproductive system, its development. Human puberty period.

CVS

22. Heart. Ionic mechanisms of building contractile cardiomyocytes, analyze changes of excitability in different phases of the Action potential.

23. Conductive system of the heart. Nodes. Potentials of pacemaker cells.

24. Heart. The position of valves and pressure change in the cavities of the heart (atria, ventricles) in the dynamics of the cardiac cycle. Specify the temporal characteristics of the phases of the cardiac cycle. Heart sounds.

25. Describe the mechanisms of regulation of the cardiovascular system (functional system).

26. ECG. The principle of the method and purpose of electrocardiography. Analyze electrocardiograms of a healthy person.

27. Classification of blood vessels.

28. Blood pressure, volumetric and linear speed of blood flow. Analyze the factors affecting the magnitude of blood pressure. Arterial pulse characteristics.

29. Capillaries. The transport mechanisms of transcapillary exchange. Lymph formation.

Metabolism. Thermoregulation

30. Thermoregulation. Centre of regulation and thermoreceptors. Thermal production and heat emission mechanism and its regulation.

31. Energy exchange. Factors affecting the amount of basal metabolism rate (BMR), total daily energy expenditure.

32. Energy balance.

Digestion

33. Digestion in the oral cavity. Motor functions (chewing, sucking, swallowing). The composition and physiological role of saliva. Salivation, its regulation.

34. Digestion in the stomach. Secretion, the composition and properties of gastric juice. Mechanisms of regulation, phases of gastric secretion.

35. Duodenal intestine. The role of the liver in digestion, functions and composition of bile. Role of the pancreas in digestion.

36. Small intestine: motility, secretion and absorption of nutrients.

37. Digestive processes in the large intestine. The importance of the large intestine micro flora for digestion and other bodily functions. The act of defecation.

38. The processes of absorption of nutrients and water in the oral cavity, stomach, small and large intestine.

39. Functional system that supports optimal metabolic levels of nutrients in the blood. Mechanisms of hunger and saturation (the theory of "empty stomach" and "blood hungry"; sensory and metabolic saturation).

Blood Physiology

40. Blood as an essential compartment of the inner environment, the composition of blood. The main physiological constants of blood.

41. Transport function of the blood. Red blood cells. Regulation of erythropoiesis (erythropoietin, hormones stimulate and inhibit erythropoiesis).

42. The basic principles of classification of blood groups in the ABO system. Rhesus factor.

43. Hemostasis. Blood clotting mechanisms to maintain the integrity of the vascular wall and to stop bleeding. Vascular-platelet and coagulation hemostasis.

44. Anticoagulation system. The main components in the anticoagulation system.

45. Innate immunity. Barriers. Functions of neutrophils, monocytes, basophils, eosinophils. Interferon, lysozyme. Differences between innate and adaptive immunity.

46. Adaptive immunity. Classification of lymphocytes, types, normal range in peripheral blood of a healthy adult person. Antigen presenting cells, classification, function. Primary and secondary immune response.

Breath

47. Respiration. Processes during inhalation and exhalation (passive and active). Alveolar pressure changes during respiration. Role of the pleural cavity in a breath and effects of pneumothorax.

48. Ventilation. Gas flow resistance (elastic and inelastic). Surfactant and surface tension. Lung volumes and capacities. Dead space.

49. Gas exchange. The mechanism of O₂ and CO₂ exchange between alveolar air and capillary blood.

50. Mechanisms of blood gases transportation. Oxyhemoglobin dissociation curve and the factors that affect the affinity of hemoglobin of oxygen. The mechanisms of carbon dioxide transport.

51. Regulation of respiration. The respiratory center, modern views on its structure. Functional system that supports optimal blood gas composition.

Kidney

52. Water and salts exchange. Water compartments, inner environment. Mechanisms of thirst formation.

53. Kidney functions. The structure and characteristics of nephrons. Nephron blood supply.

54. Urine formation. The processes of glomerular filtration in the nephron. Kidney filter, forces of filtration. Composition of ultrafiltrate.

55. Urine formation. Processes of reabsorption and secretion in the nephron. Urine composition. Micturition.

Sensory Systems (Analyzers)

56. Vestibular system. The structure and function of the receptor, conductive ways of the cortical part of the vestibular system; the role of static and stato-kinetic reflexes in maintaining balance.

57. Vision. Characteristics of light. The structure and function of receptors (retina), visual pathway and cortical part of the visual system. The theory of color vision.

58. Optical system of the eye. Mechanism of accommodation. The role of the pupil. Visual disturbances (myopia, hyperopia, astigmatism).

59. Auditory system. Characteristics of sound. Roles of the outer, middle and inner ear (structure and functions of the cochlea). The auditory pathway, cortical part functions.

60. Nociceptive systems. Pain and its biological significance. Peripheral pain mechanisms, pain system, neurotransmitter. Antinociceptive system. Functions of opioid receptors and endogenous opioids.

Integrative function of the CNS

61. Cerebral cortex. Frontal lobe function. The asymmetry of the human cerebral cortex. Speech and language.

62. Integrative function of the CNS. Needs. Classification of reactions that provide behavior.

63. Conditioned reflexes (I.P. Pavlov). Classification, differences with unconditional ones. Temporary connection.

64. Physiological mechanisms of sleep. Role of suprachiasmatic nucleus. Melatonin.

65. Memory. Various types of memory and their neurophysiological mechanisms. Learning.

66. Physiological foundations of health and the concept of health. Characteristics of health factors and risks. Principles for assessing individual health.

67. Labor activity. Classification of labor. Sport physiology. Working capacity.

68. Fatigue. Types of fatigue. Describe objective and subjective criteria of fatigue. Fighting against fatigue.

69. Homeostasis. The activity of systems aimed at maintaining homeostasis (breathing, urinary, circulation, blood, nutrition).

70. Functional systems. Automated control of homeostasis. Behavioral responses.

71. Adaptation. Stress. Stress factors. Phases of stress.

72. Brain reward systems. Pleasure centers. The role of neurotransmitters. Addictive behavior.

PRACTICAL SKILLS

Students begin to master Practical skills in practical classes. The skills include activities required for medical examinations and procedures.

There are several levels: 1) knowledge about the action being performed; 2) performance under the guidance of a teacher; 3) independent performance; 4) ability to perform; 5) skill.

In the second year, students master levels 1–3, depending on the complexity. All presented methods are described in this manual.

In subsequent courses, students continue to master skills to the next levels.

Practical skills (Normal Physiology, 2nd part)

1. Knee-jerk reflex, Achilles reflex
2. Pupil reflexes
3. Rotating trial
4. Martine-Kushelevsky's test
5. Orthostatic test
6. Chrono-reflexometry (reciprocal inhibition)
7. Visual acuity
8. Visual field
9. Campimetry
10. Color vision
11. Hearing acuity (by whispering and speaking)
12. Weber's test
13. Rinne's test
14. Masticatiography
15. Total daily energy expenditure (TDEE)
16. Body mass index (BMI)
17. Type of memory
18. Types of temperament

KEYS NPH 2ND PART

Practical Class 1. Reflex. Organization of the Nervous System, Sensory Receptors. Reflex Principle of the Central Nervous System

1 b	2b	3a
4a	5c	6a
7c	8a	9b

Practical Class 2. Coordination of Reflex Activity. Excitation and Inhibition in the Central Nervous System

1c	2a
3a	4b
5a	

Practical Class 3. Vision

1 a	2 b	3 c	4 a
5 a	6 c	7 b	8 c
9 a	10 c	11 b	12 a
13 a	14 a	15 c	16 d
17 c	18 b	19 a	20 d

Practical Class 4. Hearing. The Sense of Hearing. Pain. Nociceptive sensation. Anti-Nociceptive System

1 a	2 a	3 c	4 c
5 c	6 b	7 a	8 a
9 a	10 b	11 a	12 b
13 b	14 a	15 b	16 b
17 c	18 a	19 c	20 b

Practical Class 5. The Motor System. The Role of CNS Departments in the Regulation of Muscle Tone

c	c	a	a
c	b	d	a
b	a	b	c
a	b	b	b
b	b	a	

Practical Class 6. ANS. Autonomic Nervous System

d	d	c	c
c	d	c	d
b	a	a	c
c	d	d	d
b	a	b	

Practical Class 7. Endocrine System

1 b	2 b	3 a, c, d
4 – 1 b, 2 c, 3 a	5 – 1 b, 2 c, 3 a	6a
7b	8a	9a

Practical Class 8. Functional Systems

1 a	2 a	3 b
4 d	5 b	6 a
7 a	8 a	9 a
10 a	11 a	12 a
13 c	14 b	

Practical Class 9. Intellectual Functions of the Brain, Learning and Memory. EEG

1 a	2 b	3 c	4 a
5 d	6 e	7 c	8 b
9 b	10 c	11 a	12 a
13 d	14 a	15 b	16 c
17 b	18 a	19 d	20 a

Practical Class 10. Conditional Reflexes

1 b	2 a	3 a	4 a
5 a	6 b	7 a	8 b
9 a	10 b	11 a	12 a
13 a	14 d	15 b	16 a
17 a	18 a	19 c	20 c

Practical Class 11. Secretory Function of the Alimentary Tract.
Dietary Balance and Immunity

1 b	2 a	3 d
4 c	5 c	6 c
7 b	8 c	9 b

Practical Class 12. Motility. Smooth muscles. Propulsion
and Mixing of Food in the Alimentary Tract

1 c	2 a	3 c
4 a	5 a	6 b
7 a	8 a	9 a

Practical Class 13. Energy Balance

1 a	2 b	3 b	4 a
5 b	6 c	7 a	8 c
9 a	10 c	11 b	12 b
13 a	14 c	15 a	16 b
17 b	18 a	19 c	20 a

Practical Class 14. Adaptation

b
c
b

Practical Class 15. Labor Activity

1 a
2 a
3 a

Practical Class 16. Health Care

1 a
2 a
3 a
4 a

Educational publication

PRACTICAL PHYSIOLOGY

Part 2

Tutorial textbook

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Часть 2

Руководство к практическим занятиям по нормальной физиологии

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