

**MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS**

Educational institution

**BELARUSIAN STATE MEDICAL UNIVERSITY**

**Контрольный  
экземпляр**

**APPROVED**

by First Vice-Rector, Professor

I.N.Moroz



07.2022

Res. #10-

133/2223/edu.

**NORMAL PHYSIOLOGY**

**Curriculum of higher educational institution  
in the academic discipline for the specialty:**

**1-79 01 01 «General Medicine»**

Curriculum is based on the educational program «Normal Physiology», approved 01.07.2022, registration # УД-Л.733/2223/уч.; on the educational plan in the specialty 1-79 01 01 «General Medicine», approved 18.05.2022, registration # L 79-1-1/2223/mf.

### **COMPILERS:**

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### **RECOMMENDED FOR APPROVAL:**

by the Department of Normal Physiology of the educational institution «Belarusian State Medical University»  
(protocol # 13 of 31.05.2022);

by the Scientific and Methodical Council of the educational institution «Belarusian State Medical University»  
(protocol # 6 of 29.06.2022)

## EXPLANATORY NOTE

«Normal Physiology» is the academic discipline of the module «Biomedical Module # 1», which contains a systematized scientific knowledge of the vital functions of a healthy body and its individual parts (cells, tissues, organs, and functional systems), the mechanisms of these functions and the laws of their regulation.

The aim of the discipline «Normal Physiology» is the formation of basic professional competencies to solve problems of professional activity in assessing the physiological functions and characterizing their physiological state indicators of healthy and sick people on the basis of knowledge about the regularities of functioning and regulation of the vital functions of the whole human body, its organs and systems.

The objectives of the discipline «Normal Physiology» are to form students' scientific knowledge about the principles of organization of physiological functions and the interaction of functional systems of the human body, the basic patterns of functioning of cells, tissues, organs and systems of a healthy human body and the mechanisms of their regulation, as well as the most important indicators characterizing the normal state of physiological functions of the human body and its systems;

abilities and skills necessary for:

the formation of physiological and clinical thinking while observing the norms of medical ethics and deontology;

systemic analysis of indicators of physiological state of a healthy and sick person, his organs and systems;

interpretation of the results of laboratory and instrumental methods of examination;

the formation of a healthy lifestyle.

The knowledge, abilities, and skills acquired in the academic discipline «Normal physiology» are necessary for the successful study of the following academic disciplines: «General surgery», «Physical education»; modules: «Medical-prophylactic Module», «Biomedical Module # 2», «Therapy Module # 1», «Therapy Module # 2», «Therapy Module # 3», «Obstetrics and Gynecology Module» «Surgical Module # 2», «Surgical Module # 3», «Pediatric Module», «Mental Health Module», «Internal Diseases Module», «Clinical Pathology and Clinical Diagnosis Module».

Studying the educational discipline «Normal Physiology» should ensure the formation of students' basic professional competence:

BPC. Assess the indicators of a healthy and sick person physiological state on the basis of knowledge about the patterns of functioning and regulation of the human body vital activity, its organs and systems.

**As a result of studying the discipline «Normal Physiology» the student should**

**know:**

basic concepts of physiology;

relationship of organ structure and function, formation of functional adaptive systems;

systemic principles of organization of functions and interaction of functional systems of the human body;



the physiological foundations of a healthy lifestyle;  
basic regularities of functioning of cells, tissues, organs and systems of a healthy person, and mechanisms of their regulation;  
the main indicators characterizing the physiological state of the organs and systems of a healthy person;

**be able to:**

conduct clinical and physiological examination of the human body;  
give physiological interpretation of the indicators obtained as a result of the examination of individual functions of the body of a healthy person;  
assess the normal state of human body functions and their reserve capacities, taking into account age;

**master:**

methods of examination of basic physiological functions;  
a systematic approach to the assessment of physiological functions and their characterizing indicators.

**Total number** of hours for the study of the discipline is 288 academic hours.

Classroom hours according to the types of studies: lectures - 42 hours (including 14 hours of supervised student independent work), practical classes - 140 hours, student independent work (self-study) - 106 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a credit (3 semester) and examination (4 semester).

Form of higher education – full-time.



**ALLOCATION OF ACADEMIC TIME  
ACCORDING TO SEMESTERS OF STUDY**

Code, name of the specialty	semester	Number of academic hours						Form of intermediate assessment
		total	in-class	including			out-of-class self-studies	
				lectures (including supervised independent work)	supervised student independent work	practical classes		
1-79 01 01 «General Medicine»	3	144	92	20	7	72	52	credit
	4	144	90	22	7	68	54	exam

## THEMATIC PLAN

Section (topic) name	Number of class hours	
	lectures	practical
<b>1. Introduction. Homeostasis. The Internal Environment of the Human Body</b>	<b>2</b>	<b>16</b>
1.1. The subject and tasks of Normal Physiology	1	1
1.2. Homeostasis. Physical and chemical properties of blood	1	3
1.3. Physiological functions of erythrocytes. Hemopoiesis. Erythrocytopoiesis	-	3
1.4. Physiological functions of platelets. Thrombocytopoiesis. Hemostasis system	-	1
1.5. Physiological functions of leukocytes. Leukopoiesis. Non-specific and specific resistance of the human body. Physiological evaluation of the results of the complete blood count	-	4
1.6. Blood types. ABO system; Rhesus (Rh) and other systems. Physiological bases of blood matching for the transfusion	-	4
<b>2. Humoral Regulation of Physiological Functions</b>	<b>4</b>	<b>12</b>
2.1. Bases of information exchange of the cell with the environment. Chemical signaling	1	3
2.2. General physiology of the endocrine system	1	1
2.3. Special physiology of the endocrine system	2	8
<b>3. Physiology of Excitable Tissues</b>	<b>6</b>	<b>20</b>
3.1. Electrical signaling. Laws of response of excitable tissues	1	4
3.2. Biological potentials. Changes in excitability during excitation	1	4
3.3. Conduction of excitation along the nerve fibers	-	2
3.4. Synaptic transmission	2	2
3.5. Muscle physiology	2	4
3.6. General physiology of the central nervous system	-	4
<b>4. Nervous Regulation of Physiological Functions</b>	<b>2</b>	<b>12</b>
4.1. Role and function of the spinal cord	1	2
4.2. Role and function of the brain stem	-	1
4.3. Role and function of the cerebellum	-	1
4.4. Role and function of the intermediate brain	-	1
4.5. Role and function of the forebrain	-	2
4.6. Systemic mechanisms of muscle tone and movement regulation	1	1
4.7. Physiology of the autonomic nervous system	-	4
<b>5. Physiology of Sensory Systems</b>	<b>4</b>	<b>12</b>
5.1. General physiology of sensory systems	1	2



Section (topic) name	Number of class hours	
	lectures	practical
5.2. Visual system	1	3
5.3. Auditory and vestibular systems	2	2
5.4. Taste and smell systems	-	1
5.5. Somatovisceral system	-	2
5.6. Pain sensitivity system	-	2
<b>6. Physiology of Circulation</b>	<b>6</b>	<b>20</b>
6.1. Hemodynamics. Functional indices of blood circulation	-	3
6.2. Microcirculation	-	1
6.3. Physiological properties and characteristics of the myocardium	2	4
6.4. Cardiac cycle	1	2
6.5. Methods of the heart investigation	1	2
6.6. Regulation of the heart function	1	4
6.7. Regulation of the circulation	1	4
<b>7. Physiology of Respiration</b>	<b>6</b>	<b>20</b>
7.1. Lung ventilation	2	4
7.2. Gas exchange in the lungs and tissues	1	2
7.3. Transport of gases in blood	1	2
7.4. Regulation of respiration	1	4
7.5. Functional reserves of the hemocardiorespiratory system in gas exchange	1	8
<b>8. Physiology of Digestion</b>	<b>4</b>	<b>8</b>
8.1. General characteristics of the digestive system. Regulation of eating behavior	1	1
8.2. Digestion in the mouth and stomach	1	3
8.3. The role of the liver and pancreas in digestion	1	2
8.4. Digestion in the small and large intestine	1	2
<b>9. Substance and Energy Metabolism. Thermoregulation</b>	<b>2</b>	<b>4</b>
9.1. Substance and energy metabolism	-	1
9.2. Nutrition. Regulation of body weight	-	1
9.3. Thermoregulation	2	2
<b>10. Physiology of Excretion</b>	<b>2</b>	<b>8</b>
<b>11. Integrative Brain Activity</b>	<b>4</b>	<b>8</b>
11.1. Innate and acquired forms of adaptive reactions of the human body to changing conditions of the environment	2	4
11.2. Higher integrative functions of the brain as the physiological basis of human mental functions	2	4
<b>Total hours</b>	<b>42</b>	<b>140</b>



## CONTENT OF THE EDUCATIONAL MATERIAL

### 1. INTRODUCTION. HOMEOSTASIS. THE INTERNAL ENVIRONMENT OF THE HUMAN BODY

#### 1.1. The subject and tasks of Normal Physiology

Normal physiology as the science of vital functions of a healthy human body and its individual parts (cells, tissues, organs, functional systems), the mechanisms of these functions and patterns of their regulation.

The concept of the human body and its components. Levels of structural and functional organization of the human body. The concept of physiological functions and processes.

The systemic principle of organization and regulation of functions. Nervous and humoral mechanisms of regulation of human body functions. Local mechanisms of regulation of physiological functions. Levels of regulation: cellular, tissue, organ, organism. Types of regulation (in response to perturbation and to deviation).

The systemic approach to the study of the processes of vital activity of the human body. Functional system (according to P.K.Anokhin), principle of self-regulation. Systemogenesis.

The concept of the unity of the organism and its environment.

Relationship of physiology to other sciences. Physiology as the scientific basis of medicine. Stages of physiology development.

The period of individual discoveries (the principal role of the works of W.Harvey, R.Descartes).

Formation and development of physiology in XIX-XX centuries (I.Muller, C.Bernard, C.Ludwig, E.Dubois-Reymond, H.Helmholtz, C.Sherrington, W.B.Cannon, F.V.Ovsyannikov, I.M.Sechenov, N.A.Mislavsky, I.P.Pavlov, N.E.Vvedensky, A.A.Ukhtomsky, A.F.Samoilov, L.A.Orbeli, P.K.Anokhin, V.V.Parin, V.N.Chernigovsky, L.S.Stern and others).

Contribution of domestic physiologists to the development of physiological science (I.A. Vetohin, I.A. Bulygin, G.S. Yunev, G.A. Feshchenko, A.S. Dmitriev, N.I. Arinchin, V.N. Gurin, A.I. Kubarko and others).

Peculiarities of the modern period of development of physiology. Development of molecular-biological, analytical and integrative directions. Human physiology and scientific and technological progress. Use of engineering achievements in physiology – telemetry, computer engineering, physiological cybernetics, computer simulation of physiological functions, modern methods of visualization of physiological functions (functional magnetic resonance tomography, dispersive electrocardiographic mapping (ECG mapping), echocardiography, computer electroencephalography (EEG) and others).

#### 1.2. Homeostasis. Physical and chemical properties of blood

Homeostasis. Mechanisms of homeostasis regulation. Fluid media of the human body (intracellular fluid, interstitial fluid, blood, lymph, cerebrospinal fluid and others), their volume distribution in the human body. The concept of the internal environment of the human body.

Blood. The concept of the blood system (G.F.Lang), its age features.



Composition, quantity, properties, main functions of blood. Basic physiological constants of blood that characterize homeostasis. Organic and inorganic components of blood plasma. Blood osmotic pressure and its regulation, its role in the exchange of water and electrolytes between blood and tissues. The concept of the state of hyper- and dehydration of tissues. Blood plasma proteins, their classification and significance. Plasma oncotic pressure and its role. Rheological properties of blood. Acid-base state of blood. Physical-chemical and physiological mechanisms ensuring blood pH constancy. The concept of acidosis and alkalosis, the mechanisms of their occurrence. Changes in physiological functions in acidosis and alkalosis.

Lymph, mechanisms of its formation, quantity, composition, physical and chemical properties, functions.

Liquor (cerebrospinal fluid, CSF). Composition, physical and chemical properties, functions of cerebrospinal fluid, its dynamics. Significance of the study of CSF for diagnosis. Other transcellular fluids (pleural, pericardial, synovial and others), their composition, physical-chemical properties and physiological role.

### **1.3. Physiological functions of erythrocytes. Hemopoiesis. Erythrocytopoiesis**

Hemopoiesis (hemocytopoiesis): stem cell theory. Age peculiarities of hematopoiesis (in embryo, fetus, adult). The role of stem cell microenvironment in hematopoiesis. Properties and functions of polypotent hematopoietic stem cell and other precursor cells of mature blood cells. The concept of the possibilities of differentiation of embryonic and hematopoietic stem cells into other cell types. Nervous and humoral mechanisms of hematopoiesis regulation. Signal molecules important for hematopoiesis regulation (main groups of cytokines (hematopoietic cell growth factors, interleukins, interferons, nonhematopoietic cell growth factors), hormones, neurotransmitters and others), their origin. The role of cytokines and other signaling molecules in the regulation of self-maintenance, differentiation, proliferation and apoptosis of these cells.

Nutrients, vitamins and trace elements, which are essential for normal hematopoiesis, their importance and the body's need for them. General concept of disorders of hematopoiesis in case of deficiency of these substances in the human body.

Erythron. Erythrocytopoiesis and erythrocyte destruction, their age-related features. Erythropoietin and its role in the regulation of erythropoiesis. Features of the structure and properties of red blood cells to ensure their functions. The number of erythrocytes in the blood, methods of counting. Hemoglobin, its amount, functions, methods of determination. Features of the structure and properties that ensure the performance of the functions of hemoglobin. Types and compounds of hemoglobin. Color index and its calculation. Erythrocytic indices (mean hemoglobin content in an erythrocyte (MCH), mean hemoglobin concentration in an erythrocyte (MCHC), mean erythrocyte volume (MCV), erythrocyte distribution curve width (RDW)). The concept of anemia. Hemolysis, types and causes. Products of erythrocyte destruction, their physiological role, ways of utilization. Sedimentation rate of erythrocytes (Erythrocyte Sedimentation Rate) and factors affecting it.



#### **1.4. Physiological functions of platelets. Thrombocytopoiesis. Hemostasis system**

Thrombocytopoiesis. Blood plates (platelets), their number, structure, functions, life span. Regulation of thrombocytopoiesis, role of thrombopoietin.

The hemostasis system. Primary (vascular-platelet) and secondary (coagulation) hemostasis and its significance. The role of platelets in the mechanisms of primary and secondary hemostasis. Schmidt's enzymatic theory of hemostasis. Modern concepts of the main factors involved in blood coagulation (tissue, plasma, platelet, erythrocytic, leukocytic). Phases of blood coagulation. Fibrinolysis. The anti-coagulation system of the blood. The role of the vascular wall in the regulation of blood coagulation and fibrinolysis. Coagulogram indices.

#### **1.5. Physiological functions of leukocytes. Leukopoiesis. Non-specific and specific resistance of the human body. Physiological evaluation of the results of the complete blood count**

Leukopoiesis. Leukocytes, their types, number, functions, methods of calculation. Features of the structure and properties that ensure their functions. The concept of leukocytosis and leukopenia. Leukocyte formula: granular and agranular leukocytes, their varieties, number, functions, life span. The concept of T- and B-lymphocytes, leukocyte cluster differentiation (CD) markers. The concept of mechanisms of nonspecific and specific defense system of the human body.

The main indicators of the general blood analysis, the principles of its performance using modern methods of investigation. Physiological evaluation of the results of the analyses. The concept of age norms of the basic blood parameters. Diagnostic value of the complete blood count.

#### **1.6. Blood types. AB0 system; Rhesus (Rh) and other systems. Physiological bases of blood matching for the transfusion**

Blood types systems. AB0, Rh, HLA and other systems. Blood typing in AB0 and Rh system. Basic principles of donor blood selection. Risk factors in working with blood for health care workers, donors and recipients. Consequences of mismatched blood transfusion. Significance of HLA system for transplantation of donor organs and tissues. Blood components and preparations. Blood substitute solutions, physiological requirements for them, and their classification according to the type of function they perform in the human body.

## **2. HUMORAL REGULATION OF PHYSIOLOGICAL FUNCTIONS**

### **2.1. Bases of information exchange of the cell with the environment. Chemical signaling**

Information exchange between the cell and the environment. Information, signal. Types of information signals.

Chemical signaling. The main ways of intercellular communication involving chemical signals, their characteristics. Classification and properties of signaling molecules (ligands). Molecular (cellular) receptors. Classification according to structure and localization in the cell. Structure and functions of transmembrane and intracellular receptors. Metabotropic and ionotropic receptors. Receptors associated with G-proteins.



Ligand-receptor interactions. Main pathways of intracellular signal transmission involving seven-segment transmembrane receptors (G-protein-coupled receptors; 7-TMS). First and second messengers and their functions. Ligands interacting with 7-TMS receptors and physiological functions controlled involving these receptors. 1-transmembrane segment receptors (1-TMS), their structure, features of the mechanism of action. Ligands interacting with 1-TMS receptors and physiological functions controlled by these receptors.

Ion channels. Classification. Structure and mechanism of action of ligand-gated ion channels by the example of n-cholinoreceptor and other types of receptors. Their ligands. Role of hormones and second messengers in regulation of permeability of ligand-dependent ion channels. The notion of other mechanisms of ion channels permeability regulation.

Intracellular signal transmission involving intracellular receptors. Ligands acting through intracellular receptors. Mechanism of action and main physiological effects. The main physiological effects of ligand-receptor interaction at the cell level.

## **2.2. General physiology of the endocrine system**

The significance of the endocrine system for the vital functions of the human body. Modern ideas about the functions of the endocrine system. General characteristics of the endocrine system. Morphological and functional classification of endocrine glands. Hormones as signal molecules: definition of the concept, classification according to the chemical structure and the function performed. Mechanisms of action of hormones. General principles of regulation of synthesis and secretion of hormones. Multilevel system of regulation of hormone secretion. Links between endocrine glands and nervous system. Participation of endocrine system in homeostasis regulation. Notion of methods of endocrine system function evaluation in humans.

## **2.3. Special physiology of the endocrine system**

Pituitary gland, its functions, morphological and functional connections with hypothalamus. Hormones of hypophysis and hypothalamus, their role in regulation of endocrine and non-endocrine organs activity. Interaction of nervous and humoral mechanisms of regulation of functions on hypothalamic level. The most frequent manifestations of disorders of endocrine function of pituitary gland and hypothalamus.

Epiphysis, its endocrine functions.

Thyroid gland. Iodine-containing thyroid hormones, mechanisms of their action and effects caused by them. The influence of thyroid hormones on the processes of growth and development of the central nervous system (CNS). Consequences for the CNS functions of hypothyroidism in the fetus and newborns. Participation of thyroid hormones in the processes of adaptation. Regulation of hormones secretion. Characteristic manifestations of excess or insufficient secretion of hormones. Calcitonin.

Parathyroid glands. Parathormone.

Regulation of calcium and phosphorus homeostasis in the human body. Influence of calcitonin, parathormone and vitamin D on calcium and phosphorus metabolism. Daily requirement for calcium and sources of calcium in the human body.



Adrenal glands. Hormones of the adrenal glands cortex and medulla. Mechanisms of action of hormones and effects caused by them. Regulation of hormones secretion. Characteristic manifestations of excess or insufficient hormones secretion. Regulation of endocrine function of the adrenal glands.

Sex glands. Sex hormones. Mechanisms of action of hormones and the effects caused by them. Mechanisms of regulation of hormones secretion. Characteristic manifestations of excess or insufficient secretion of hormones. Age peculiarities of endocrine function of the reproductive glands. Endocrine function of the placenta. The concept of the reproductive system of the human body.

Pancreas, its endocrine function. Pancreatic hormones and their role in the regulation of carbohydrate, fat and protein metabolism. Mechanisms of action of hormones. Regulation of hormones secretion. The concept of hypo- and hyperglycemia and their causes.

The thymus gland and its role in different age periods. The concept of the diffuse endocrine system (APUD-system) of the intestine. Endocrine function of heart, vessels, adipose tissue, liver, and kidneys. Hormonal mechanisms to maintain water-electrolyte balance in human body (antidiuretic hormone, renin-angiotensin-aldosterone system, natriuretic peptides, prostaglandins). Hormonal mechanisms of body weight regulation. Involvement of endocrine glands in adaptive activity of the body. General adaptation syndrome, stress. Distress and eustress. The concept of stress-realizing and stress-limiting systems of the human body.

Age-related changes in endocrine functions.

### **3. PHYSIOLOGY OF EXCITABLE TISSUES**

#### **3.1. Electrical signaling. Laws of response of excitable tissues**

Electrical signaling and its role in the regulation of physiological functions.

The concept of irritability and excitability as the basis of tissue (cell) response to stimulation. Excitation and forms of its manifestation.

Classification of stimuli. Characteristics of stimuli that are important for the occurrence of excitation. Indices (parameters) of excitability (force threshold, time threshold, minimal stimulus gradient). The concept of rheobase and chronaxie. Relationship between the strength of a stimulus and the time of its action on the excitable tissue, which is important for the excitation occurrence. Force-duration curve. The concept of lability (N.E.Vvedensky).

Laws of response of excitable tissues to stimuli (the law of force, duration, «all or nothing», stimulus gradient and others). Reaction of excitable tissues to the action of direct electric current (polar law).

#### **3.2. Biological potentials. Changes in excitability during excitation**

Modern concepts of the structure of the membranes of excitable cells, providing their functions. The concept of passive (leakage channels), voltage-gated, ligand-gated and other types of ion channels. The concept of ion pumps, exchange mechanisms of ion transport. Ionic gradients and their role in the generation of electrical potentials of the cells.

Bioelectrogenesis. Biopotentials as carriers of information in living organisms. Types of biopotentials, their comparative characteristics.



Resting membrane potential, its origin, mechanism of resting potential maintenance (selective permeability of cell membrane, ionic gradients, K-Na pump functioning and others).

Modern ideas about the mechanisms and phases of action potential development. Changes in excitability during excitation. Refractory period, its causes and significance.

Sensory receptors. Role, classification, basic properties (high sensitivity to the action of an adequate stimulus, background activity and others). Mechanisms of transformation of stimulus energy into nervous impulses in primary and secondary-sensitive sensory receptors. Mechanisms of adaptation of sensory receptors. The concept of the principles of analog and discrete encoding in receptors. Receptive field and reflexogenic zone.

### **3.3. Conduction of excitation along the nerve fibers**

Generation of nerve impulses in sensory receptors and axon hillocks. Nerve fiber. Physiological role of the structural elements of the nerve fiber. Mechanism and laws of nerve impulse conduction along a nerve fiber. Axonal transport of substances, its characteristic and importance. Growth factors. Characteristics of nerve fibers of type A, B, C (Erlanger-Hasser classification of nerve fibers in warm-blooded organisms). Principles of classification of afferent nerve fibers of warm-blooded animals by Lloyd-Hunt.

### **3.4. Synaptic transmission**

Synapse. Structure and classification of synapses, their physiological role. Modern concepts of the mechanisms of signal transmission in synapses. Neurotransmitters, their classification, synthesis, mechanism of secretion into synaptic cleft, interaction with ionotropic receptors of postsynaptic membrane. Cotransmitters and neuromodulators. Processes that ensure restoration of synapse readiness to conduct the next signal. Postsynaptic potentials. Summation of potentials. General properties of synapses (with the example of neuromuscular junction). Participation of synapses in regulation of intracellular processes. The concept of metabotropic receptors. Notion of the possibilities of pharmacological influence on signal transmission processes in synapses (influence on neurotransmitter secretion, on postsynaptic membrane receptors, on neurotransmitter or its precursors reuptake, on synaptic cleft enzymes and other).

### **3.5. Muscle physiology**

Skeletal muscles. Physical and physiological properties of skeletal muscles. Types and regimes of contraction. Single muscle twitch and its phases. Summation of contractions, tetanus. Dependence of amplitude of contraction on frequency of stimulation. Optimum and pessimum (N.E.Vvedensky). Muscle tone. Force and work of muscles. Muscle fatigue. The law of medium-level loads. Types of muscle fibers. Motor units and their peculiarities in different muscles. Changes in the muscle following denervation. Physiological rationale for the use of methods that delay the development of muscle atrophy and contribute to the restoration of muscle function (electrical stimulation, massage and others). Mechanism of contraction and relaxation of single muscle fiber and muscle. Excitation-contraction coupling. Electromyography.

Ensuring the metabolism of muscle as an organ under conditions of relative rest and at different levels of physical activity (blood flow, oxygen and nutrient consumption, energy expenditure).



Smooth muscles. Physiological properties and peculiarities of smooth muscles in comparison with skeletal muscles. Transmission of signals from nerve fiber to smooth muscle. Types of neurotransmitters. Receptors of smooth muscle fibers ( $\alpha$ - and  $\beta$ -adrenoreceptors, M-cholinoreceptors and others). Mechanisms of contraction and relaxation of smooth muscle cells. Features of regulation of contraction (force, duration, tone) of smooth muscles. The role of calcium ions in the function of smooth muscles. The concept of the nature of smooth muscle tone and the possibilities of its regulation through the influence on the processes of transmission and perception of signals by receptors of smooth myocytes.

The concept of changes in the peripheral nervous system, synaptic transmission and muscle tissue at different ages.

### **3.6. General physiology of the central nervous system**

Functions of the CNS and its role in ensuring the vital activity of the integral human organism and its relationship with the external environment. The concept of the central and peripheral nervous system. Methods of studying the nervous system.

Neuron. Functional classification of neurons. Physiological properties of nerve cells and functions of neuron structural elements (soma, axon, dendrites). Morphological and biophysical features of neurons, providing their specific functions (perception, integration, information transfer). Peculiarities of emergence and distribution of excitation in a neuron.

Combining neurons into neural circuits. Types and functions of nerve circuits. Basic principles of excitation distribution in nerve circuits (divergence, convergence, reverberation, etc.). Determinism and variability of neural circuits. Notion of plasticity mechanisms. Concept of conductive pathways and their functions. Role of neuroglia.

Features of the structure and functions of CNS synapses in comparison with peripheral synapses. Neurotransmitters in CNS. Physiological concept of the nerve center. Functions of nerve centers, their properties (spatial and temporal summation, transformation of excitation rhythm, tone, plasticity, fatigue of nerve centers). Afferent and efferent nervous pathways, their varieties and functions.

Reflex principle of nervous system functioning (R.Descartes, J.G.Prochazka, I.M.Sechenov, I.P.Pavlov, P.K.Anokhin). Reflex as a stereotypic adaptive response of the human body to the action of stimuli, which occurs with the participation of the nervous system. Types of reflexes. Reflex arc, classification. Feedback and its significance. Multilevel organization of reflex. Substrate, mechanism and forms of manifestation of excitation on the neuron, in the nerve center.

Inhibition in the nervous system (I.M.Sechenov, F.Goltz). Modern concepts of the mechanisms of central inhibition (J.Eccles, B.Renshaw). Inhibition in CNS: primary (postsynaptic and presynaptic), secondary (pessimal and inhibition after excitation).

The interaction of excitation and inhibition processes as the basis of CNS coordination activity. Basic principles of coordination: principle of conjugate (reciprocal) inhibition, principle of common final pathway (Ch.Sherrington), dominance principle (A.A.Ukhtomsky), feedback principle (P.K.Anokhin). Interaction between the various levels of the CNS in the process of function regulation. The concept of integrative activity of the CNS.



Peculiarities of brain metabolism and its provision by the cerebral circulation system. Duration of brain neurons survival under conditions of hypoxia, anoxia, hypothermia, hyperthermia. Possibilities of restoration of brain functions. Resuscitation time. The concept of the structure and function of the blood-brain barrier (BBB). Features of the barrier function of the GEB in different parts of the brain and in different states of the human body. The role of cerebrospinal fluid in the brain's vital functions.

Age-related changes in the CNS.

#### **4. NERVOUS REGULATION OF PHYSIOLOGICAL FUNCTIONS**

##### **4.1. Role and function of the spinal cord**

The spinal cord. Structural and functional organization. Reflex activity of the spinal cord. Sensory functions of the spinal cord. Perception and processing of signals from skin receptors, proprio- and interoreceptors. Motor functions. Spinal mechanisms of regulation of muscle tone, posture and movements. Conduction functions of the spinal cord. Afferent and efferent conductive pathways of the spinal cord. Autonomic functions. Spinal mechanisms of autonomic functions regulation (regulation of vascular tone, internal organs functioning, sweat glands activity etc.). Integrative functions. Distribution of muscle tone, organization of complex movements. Spinal mechanisms of integration of somatic and autonomic functions. Clinically important spinal reflexes in humans (somatic and vegetative).

##### **4.2. Role and function of the brain stem**

Brain stem. The medulla oblongata. Structural and functional organization. Sensory functions of medulla oblongata. Perception and processing of signals from skin receptors, proprio- and interoreceptors, from taste, hearing receptors and vestibular receptors. Motor functions. Regulation of muscle tone, posture and movements. Conduction functions. Afferent and efferent conductive pathways. Autonomic functions. Bulbar mechanisms of regulation of vascular tone. Vasomotor center. Reflex regulation of cardiac activity. The respiratory center. Regulation of the functions of the digestive system and other internal organs. Integrative functions. Distribution of the muscle tone, posture maintenance, organization of complex movements. Integration of autonomic functions. Integration of autonomic and somatic functions. Protective reflexes.

The midbrain and the pons. Structural and functional organization. Sensory functions. Perception and processing of signals from skin receptors, proprioceptors. Processing of visual and auditory information. Conductive functions. Conductive sensory pathways. Motor functions. Regulation of muscle tone, posture and movements. Relationship with cerebellum. Oculomotor functions. Autonomic functions. Autonomic nervous system pathways. Pupillary and other reflexes. Integrative functions. Organization of visual and auditory orientative reflexes. Organization of complex movements, integration of autonomic and somatic functions (chewing, swallowing, etc.), regulation of breathing.

Reticular formation of the brainstem. Structural and functional organization. Descending and ascending influences of reticular formation on CNS activity. Participation of reticular formation in maintenance and redistribution of muscle tone,



in regulation of autonomic functions. Participation of reticular formation in integrative activity of CNS.

#### **4.3. Role and function of the cerebellum**

Cerebellum. Structural and functional organization. Participation in realization of sensory functions. Perception and processing of information from skin receptors, proprioceptors, receptors of the vestibular apparatus, visual and auditory systems and from the large hemisphere cortex. Motor functions. Participation in distribution of muscle tone, posture organization, involvement in purposeful slow and fast ballistic movements, correction of motor programs. Autonomic functions. Participation of the cerebellum in regulation of functions of the cardiovascular, respiratory, digestive and other systems. Integrative functions. Integration of sensory and motor functions.

#### **4.4. Role and function of the intermediate brain**

Thalamus. Structural and functional organization of thalamus. The main sensory and motor conducting pathways. Functional characteristics of thalamic nuclei. Participation of thalamus in formation of pain sensations and in realization of higher integrative brain functions.

Hypothalamus. Structural and functional organization. Participation in realization of sensory functions. Connections of hypothalamus with the cerebral cortex and other parts of the brain. Neurosecretory cells. Hypothalamic sensory neurons (thermo-, osmosensitive and others). Polysensory neurons. Endocrine functions (hypothalamic hormones and releasing factors). Autonomic functions. The higher centers of autonomic nervous system. Integrative functions of the autonomic nervous system. Integration of the neuroendocrine functions, somatic and autonomic functions, participation in realization of the higher integrative functions of the brain.

#### **4.5. Role and function of the forebrain**

The cortex of the large hemispheres of the brain. Structural and functional organization. Modules (columns) as examples of structural and functional units. The role of the cerebral cortex in the formation of organism's systemic activity. Modern ideas about localization of functions in the cortex. Plasticity of the cortex.

Limbic system. Structural and functional organization of limbic system. Its role in formation of motivations, emotions, memory organization. Participation of limbic structures in integrative activity of CNS.

Basal nuclei. Structural and functional organization of the basal nuclei. Integrating function of basal nuclei in organization and realization of complex movements and integrative brain functions (motor, limbic, oculomotor and cognitive loops). Role of dopamine, acetylcholine and other mediator systems.

Age peculiarities of CNS functions.

#### **4.6. Systemic mechanisms of muscle tone and movement regulation**

Structural and functional bases of the multilevel system of regulation of muscle tone, posture maintenance and organization of movements. Intrinsic mechanisms of the spinal cord providing regulation of muscle tone. The spinal cord as a common final pathway for supraspinal CNS sections in the mechanisms of regulation of muscle tone, posture maintenance, and movement organization. Changes in muscle structure and function in hypodynamy, denervation and other conditions. The most characteristic changes of muscle tone and movements in disorders of the spinal cord, brain stem,



structure and function in hypodynamy, denervation and other conditions. The most characteristic changes of muscle tone and movements in disorders of the spinal cord, brain stem, cerebellum, basal nuclei, large cerebral cortex. Theoretical basis of correction of disorders of tone, trophics of muscles and movements. Significance of electrodiagnostics and electrical stimulation in prevention of muscle atrophy and restoration of their functions in case of innervation disorders, hypodynamy and other conditions.

The concept of changes in muscle tone, posture maintenance and movement organization at different ages.

#### **4.7. Physiology of the autonomic nervous system**

The role of the autonomic (vegetative) nervous system (ANS) in ensuring the vital functions of the integral organism. Functions of the ANS. Comparative description of the general structure and physiological properties of the ANS and somatic nervous system (afferent, central, efferent sections). Comparative characteristics of the structure and physiological properties of the sympathetic and parasympathetic sections of the ANS. The concept of metasymphathetic nervous system. Autonomic ganglia, their functions (transmissive, reflexive, integrative). Preganglionic and ganglionic neurons and their axons: morphological, functional and neurochemical differences. Neurotransmitters, receptors of ANS and its effector cells. Factors determining the response of effector cells to neurotransmitter action. The concept of principles of autonomic functions correction by influence on transmitters-receptor interaction mechanisms.

General characteristic of the influence of sympathetic and parasympathetic parts of ANS on effector organs, their sensory functions. Synergism and relative antagonism of their influences. Autonomic reflexes. ANS centers, their tone. Interaction of somatic and ANS in regulation of body functions. Adaptation and trophic function of the ANS. Participation of the ANS in integration of functions in forming behavioral acts. Tone of the autonomic centers. Autonomic reactivity and autonomic provision of somatic functions. Age-related changes in the ANS.

### **5. PHYSIOLOGY OF SENSORY SYSTEMS**

#### **5.1. General physiology of sensory systems**

The concept of sense organs, analyzers, sensory systems. I.P.Pavlov's teaching about analyzers. General principles of the structure of sensory systems, their role in maintaining the functional state of the human body, classification of sensory systems.

Mechanisms of perception of action of stimuli of external and internal environment of a human body by receptors. Coding, recoding, decoding, transmission, processing of information in receptors, conductive pathways and central parts of sensory systems. The role of sensory systems in brain development and cognition of the world.

#### **5.2. Visual system**

The visual system. The structure and functions of the visual system. Features of the structure and properties of the eye, providing the function of vision. Structure and functional significance of the retina. Photochemical processes in retinal receptors under the action of light and in the dark. Functions of photoreceptor, horizontal,



amacrine and ganglion cells of the retina. Role of the pigment epithelium. Blood supply to the eye and retina. Information transmission and processing in conductive pathways and central parts of the visual system. Theories of color perception. Basic forms of color perception disorders. Field of vision. Visual acuity. Refraction and accommodation. Basics of correction of refractive errors. Adaptation, mechanisms and levels of adaptation. Eye movements. Central and peripheral mechanisms of coordination of visual and oculomotor functions. Age features of vision.

### **5.3. Auditory and vestibular system**

The auditory system. Peculiarities of the structure and properties of the sound-conducting and sound-perceiving apparatuses that provide the hearing function. Mechanisms of perception and analysis of sounds. Transmission and processing of information in the conductive pathways and central parts of the auditory system. Adaptation. Protective reflexes. Binaural hearing. Age-specific features of hearing. Basics of hearing impairment correction.

Vestibular system. Peculiarities of structure and properties of receptor division providing perception and estimation of body position and its movement in space. Transmission and processing of information in the conductive pathways and central sections of the vestibular system. Reactions of the human body to the vestibular system stimulation. Possibilities of their correction.

### **5.4. Taste and smell systems**

Olfactory system. Reception of smells. Conductive pathways and central sections of the olfactory system. Perception and classification of smells. Human body reactions to stimulation of the olfactory system. Protective reflexes.

The taste system. Taste reception. Conduction pathways and central parts of the gustatory system. Perception of taste. Classification of taste sensations. Reactions of the human body to gustatory stimuli.

### **5.5. Somatovisceral system**

The somatovisceral sensory system. Skin sensitivity. Mechanoreception. Types of receptors. Transmission and processing of information in conductive pathways and central sections. Thermoreception. Role of skin, internal organs, vessels and CNS in thermoreception. Information transmission and processing in conductive pathways and central sections. Reactions of human body to heat and cold.

Proprioceptive sensitivity. Receptor mechanisms. Peculiarities of the structure of conductive pathways and central departments. Role in perception and evaluation of body position in space, in the formation of muscle tone, posture and movement.

Interoceptive sensitivity. Receptor mechanisms. Types of interoceptive sensitivity. Reactions of the human body to irritation of interoceptors. The role of interoception in the maintenance of homeostasis.

### **5.6. Pain sensitivity system**

Nociception. Classification of pain. Reception of pain stimuli. Peculiarities of structure and properties of conductive pathways and central departments. Central mechanisms of pain. Antinociceptive systems. Neurochemistry of antinociception. The concept of principles of pain management. Projective and reflected pain.



## **6. PHYSIOLOGY OF CIRCULATION**

### **6.1. Hemodynamics. Functional indices of blood circulation**

Basic laws of hemodynamics. Morphological and functional classification of blood vessels. The concept of systemic, organ and local blood flow. Factors causing blood flow through vessels. Volumetric and linear velocities of blood flow in different parts of the vascular bed; factors that determine them. Peripheral resistance to blood flow, its significance. Blood pressure, its types: arterial (systolic, diastolic, pulse, mean), venous pressure. The role of blood pressure; factors determining its value. Blood pressure in different parts of the vascular bed. Arterial pressure (BP) in different functional states of human body. The concept of normal values of BP, age-related changes in BP. Methods of measuring blood pressure. Arterial pulse, its origin and characteristics. Pulse wave propagation velocity, methods of measuring and registration. Blood flow in the venous vessels, venous return of blood. Blood pressure in the veins. Central venous pressure. Venous pulse, methods of measuring and registration.

Peculiarities of organ (regional) blood flow. Blood circulation in brain, myocardium, lungs and other organs, its regulation. Influence of nervous, hormonal, metabolic, myogenic mechanisms and factors secreted by endothelium on smooth muscle cells tone of vascular wall. The concept of methods of studying organ blood flow.

### **6.2. Microcirculation**

Microcirculation and the main physiological processes occurring at the level of the microcirculatory bed. Structural and functional characteristics of the main components of the microcirculatory system. Capillary blood flow and its peculiarities. Pre- and post-capillary resistance, blood pressure in capillaries of various organs. Transcapillary exchange of fluids and various substances between blood and tissues and its mechanisms. Starling's equation. Factors affecting the processes of microcirculation and transcapillary exchange (indices of hemodynamics, blood properties, state of vascular wall, lymph flow, properties of interstitial fluid). The concept of mechanisms of oxygen, nutrients and other substances delivery to cells from interstitial spaces and removal of carbon dioxide and other metabolites from cells.

Lymphatic system, its structure and functions. Lymph formation and lymph outflow, mechanisms of their regulation.

### **6.3. Physiological properties and characteristics of the myocardium**

The role and place of the circulatory system in the human body as a system that serves metabolic processes. Structural and functional characteristics of the circulatory system.

Physiological properties and characteristics of the heart muscle. Blood supply to the myocardium. Blood flow in coronary vessels in systole and diastole. Consumption of oxygen and nutrients by the heart at relative rest and during physical activity. The concept of determinants that determine myocardial oxygen consumption.

Structure, physiological properties and functions of the cardiac conductive system. Current understanding of the substrate, nature and gradient of automatism. Propagation of excitation through the cardiac conductive system. Interaction of the cardiac conductive system with typical cardiomyocytes. Excitation of contractile



cardiomyocytes and its mechanisms. Propagation of excitation in myocardium. Excitation-contraction coupling. Cardiomyocyte contraction, role of calcium ions. Structure, physiological properties and functions of contractile myocardium. Laws of cardiac contraction. Myocardial contractility and its indices.

Functions of the atria, ventricles and valves of the heart. Direction of blood flow. Connection of the systemic and pulmonary circles of the circulation.

#### **6.4. Cardiac cycle**

Structure of cardiac cycle, sequence of phases and periods. Position of valves, changes of pressure and blood volumes in heart chambers during different phases of cardiac cycle. The concept of preload and afterload. Comparative characteristics of pumping function of right and left ventricles. Systolic and minute volumes of blood flow at relative rest and at physical load. Methods of their determination. Ejection fraction, cardiac index. Cardiac performance. Reserves of the heart functioning and coronary blood flow, their realization during physical activity.

#### **6.5. Methods of the heart investigation**

External manifestations of cardiac activity. Electrical manifestations of cardiac activity. Electrocardiography (ECG). Formation of ECG components. General plan of analysis and criteria of ECG norm, its diagnostic value. The concept of extrasystole, ECG-signs of myocardial ischemia. Sound manifestations of cardiac activity. Heart sounds, their origin. Heart auscultation and phonocardiography, their diagnostic value. Mechanical manifestations of cardiac activity. The apex beat of the heart, arterial and venous pulse. Sphygmography and its diagnostic value. Ultrasound heart investigation (echocardiography). Invasive techniques of the heart examination. Polycardiography – timing of periods and phases of cardiac cycle, matching of electrical (ECG record), sound (phonocardiogram) and mechanical (sphygmogram) manifestations of cardiac activity.

Age-related changes in cardiac activity.

#### **6.6. Regulation of the heart function**

Regulation of heart functioning (intracardial and extracardial mechanisms). Regulated indexes of cardiac pumping function: heart rate, stroke volume, cardiac output (minute blood flow volume). Effector mechanisms of regulatory influences on cardiac function. Adaptation of cardiac activity to the needs of the human body.

#### **6.7. Regulation of circulation**

Regulation of blood circulation as a system of maintenance of metabolic processes of the human body. Regulated parameters of the circulatory system: cardiac activity, vascular tone, circulating volume of blood, its composition and properties.

Vascular tone and its nature. The regulation of vascular tone as one of the main mechanisms of maintaining blood pressure in the systemic and local blood flow. Reflex regulation of vascular tone. The vasomotor center: its afferent connections and efferent influences. Humoral regulation of vascular tone. Vasoconstricting and vasodilating endogenous substances. Mechanisms of fast and slow response regulation.

Local mechanisms of blood circulation regulation. The role of local metabolic factors in the regulation of arteriolar tone, factors secreted by vascular endotheliocytes (endothelin, nitric oxide, angiotensin II and others). Significance of gas-transmitter system (CO, NO, HS and others) in regulation of blood circulation and respiration.



Myogenic regulation of arteriolar tone.

Functional system that provides regulation of systemic arterial pressure. Physiological prerequisites of arterial pressure disturbances and theoretical basis for the correction of these disturbances. Age peculiarities of hemodynamics.

## **7. PHYSIOLOGY OF RESPIRATION**

### **7.1. Lung ventilation**

The role and place of the respiratory system in the human body as a system that serves metabolic processes. The main stages of respiration (external respiration, blood gas transport system, gas exchange, cellular respiration).

External respiration. Physiology of the respiratory airways. Regulation of their lumen. Significance of the airways ciliated epithelium. Respiratory cycle. Ventilation of the lungs, its unevenness in different parts. Elastic properties of the thorax. Surfactant. Pressure in pleural cavity, its role and change during breathing. Biomechanics of inspiration and expiration. Work of the respiratory muscles. Relationship between pulmonary blood flow, ventilation and gravity.

Indices of external respiration (vital capacity, minute lung ventilation, flow indices of external respiration, «flow-volume» curve) and their changes in obstructive and restrictive lung disorders, age-related changes. Spirometry, spirometry, peakflowmetry (pneumotachometry).

### **7.2. Gas exchange in the lungs and tissues**

Gas exchange in the lungs. Composition of atmospheric, expired and alveolar air. Partial pressure of oxygen and carbon dioxide in alveolar air and in blood. Relative constancy of alveolar air composition. Diffusion capacity of the lungs. Factors that influence the processes of oxygen and carbon dioxide diffusion between alveolar air and blood, blood and tissues.

Gas exchange between blood and tissues. Oxygen utilization coefficient of tissues at rest and during physical activity.

Cellular respiration. The concept of aerobic and anaerobic methods of energy production and their contribution to the metabolism of cells of different tissues depending on their functional state.

### **7.3. Transport of gases in blood**

Transport of gases by the blood. Binding of gases by hemoglobin. Mechanisms of regulation of oxygen-binding blood properties inside erythrocytes. Hemoglobin oxygen binding and oxyhemoglobin dissociation curve. Factors affecting hemoglobin affinity for oxygen and carbon dioxide. Oxygen capacity of the blood. Carbon dioxide transport. Indices that allow evaluation of blood oxygen saturation and carbon dioxide removal.

### **7.4. Regulation of respiration**

Respiration regulation as a way to meet the needs of cellular respiration and maintain blood gas constants ( $pO_2$ ,  $pCO_2$ , pH). Regulated indices of external respiration: respiration rate, depth of breathing (tidal volume). The respiratory center, its parts. Mechanisms providing respiratory periodicity. Receptors of the airways, lungs and respiratory muscles. Reflex reactions to their stimulation. Hering-Breuer reflexes. Receptors of pH,  $CO_2$  and  $O_2$  in the human body and their role.



Relationship between gas exchange and acid-base balance. Functional system of maintenance of relative constancy of partial pressure of gases in blood. Changes of external respiration indices under changes of pH and gas composition of blood. Relation between ventilation of alveoli and blood flow in the pulmonary circulation, mechanisms ensuring its constancy under changes in gas composition and blood pH. External respiration during muscular work, increased and decreased atmospheric pressure. Breathing and phonation. The first inspiration of a newborn. Hypoxia and its signs. Theoretical basis of various types of artificial respiration. Age-related changes in breathing.

### **7.5. Functional reserves of the hemocardiorespiratory system in gas exchange**

Interaction of respiratory, cardiovascular and blood systems in gas exchange. Their functional reserves in oxygen delivery. Indices of reserves of hemocardiorespiratory system: ECG indices, maximal oxygen consumption (MOC), oxygen debt, anaerobic threshold and others. Age-related changes in the reserves of the cardiovascular and respiratory systems.

## **8. PHYSIOLOGY OF DIGESTION**

### **8.1. General characteristics of the digestive system. Regulation of eating behavior**

General characteristics of the functional system of nutrition, the role and place in it of digestive processes. Nutritional motivations. Physiological mechanisms of hunger and satiety. Appetite. Modern concepts of the feeding centers. Role of neurohumoral factors, eating habits in regulation of feeding behavior.

Types of digestion depending on the features of hydrolysis and its localization. Digestive-transport conveyor system. Features of nervous and humoral regulation of various parts of the gastrointestinal tract. Experimental and clinical methods of investigating the functions of the gastrointestinal tract. The significance of I.P. Pavlov's works in the development of ideas about the functions and mechanisms of regulation of the secretory function of the digestive glands. Digestive and non-digestive functions of the gastrointestinal tract.

### **8.2. Digestion in the mouth and stomach**

Digestion in the oral cavity. Mechanical and chemical processing of food. Salivation, chewing, swallowing. Mechanisms of their regulation. The amount, composition and properties of saliva. The role of saliva in digestion.

Digestion in the stomach. The composition and properties of gastric juice. Formation and role of hydrochloric acid and mucus of gastric juice. Phases and mechanisms of regulation of gastric glands secretion on an empty stomach and after meals. Motor and evacuation functions of the stomach on an empty stomach and after a meal, their regulation.

### **8.3. The role of the liver and pancreas in digestion**

The role of the pancreas in digestion. Composition and properties of pancreatic juice. Mechanisms of regulation of pancreatic juice secretion on an empty stomach and after a meal. The role of the liver in digestion. Bile formation and bile secretion. The composition and properties of bile, its participation in the processes of digestion.



Mechanisms of regulation of bile formation and secretion on an empty stomach and after meals.

#### **8.4. Digestion in the small and large intestine**

Digestion in the duodenum, jejunum and ileum. The role of pancreatic juice and bile. Composition and properties of intestinal juice. Mechanisms of regulation of intestinal secretion. Luminal and membrane hydrolysis of nutrients. Motor function of the small intestine and its regulation.

Digestion in the large intestine. The importance for the human body of the microbiota of the large intestine. Motor activity of the large intestine. Defecation.

Absorption of hydrolysis products of food substances, water, electrolytes, vitamins in different parts of the digestive tract, its mechanisms. The conjunction of hydrolysis and absorption (digestive-transport conveyor). Regulation of absorption. Age features of digestion. Nervous, humoral and local mechanisms of regulation of digestive functions and their relationship in different parts of the gastrointestinal tract. The importance of blood flow in the gastrointestinal tract for its vital functions.

### **9. SUBSTANCE AND ENERGY METABOLISM. THERMOREGULATION**

#### **9.1. Substance and energy metabolism**

The concept of integral indices of metabolism and energy. The exchange of substances between the human body and the external environment as a basic condition of life. Characteristics of the processes of anabolism and catabolism, their relationship, the ratio of these processes in different conditions of life activity. The plastic role of metabolism. Essential substances for the human body. General concepts of fat, carbohydrate and protein metabolism. Nitrogen balance. Positive and negative nitrogen balance. The energy role of metabolism. Sources of energy.

Energy balance of the human body. Methods of determining the energy expenditure of the human body (direct and indirect calorimetry). Caloric value of nutrients. Caloric equivalent of oxygen. Respiratory quotient. Basal Metabolic Rate (BMR), the value and its determining factors. Energy expenditure of the human body under conditions of basal metabolism. The value of the BMR measurement. Energy expenditure of the human body under different types of labor activity (according to the degree of physical labor intensity). Specific dynamic (thermogenic) effect of food. Total energy expenditure of the human body.

#### **9.2. Nutrition. Regulation of body weight**

The principles of a healthy diet. The balance of energy intake and expenditure. The use of data on the body's energy expenditure and the human body's need for plastic substances to compose nutritional diets. The concept of the body weight norm. Overweight (obesity) and underweight. Excessive consumption of carbohydrates and fats as risk factors for diseases. Processes of deposition and use of deposited nutrients (glycogen depot in the liver and muscles, fat depot). Daily norms of consumption of fats, proteins, carbohydrates, the most important vitamins, microelements. Mechanisms of regulation of metabolism in the human body. Humoral mechanisms of body weight regulation (leptin, ghrelin, insulin, cholecystokinin, neuropeptide Y, orexins, dopamine, serotonin and others). Integration of metabolic processes. The concept of the peculiarities of metabolism in children. Peculiarities of nutrition in the



elderly and old age.

### 9.3. Thermoregulation

Role and place of thermoregulation as a system providing optimal conditions for metabolic processes. The importance of the temperature constancy of the human body internal environment for the normal course of the vital activity processes. The concept of homiothermy, poikilothermy and heterothermy. Human body temperature and its daily fluctuations. Temperature of different parts of the skin and internal organs. Thermometry.

Physical and chemical thermoregulation. Sources of heat production in the body. Regulation of heat production processes.

Heat loss of the body. Physical processes of heat loss. Physiological mechanisms of regulation of heat loss processes.

The functional system that maintains the temperature of the human body internal environment. Nervous and humoral mechanisms of thermoregulation. The role of peripheral and central receptors in thermoregulation processes. Age peculiarities of thermoregulation. Hyperthermia and fever. Protective role of fever. The concept of endo- and exopyrogens. Hypothermia.

## 10. PHYSIOLOGY OF EXCRETION

Role and place of excretion as a system serving metabolic processes. Organs of excretion (kidneys, skin, lungs, digestive tract). Their participation in the maintenance of the human body homeostasis.

Kidney. Excretory and non-excretory functions of the kidney. Nephron as a structural and functional unit of the kidney. Blood flow in the kidney, peculiarities of its regulation.

Basic processes of urine formation (glomerular filtration, tubular reabsorption and secretion). Mechanisms of glomerular filtration, composition of primary urine. Reabsorption in tubules and collecting tubes. Features and mechanisms of reabsorption of various substances. The countercurrent-multiplying system. Secretory processes in the tubules. Processes of synthesis in the kidney. Urine formation and urination. Final urine and its composition. The importance of quantitative and qualitative analysis of urine for evaluation of the state of human body functions.

Neurohumoral regulation of urine formation (filtration, reabsorption, secretion processes). Regulated parameters (renal hemodynamics; volumetric filtration rate; reabsorption of water, glucose,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{P}_i$ ,  $\text{H}^+$ ,  $\text{HCO}_3^-$ , urea and others). The role of the kidneys in the maintenance of acid-base balance, osmotic pressure, ionic composition of blood, blood volume, in the regulation of systemic blood flow, hematopoiesis, water-electrolyte balance. Indices of urinary system functions (frequency, volume of urination, nocturnal and daily diuresis). Urinary excretion regulation. Clinical and physiological methods of investigation of renal function. The concept of the consequences of kidney removal. The concept of an artificial kidney and blood dialysis. Physiological basis of the possibility of the transplanted kidney regulation. Age-related changes in urine formation and urine excretion.



## **11. INTEGRATIVE BRAIN ACTIVITY**

### **11.1. Innate and acquired forms of adaptive reactions of the human body to changing conditions of the environment**

Integrative functions of the brain that ensure the integrity of the human organism (integration of somatic, autonomic, endocrine functions). Levels of integration. Integrative functions of the brain that provide interaction of the human organism with the environment and adaptation of the human organism to the changing conditions of existence (behavioral and mental functions).

Innate forms of behavior (unconditioned reflexes and instincts), their importance for the adaptive activity of the human body.

The concept of higher nervous activity (I.P. Pavlov). Acquired forms of behavior. Importance of learning and neuronal memory in their formation. Types of learning. Conditioned reflex as a form of adaptation of animals and humans to changing conditions of existence. Classification of conditioned reflexes. Terms for the formation of conditioned reflexes. Mechanisms of formation of the temporary connection. Long-term potentiation. Mechanisms of facilitation of nerve impulse conduction through a synapse (E. Kandel). Dynamic stereotype.

Inhibition in higher nervous activity. Types of inhibition and its role. Modern understanding of the mechanisms of inhibition.

Memory, its types and mechanisms. The role of different parts of the brain in memorizing, storing and reproducing information. Reserves and ways to improve memory.

Types of higher nervous activity of animals and humans (I.P. Pavlov), their classification, characteristics, methods of determination. I.P. Pavlov's doctrine of the first and second signal systems.

### **11.2. Higher integrative functions of the brain as the physiological basis of human mental functions**

Higher mental functions of the brain. Neurophysiological basis of human mental functions (attention, perception, memory, motivations, emotions, thinking, consciousness, speech). Significance of functional state of CNS for realization of mental functions.

Parity in activity of the cerebral cortex, functional asymmetry of the human cerebral hemispheres and its role in realization of mental functions (speech, thinking and others). Functions of the associative cortex of the cerebral cortex. Functions of the frontal cortex areas.

Attention and its physiological mechanisms. The role of attention in the processes of memory and learning.

Sleep and wakefulness states. Modern understanding of the role and mechanisms of sleep. Somatic, autonomic and endocrine functions during sleep.

Emotions and their neurophysiological mechanisms. The role of needs and motivations in the formation of emotions. The role of emotional states. Behavioral, autonomic and endocrine manifestations of emotions. Emotional tension as a risk factor for health.

Thinking and speech, their neurophysiological mechanisms. The development of abstract thinking in humans. Functional asymmetry of the cerebral cortex related to the development of speech in humans.

Purposeful behavior, its systemic mechanisms (on the example of eating behavior). Architecture of integral behavioral act from the position of functional systems theory (P.K. Anokhin). Motivation and dominance, their neurophysiological mechanisms and role in goal-directed behavior.

The concept of the physiological bases of consciousness and their neurophysiological mechanisms. Medical criteria for assessing human consciousness.

Age-related changes in human higher nervous activity.



## ACADEMIC DISCIPLINE CURRICULAR CHART

Section , topic #	Section (topic) name	number of hours			Self-studies	Form of control
		lectures	supervised student work	practical		
	<b>3<sup>rd</sup> semester</b>					
<b>1.</b>	<b>Introduction. Homeostasis. The Internal Environment of the Human Body</b>	<b>2</b>	<b>1</b>	<b>16</b>	<b>12</b>	
1.1.	Introduction. The subject and tasks of Normal Physiology	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
1.2.	Homeostasis. Physical and chemical constants of blood	-	-	4	3	
1.3.	Physiological functions of Red Blood Cells. Hemopoiesis.	-	-	4	3	
1.4.	Erythrocytopoiesis. Physiological functions of platelets. Thrombopoiesis. Hemostasis system	-	-	4	3	
1.5.	Physiological functions of White Blood Cells. Leukopoiesis. Non-specific and specific resistance of the human body. Physiological evaluation of the complete blood count	-	-	4	3	
1.6.	Blood types. AB0, Rh and other systems. Physiological bases of blood matching for the transfusion. Blood substituting solutions	-	-	4	3	
	The subject and tasks of Normal Physiology. Homeostasis. Essential physical and chemical constants of blood	2	1	-	-	
<b>2.</b>	<b>Humoral Regulation of Physiological Functions</b>	<b>4</b>	<b>1</b>	<b>12</b>	<b>8</b>	
2.1.	Bases of information exchange of the cell with the environment. Chemical signaling. General physiology of endocrine system	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays;
2.2.		-	-	4	3	



2.3.	Special physiology of the endocrine system. Essential hormones, their mechanisms of action and effects	-	-	4	3	written accounts on classroom (home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
	Bases of information exchange of the cell with the environment. Chemical signaling. General physiology of endocrine system	2	0,5	-	-	
	Endocrine system. Essential hormones, their effects and mechanisms of action	2	0,5	-	-	
	Concluding lesson on the sections «Introduction. Homeostasis. The internal environment of the human body. Humoral regulation of physiological functions»	-	-	4	4	Colloquiums; electronic tests; final tests; control questioning
<b>3.</b>	<b>Physiology of Excitable Tissues</b>	<b>6</b>	<b>2</b>	<b>20</b>	<b>14</b>	
3.1.	Electrical signaling. Laws of excitable tissues. Biological potentials. Excitability changes during excitation.	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works;
3.3.	Excitation conduction by nerve fibers. Synaptic transmission	-	-	4	3	(home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
3.4.	Physiology of skeletal and smooth muscles	-	-	4	2	Colloquiums; electronic tests; final tests; control questioning
3.5.	General physiology of the central nervous system	-	-	4	2	
3.6.	Electrical signaling. Biological potentials. Conduction of excitation along the nerve fibers	2	0,5	-	-	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
	Synaptic transmission. Neuromuscular junction	2	0,5	-	-	Colloquiums; electronic tests; final tests; control questioning
	Skeletal muscle physiology	2	1	-	-	Colloquiums; electronic tests; final tests; control questioning
	Concluding lesson on «Physiology of excitable tissues»	-	-	4	4	
<b>4.</b>	<b>Nervous Regulation of Physiological Functions</b>	<b>2</b>	<b>1</b>	<b>12</b>	<b>8</b>	
4.1.	The role and functions of the spinal cord, medulla, midbrain, cerebellum and reticular formation	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works;
4.2.						
4.3.						
4.4.	The role and functions of the intermediate brain and forebrain. Systemic mechanisms of muscle tone and movement regulation	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works;
4.5.						
4.6.						
4.7.	Physiology of the Autonomic Nervous System	-	-	4	2	accounts on practical works; accounts on classroom (home)



							practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
	Physiology of the CNS. Physiology of the spinal cord and brainstem. Systemic mechanisms of muscle tone and movement regulation	2	1	-	-	-	Interviews; electronic tests; quizzes; tests, abstracts preparation
<b>5.</b>	<b>Physiology of Sensory Systems</b>	<b>4</b>	<b>1</b>	<b>12</b>	<b>8</b>		
5.1.	General physiology of sensory systems. Visual system	-	-	4	2		Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
5.3.	Physiology of auditory, vestibular, taste, olfactory and somatosensory systems	-	-	4	2		
5.4.							
5.5.							
5.6.	Physiology of visual sensory system	2	0.5	-	-		
	Physiology of auditory and vestibular systems	2	0.5	-	-		
	Concluding lesson on the sections «Special physiology of the Central Nervous System. Physiology of sensory systems»	-	-	4	4		Colloquiums; electronic tests; final tests; control questioning; conference reports; publication of articles, reports; applications for inventions and utility models; assessment on the basis of the modular rating system; credit
<b>6.</b>	<b>Physiology of Circulation</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>		
	Physiological properties and characteristics of the heart	2	-	-	-		Interviews; oral quizzes; tests, electronic tests; control questioning, essays



4th semester						
6.	Physiology of Circulation	4	2	20	18	
6.1.	Hemodynamics. Functional indices of blood circulation.	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom
6.2.	Microcirculation	-	-	4	3	(home) practical exercises; written accounts on practical works;
6.3.	Physiological properties and peculiarities of the heart muscle	-	-	4	4	accounts on classroom (home) practical exercises with their oral
6.4.	Cardiac cycle. Methods of the heart investigation	-	-	4	4	defense; accounts on practical works with their oral defense; electronic
6.5.	Regulation of the heart function	-	-	4	-	workshops; visual practical works
6.6.	Regulation of the circulation (regulation of the Arterial Blood Pressure)	-	-	4	-	
6.7.	Cardiac cycle. Methods of the heart investigation	2	1	-	-	
	Regulation of the heart function and circulation	2	1	-	-	
7.	<b>Physiology of Respiration</b>	6	2	20	14	
7.1.	Lung ventilation and basic types of its disorder. Lung ventilation indices	-	-	4	2	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom
7.2.	Gas exchange in the lungs and tissues. Transport of gases in blood	-	-	4	2	(home) practical exercises; written accounts on practical works;
7.3.	Regulation of respiration	-	-	4	3	accounts on classroom (home) practical exercises with their oral
7.4.	Functional reserves of the hemocardiorepiratory system in gas exchange	-	-	4	3	defense; accounts on practical works with their oral defense; electronic
7.5.	Respiration. Lung ventilation	2	0.5	-	-	workshops; visual practical works
	Gas exchange in the lungs and tissues. Transport of gases by blood	2	0.5	-	-	
	Regulation of respiration. Functional reserves of the hemocardiorepiratory system in gas exchange	2	1	-	-	
	Final lesson on the sections «Physiology of circulation. Physiology of respiration»	-	-	4	4	Colloquiums; electronic tests; final tests; control questioning
8.	<b>Physiology of Digestion</b>	4	1	8	6	
8.1.	General characteristics of digestion. Regulation of eating behavior. Digestion in the oral cavity and stomach	-	-	4	3	Interviews; oral quizzes; tests, electronic tests; control questioning;
8.2.		-	-	4	3	



8.3.	Digestion in the small and large intestine. The role of the pancreas and liver in digestion.	-	-	4	3	reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
8.4.	Physiology of digestion. Digestion in the oral cavity and stomach	2	0.5	-	-	
	Digestion in the small and large intestine. The role of the pancreas and liver in digestion	2	0.5	-	-	
<b>9.</b>	<b>Substance and Energy Metabolism. Thermoregulation</b>	<b>2</b>	<b>1</b>	<b>4</b>	<b>4</b>	
9.1.	Substance and energy metabolism. Principles of healthy nutrition. Thermoregulation	-	-	4	4	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works
9.2.	Thermoregulation	2	1	-	-	
9.3.						
<b>10.</b>	<b>Physiology of Excretion</b>	<b>2</b>	<b>1</b>	<b>8</b>	<b>6</b>	
10.	Physiology of excretion	2	1	4	2	Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom (home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works



									with their oral defense; electronic workshops; visual practical works
	The final lesson on the sections «Physiology of digestion. The metabolism of substances and energy. Thermoregulation. Excretion»	-	-	4	1	8	4	4	Colloquiums; electronic tests; final tests; control questioning
<b>11.</b>	<b>Integrative Brain Activity</b>	<b>4</b>	<b>1</b>	<b>8</b>	<b>6</b>				
11.1.	Innate and acquired adaptive reactions of the organism to changing environmental conditions	2	0,5	4	3				Interviews; oral quizzes; tests, electronic tests; control questioning; reports at practical classes; essays; written accounts on classroom
11.2.	Higher integrative functions of the brain as the physiological basis of human mental functions								(home) practical exercises; written accounts on practical works; accounts on classroom (home) practical exercises with their oral defense; accounts on practical works with their oral defense; electronic workshops; visual practical works; exam
		<b>42</b>	<b>14</b>	<b>140</b>	<b>106</b>				



## INFORMATION AND INSTRUCTIONAL UNIT

### LITERATURE

#### Basic:

1. Нормальная физиология : учебник = Normal Physiology : textbook / В. В. Зинчук [и другие] ; под редакцией В. В. Зинчука. – Минск : Вышэйшая школа, 2020. – 496 p.

#### Additional:

2. Hall, J. E. Guyton and Hall Textbook of Medical Physiology / J. E. Hall. – 13th ed., Elsevier Inc., 2015. – 1168 p.

3. Ganong's Review of Medical Physiology / K. E. Barret [at al.] –25th ed., McGraw-Hill Companies, 2016. – 726 p.

4. Fox, S. I. Human Physiology / S. I. Fox. – 14th ed. – New York : McGrawHill, 2016. – 832 p.

5. Северина, Т. Г. Физиология крови. Материалы лекций = Physiology of blood. Lecture notes : пособие / Т. Г. Северина. – Минск : БГМУ, 2014. – 51 p.

6. Constanzo, L. S. Physiology / L. S. Constanzo – 6th ed., Elsevier Inc., 2016. – 520 p.

7. Rhoades, R. A. Medical Physiology: Principles for Clinical Medicine / R. A. Rhoades, D. R. Bell. – 4th ed. – LWW, 2018. – 968 p.

8. Physiology : textbook / edited by V. M. Moroz, O. A. Shandra. – 2nd edition. – Vinnitsia: Nova Knyha, 2016. – 728 p.

### METHODOLOGICAL RECOMMENDATIONS FOR THE ORGANIZATION AND PERFORMANCE OF SUPERVISED STUDENT INDEPENDENT WORK IN THE ACADEMIC DISCIPLINE

Main forms of supervised student independent work:

- preparation and presentation of abstracts;
- presentation of reports and essays;
- studying topics and problems that have not been discussed at the lectures;
- taking notes of original sources (sections of anthologies, collections of documents, monographs, textbooks);
- computer (electronic) testing;
- preparation of tests for the organization of mutual assessment;
- preparation of didactic materials;
- participation in active forms of education.

Control of supervised student independent work is carried out in the form of:

- test paper;
- concluding class, colloquium in the form of an oral conversation, written work, testing;
- discussion of abstracts;

defense of educational assignments;  
 defense of the accounts (protocols) of the practical works;  
 evaluation of an oral answer to a question, report, or problem solving in a practical class;  
 checking up abstracts, written essays, and reports;  
 electronic tests;  
 individual interview.

### LIST OF AVAILABLE DIAGNOSTIC TOOLS

The following forms are used for competences assessment:

1. Oral form:  
 interviews;  
 oral quizzes;  
 colloquiums;  
 reports at practical classes;  
 conference reports.
2. Written form:  
 tests;  
 control questioning;  
 final tests;  
 written accounts on classroom (home) practical exercises;  
 written accounts on practical works;  
 essays;  
 article/report publications;  
 applications for inventions and utility models;  
 assessment based on a modular rating system.
3. Oral-written form:  
 accounts of classroom (home) practical exercises with their oral defense;  
 accounts of practical works with their oral defense;  
 credit;  
 examination;  
 assessment based on a modular rating system.
4. Technical form:  
 electronic tests;  
 electronic workshops (practicals);  
 visual practical work.

### LIST OF AVAILABLE TEACHING METHODS

Traditional method (lecture, practical classes);

Active (interactive) methods:

- Problem-Based Learning (PBL);
- Team-Based Learning (TBL);
- Case-Based Learning (CBL);
- Research-Based Learning (RBL);



training based on simulation technologies.

### LIST OF PRACTICAL SKILLS

1. Implementation of measures to prevent infection with viral hepatitis and human immunodeficiency virus during the investigation of blood and other biological materials. Technique of taking capillary blood.
2. Physiological evaluation of complete blood count indices obtained using manual and semi-automatic methods of counting (number of erythrocytes, hemoglobin, color index and erythrocytic indices, leukocyte count and leukocytic formula, platelet count, erythrocytes sedimentation rate according to Panchenkov's method).
3. Blood typing in AB0 and Rh systems using standard sera and monoclonal antibodies.
4. Physiological evaluation of electromyography results.
5. Dynamometry (manual and standing, ergometry) and physiological evaluation of the results.
6. Measurement of arterial pressure and physiological assessment of the results.
7. Assessment of arterial pulse properties by palpation and sphygmography and physiological evaluation of pulse indices.
8. Conducting electrocardiography. ECG analysis (calibration, rhythm, heart rate (heart excitations rate), waves, intervals, segments, complexes).
9. Physiological evaluation of phonocardiography results.
10. Physiological evaluation of polycardiography results (ECG, Phonocardiography, sphygmography).
11. Calculation and physiological estimation of pulse wave velocity.
12. Calculation of ejection fraction, physiological evaluation of cardiac pumping function parameters.
13. Calculation of filtration/reabsorption ratio in different parts of the vascular bed.
14. Conducting spirometry and spirometry. Calculation of proper values. Physiological evaluation of the obtained values.
15. Pneumotachometry (peakflowmetry). Calculation of proper values. Physiological evaluation of the values obtained.
16. Physiological evaluation of the flow-volume curve. Calculation of the Tiffeneau index and its physiological evaluation.
17. Determination of the strength of the respiratory muscles.
18. Calculation of blood oxygen capacity and oxygen utilization coefficient, and their physiological evaluation.
19. Pulse oximetry and physiological assessment of hemoglobin oxygen saturation curve.
20. Determination of functional reserves of the hemocardiorespiratory system according to cycle ergometry and ECG.
21. Conducting sialometry and physiological evaluation of the results.
22. Calculation of the proper values of the basal metabolic rate and the total energy expenditure of the body.

23. Determination of energy expenditure by indirect calorimetry with complete and incomplete gas analysis.
24. Determination of the respiratory quotient and its physiological evaluation.
25. Body mass evaluation. Calculation of body mass index. Physiological assessment of the obtained indices and the formation of evidence-based recommendations for the correction of body mass.
26. Compiling a diet based on the total metabolic rate of the body.
27. Measuring axillary body temperature using mercury (or similar) and electronic thermometers. Evaluation of possible performance errors. Physiological evaluation of the results.
28. Studying of basic tendon reflexes (knee, Achilles, etc.), physiological evaluation of the results.
29. Studying of pupillary reflexes. Physiological evaluation of the obtained indices.
30. Studying of the state of cerebellar functions. Physiological evaluation of the obtained indices.
31. Evaluation of EEG rhythms in different functional states of the CNS.
32. Assessment of functions of the visual sensory system (visual acuity, perimetry, campimetry, color vision examination).
33. Assessment of auditory sensory system functions (audiometry, Weber and Rinne experiments).
34. Assessment of vestibular system functions (studying of vestibular-autonomic reactions, determination of post-rotational nystagmus duration).
35. Determination of taste sensitivity thresholds.
36. Assessment of somatosensory system functions (examination of tactile, pain, temperature, proprioceptive sensitivity, esthesiometry).
37. Calculation of glomerular filtration rate by inulin (creatinine) clearance.
38. Physiological evaluation of the composition and properties of the final urine.
39. Assessment of tone and reactivity of sympathetic and parasympathetic divisions of ANS (clinostatic and orthostatic tests, cold test, study of Hering's respiratory-cardiac reflex, Dagnini-Ashner reflex and physiological evaluation of obtained indices).
40. Evaluation of endocrine system functions (measurement and evaluation of body height, body weight, temperature, basal metabolic rate, carbohydrate metabolism indices and others).
41. Evaluation of integrative functions of the brain (evaluation of indicators of attention and information processing speed according to the results of the correction test, evaluation of emotions manifestation, memory, functional asymmetry of the brain hemispheres, etc.).

#### **LIST OF EQUIPMENT USED**

1. Gas analyzer;
2. Antiseptics and disinfectants;
3. Audiometer (sound generator);



4. Biological material of the experimental animal (rats) – blood, blood plasma, intestines;
5. Bicycle ergometer;
6. Floor scales;
7. Sali's hemometer kit;
8. Glucometer;
9. Laboratory dynamometer;
10. Hand dynamometer;
11. Dynamometer for back muscles strength measurement;
12. Nose clip;
13. Ionometer (pH-meter);
14. Alveolar air collection chamber;
15. Capillaroscope (with video adapter);
16. Barani's chair;
17. Couch;
18. Lancet device;
19. Ruler;
20. Magnifying glass;
21. Gauze, absorbent cotton;
22. Microscope;
23. Donders model;
24. Neurological mallet with needle and brush;
25. Body composition monitor;
26. A set of weights 0.5-3 kg;
27. Set of containers for disinfection of biological materials and equipment, small (100-300 ml) and large (1-5 liters);
28. A set of tuning forks;
29. A set of laboratory utensils and equipment (graduated and non-graduated test tubes, flasks, vials, pipettes, burettes, funnels; tripods, rubber and friction glass stoppers, beakers, glassograph, cotton, tweezers, round glass sticks, glass sticks with spatula, dissecting needle, surgical scissors, eye scissors, glass tubes, rubber tubes; litmus paper);
30. Monoclonal reagent kit for determination of AB0 and Rh blood groups;
31. Set of disposable mouthpieces, masks, connecting hoses for spirometry and pneumotachometry;
32. Set of standard sera for blood typing in AB0 system and reagent for blood typing in Rh system;
33. Chemicals kits (distilled water, NaCl, sodium bicarbonate, glucose, ammonia, hydrochloric acid, Lugol or iodine solution, Ringer's solution, hydrogen peroxide, sodium glutamate, quinine or benzalkonium chloride, citric acid, acetic acid, sodium citrate or EDTA, methylene blue, ionometer calibration buffer set, saccharin; egg white or fibrin, gastric juice; starch; bile; vegetable oil);
34. Electrocardiogram, phonocardiogram, polycardiogram, electroencephalogram sets;
35. Headphones;

36. Nomograms (DuBois to determine the surface area of the body; to determine the minute volume of respiration; to determine the proper values of indicators of human physical development);
37. Objects of different colors for perimetry;
38. Oxyhemograph;
39. Osmometer;
40. Oscilloscope;
41. Forster's Perimeter;
42. Personal computer;
43. Blood typing plates;
44. Pneumotachograph;
45. Pneumotachometer (peakflowmeter);
46. Rabkin or Ishihara polychromatic tables;
47. Watch slides, flat slides, slides with Goriaev grid, cover slides.
48. Panchenkov's device with Panchenkov capillaries;
49. Projector;
50. Pulse oximeter;
51. Pulse oximeter wrist gauge;
52. Height meter;
53. Measuring tape for 5 m;
54. Sanitary and hygienic clothing (rubber gloves, masks, goggles or face shield, waterproof apron and armbands);
55. Stopwatch;
56. Sterile scarifiers (lancets) disposable;
57. Leukocyte mixer;
58. Erythrocyte mixer;
59. Spirograph automatic;
60. Water spirometer;
61. Dry-air spirometer;
62. Spirit stove;
63. Harris-Benedict tables;
64. Tables for determination of visual acuity (Golovin, Sivtsev, Orlova) with standard light;
65. Standard correction tables;
66. Tables with numeric and letter complexes;
67. TV set;
68. Medical mercury-free thermometer;
69. Water thermometer (0-50° C);
70. Infrared thermometer with the ability to determine body temperature and surface temperature;
71. Electronic thermometer;
72. Thermostat or water bath;
73. Test strips for general urinalysis;
74. Tonometer automatic;
75. Tonometer mechanical with phonendoscope;



76. Pointer;
77. Biopotential amplifier;
78. Filter paper;
79. Neurological flashlight;
80. Phonendoscope with tubes of different lengths;
81. Hourglass for 5 min;
82. Standard cap for EEG recording;
83. Eye shield;
84. Electrodes (push-button metal; plate metal; disposable surface electrodes; crocodile type; bridge electrodes for EEG recording);
85. Electrocardiographer;
86. Electromyographer;
87. Electromyoreflexometer;
88. Electrical conductive paste;
89. Electroencephalographer;
90. Esthesiometer (Weber's compass).

### LIST OF LECTURES

#### 3<sup>rd</sup> semester

1. The subject and tasks of Normal Physiology. Homeostasis. Essential physical and chemical constants of blood.
2. Bases of information exchange of the cell with the environment. Chemical signaling. General physiology of the endocrine system.
3. Endocrine system. Essential hormones, their effects and mechanisms of action.
4. Electrical signaling. Biological potentials. Conduction of excitation along the nerve fibers.
5. Synaptic transmission. Neuromuscular junction.
6. Skeletal muscle physiology.
7. Physiology of the CNS. Physiology of the spinal cord and brainstem. Systemic mechanisms of muscle tone and movement regulation.
8. Physiology of the visual sensory system.
9. Physiology of the auditory and vestibular sensory systems.
10. Physiological properties and characteristics of the heart.

#### 4<sup>th</sup> semester

11. Cardiac cycle. Methods of the heart investigation.
12. Regulation of the heart function and circulation.
13. Respiration. Lung ventilation.
14. Gas exchange in the lungs and tissues. Transport of gases in blood.
15. Regulation of respiration. Functional reserves of the hemocardiorespiratory system in gas exchange.
16. Physiology of digestion. Digestion in the oral cavity and stomach.
17. Digestion in the small and large intestine. The role of the pancreas and liver in digestion.

18. Thermoregulation.
19. Physiology of excretion.
20. Innate and acquired forms of adaptive reactions of the human body to changing environmental conditions.
21. Higher integrative functions of the brain as the physiological basis of human mental functions.

### LIST OF PRACTICAL CLASSES

#### 3<sup>rd</sup> semester

- Lesson 1. Introduction. The subject and tasks of Normal Physiology. Homeostasis. Physical and chemical properties of blood.  
 Practical work:  
 Hemolysis and its types;  
 Determination of blood plasma osmotic pressure by cryoscopic method;
- Lesson 2. Physiological functions of Red Blood Cells and platelets. Erythropoiesis. Thrombocytopoiesis. Hemostasis  
 Practical work:  
 Technique of taking capillary blood;  
 Counting Red Blood Cells in a counting chamber under a microscope;  
 Determination of the amount of hemoglobin by Sali's method;  
 Calculation of Color Index and other indices of Red Blood Cells;  
 Determination and physiological assessment of primary hemostasis indices.
- Lesson 3. Physiological functions of White Blood Cells. Leukopoiesis. Non-specific and specific resistance of the human body. Physiological evaluation of the results of the complete blood count.  
 Practical work:  
 Counting White Blood Cells in a counting chamber under a microscope;  
 Calculation of the percentage of White Blood Cells different types in a blood smear (leukocyte formula);  
 Determination of Erythrocytes Sedimentation Rate by Panchenkov's method;  
 Physiological evaluation of the complete blood count test.
- Lesson 4. Blood types. AB0 system. Rhesus (Rh) and other systems. Physiological bases of blood matching for the transfusion. Blood substituting solutions.  
 Practical work:  
 Blood typing in AB0 system using standard sera;  
 Blood typing in Rhesus system;  
 Blood typing in ABO and Rh systems using monoclonal sera (reagents).
- Lesson 5. Bases of information exchange of the cell with the environment. Chemical signaling. General physiology of endocrine system.  
 Practical work:  
 Studying the receptor mechanism of the effect of adrenalin on the heart rate;  
 Human height evaluation.
- Lesson 6. Special physiology of the endocrine system. Essential hormones, their mechanisms of action and effects.



Practical work:

Studying the mechanisms of peripheral endocrine gland hormones regulation and their negative feedback influence on hypothalamic and pituitary hormones.

Lesson 7. Concluding lesson on the sections «Introduction. Homeostasis. The internal environment of the human body. Humoral regulation of physiological functions».

Lesson 8. Electrical signaling. Laws of excitable tissues. Biological potentials. Excitability changes during excitation.

Practical work:

The effect of Na ions<sup>+</sup> and K<sup>+</sup> on resting membrane potential and action potential; Studying the resting membrane potential, types of its changes and their effect on membrane excitability;

Studying the action membrane potential mechanisms.

Lesson 9. Excitation conduction by nerve fibers. Synaptic transmission.

Practical work:

Demonstration of local anesthetics effect development depending on the duration of action;

Comparison of the structure of central (interneuronal) synapse and peripheral synapse (neuromuscular junction).

Lesson 10. Physiology of skeletal and smooth muscles.

Practical work:

Dynamometry of hands and back muscles.

Lesson 11. General physiology of the central nervous system. The role and functions of the nervous system and its structural elements. Inhibition in CNS. General principles of CNS activity coordination.

Practical work:

Studying of knee and Achilles reflexes;

Determination of the Achilles reflex time;

Electromyography;

Studying of reciprocal inhibition of motor acts by electromyography.

Lesson 12. Concluding lesson on the section «General physiology of excitable tissues».

Lesson 13. The role and functions of the spinal cord, medulla, midbrain, cerebellum and reticular formation.

Practical work:

Professional vocabulary and basic concepts;

Studying of some tendon reflexes in humans (mandibular, upper limb flexor and extensor reflexes);

Studying of pupillary reflexes;

Studying of tactile sensitivity in humans;

Studying of the muscle-joint sensation (kinesthesia);

Studying of cerebellum functions.

Lesson 14. The role and functions of the thalamus, hypothalamus, basal nuclei, limbic system and brain cortex. Systemic mechanisms of muscle tone and movements regulation.

Practical work:

Electroencephalography;

Lesson 15. Physiology of the Autonomic Nervous System.

Practical work:

Clinostatic reflex;

Orthostatic reflex;

Hering's respiratory-cardiac reflex;

Assessment of neurotransmitter mechanisms of the effect of sympathetic and parasympathetic parts of the ANS on the heart functioning.

Lesson 16. General physiology of sensory systems. Visual system.

Practical work:

Evaluation of visual acuity;

Studying of color vision;

Determination of visual field bounds (perimetry);

Determination of retina's central regions sensitivity of the (campimetry);

Evaluation of the simple sensorimotor reaction velocity.

Lesson 17. Physiology of auditory, vestibular, taste, olfactory and somatosensory systems.

Practical work:

Studying of some mechanisms of the sound source direction determination;

Studying of bone and air conduction;

Studying the dependence of auditory sensitivity on sound frequency (audiometry);

Studying of tactile sensitivity. Esthesiometry (measurement of spatial thresholds);

Studying of functional state of the vestibular system;

Study of taste sensitivity.

Lesson 18. Concluding lesson on the sections «Special physiology of the Central Nervous System. Physiology of sensory systems» (the end-of-term lesson).

**4<sup>th</sup> semester**

Lesson 19. Hemodynamics. Functional indices of blood circulation. Microcirculation.

Practical work:

Studying of the arterial pulse properties by palpation;

Arterial blood pressure measurement of by Korotkoff's auscultatory method;

Pulse assessment by sphygmogram analysis;

Studying of blood flow in the vessels of the microcirculatory bed using video (microcirculation).

Lesson 20. Physiological properties and peculiarities of the heart muscle.

Practical work:

Heart automaticity and various factors affecting it;

Studying of the mechanisms of action potentials (AP) generation by pacemaker cells (sinoatrial node) and ventricular contractile myocardium cells.

Lesson 21. Cardiac cycle. Methods of the heart investigation.

Practical work:

Recording of ECG and its analysis;

Registration and analysis of phonocardiogram (recorded synchronously with ECG);



- Studying the basics of ultrasound examination of the heart (echocardiography).
- Lesson 22. Regulation of the heart function.
- Practical work:
- Oculocardiac reflex (Dagnini–Aschner reflex);
  - Orthostatic reflex;
  - Effect of some substances on the function of a frog's isolated heart;
  - Effect of parasympathetic and sympathetic parts of the autonomic nervous system on heart function.
- Lesson 23. Regulation of circulation (regulation of the Arterial Blood Pressure).
- Practical work:
- Orthostatic test;
  - Analysis of receptor and ion mechanisms of blood pressure and heart function regulation.
- Lesson 24. Lung ventilation and basic types of its disorder. Lung ventilation indices.
- Practical work:
- Spirometry;
  - Spirography;
  - Pneumotachometry (peakflowmetry);
  - Studying of lung ventilation indices using an automatic spirometer. Analysis of «flow-volume» curve.
- Lesson 25. Gas exchange in the lungs and tissues. Transport of gases by blood.
- Practical work:
- Determination of alveolar and expired air content. Calculation of functional dead space volume;
  - Oxyhemometry, oxyhemography, pulse oximetry;
  - Modeling of ventilation and blood flow mismatch in the lungs, its effect on respiration and gas exchange.
- Lesson 26. Regulation of respiration.
- Practical work:
- Testing the strength of the respiratory muscles;
  - Effect of CO<sub>2</sub> content in alveolar air on external respiration;
  - Chemoreceptors and other receptors influence on lung ventilation.
- Lesson 27. Functional reserves of the hemocardiorespiratory system in gas exchange.
- Practical work:
- Test of a 6-minute walk;
  - Test PWC<sub>170</sub> (bicycle ergometry)
  - Revealing the hierarchy of homeostatic indices of respiration and circulation;
  - Calculation of maximal oxygen consumption using maximal oxygen pulse and calculated maximal heart rate.
- Lesson 28. Concluding lesson on the sections «Physiology of circulation and respiration».
- Lesson 29. General characteristics of digestion. Regulation of eating behavior.
- Digestion in the oral cavity and stomach.
- Practical work:
- Digestion of starch by human saliva enzymes;

Studying of the enzymatic properties of gastric juice.

Lesson 30. Digestion in the small and large intestine. The role of the pancreas and liver in digestion.

Practical work:

The effect of bile on fats;

Parietal digestion;

Amylase activity of blood plasma;

Evaluation of body mass.

Lesson 31. Energy balance and metabolism. Principles of healthy nutrition.

Thermoregulation

Practical work:

Calculation of the Basal Metabolic Rate due values by tables and formulas;

Measurement of the metabolic rate using method of the indirect calorimetry by gas analysis;

Measurement of the axillary body temperature;

Studying of the role of blood circulation in heat transfer process in the superficial tissues using the method of color thermography.

Lesson 32. Physiology of excretion.

Practical work:

Performing a common urine analysis using the express method;

Studying of some renal functions on a model.

Lesson 33. Concluding lesson on the sections «Physiology of digestion. Substance and energy metabolism. Thermoregulation. Excretion»

Lesson 34. Innate and acquired adaptive reactions of the organism to changing environmental conditions.

Practical work:

Assessment of the associative memory volume;

Evaluation of a short-term auditory memory volume using letter and digit complexes in the human.

Lesson 35. Higher integrative functions of the brain as the physiological basis of human mental functions.

Practical work:

Identification of hemispheres functional asymmetry;

Assessment of attention indices using a correction test.



## SAMPLES OF ABSTRACT TOPICS

1. Electrophysiological activity of the brain in different states.
2. Development of student scientific work at the Department of Normal Physiology. Anniversary dates.
3. Electrophysiological activity of the brain in extra- and intraverts.
4. Physiological basis of regeneration of nerve fibers and other tissues.
5. Functional organization of the basal nuclei of the brain.
6. The role of calcium potentials of the cerebellum.
7. Age-related changes in the organ of vision.
8. Basics of nonspecific and specific immunity.
9. Leukocyte formula in children and adults.
10. The blood aggregate state regulation system, its components and functions.
11. Anti-coagulation and fibrinolytic systems.
12. Apoptosis. A review of the physiological mechanisms of cell death.
13. Current understanding of the mechanisms of cardiac automaticity.
14. Physiological role of HCN channels.
15. Central regulation of cardiac activity.
16. Blood flow in coronary and cerebral vessels and peculiarities of its regulation.
17. Renin-angiotensin-aldosterone and kallikrein-kinin systems.
18. Modern methods of investigation of cardiovascular system functions.
19. Circulatory system in the fetus and newborn.
20. Mechanisms that ensure the patency of the upper airways.
21. Reflex influences from the receptors of the nose, pharynx and mouth on respiration.
22. The effect of gravity on blood flow.
23. Mechanisms of regulation of O<sub>2</sub> and CO<sub>2</sub> transport.
24. Breathing under special conditions (hypo- and hyperbaric).
25. Physiological basis of a decompression sickness.
26. The role of aquaporins in physiological functions.
27. Regulation of body mass.
28. Mechanisms of regulation of energy metabolism in children and adults.
29. Principles of healthy diets. The basics of diet therapy.
30. Nervous and hormonal mechanisms of the general adaptation syndrome.
31. Physiological mechanisms of alcohol and other addictions formation.
32. Current state of alcohol and other addictions control in the Republic of Belarus and in the world. Physiological basis of addiction prevention.
33. Current state of tobacco addiction control in the Republic of Belarus and in the world. Changes of physiological functions in tobacco smoking.
34. Sleep and its disorders.
35. Mental and physical performance. Fatigue and its prevention.
36. Epiphysis hormones and their role in the regulation of physiological functions of the body.

37. Participation of calcium ( $\text{Ca}^{2+}$ ) and phosphates ( $\text{P}_i$ ) ions in the maintenance of the functional state of bone tissue.
38. The importance of vitamin  $\text{D}_3$ , physical activity and other factors for bone formation in children and adults.
39. Nobel Prize in Physiology or Medicine. A review of the most important scientific achievements.
40. Reviews of scientific literature in the field of physiology.



**PROTOCOL OF THE CURRICULUM APPROVAL  
BY OTHER DEPARTMENTS**

Title of the discipline requiring approval	Department	Amendments to the curriculum in the academic discipline	Decision of the department that designed the curriculum (date, protocol # )
1. Psychology of Interpersonal Relationships	Psychiatry and Medical Psychology	There are no offers	Take into account 31.05.2022, protocol # 13
2. General Surgery	General Surgery	There are no offers	Take into account 31.05.2022, protocol # 13
3. Physical Education	Physical Education and Sports	There are no offers	Take into account 31.05.2022, protocol # 13
4. General Hygiene	General Hygiene	There are no offers	Take into account 31.05.2022, protocol # 13
5. Radiation Medicine and Ecology	Radiation Medicine and Ecology	There are no offers	Take into account 31.05.2022, protocol # 13
6. Pathological Physiology	Pathological Physiology	There are no offers	Take into account 31.05.2022, protocol # 13
7. Pharmacology	Pharmacology	There are no offers	Take into account 31.05.2022, protocol # 13
8. Propaedeutics of Internal Diseases	Propaedeutics of Internal Diseases	There are no offers	Take into account 31.05.2022, protocol # 13

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T.G.Severina

Curriculum content, composition and the accompanying documents comply with the established requirements.

Dean of the Medical Faculty for International Students of the educational institution «Belarusian State Medical University»

28.06. 2022

O.S.Ishutin


Methodologist of the educational institution «Belarusian State Medical University»


28.06. 2022


S.V.Zaturanova




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