

## COURSE OF NORMAL PHYSIOLOGY

The course of Normal Physiology is intended for students of a medical specialty studying in English. This course based on international and Russian scientific resources and helps understand the fundamental principles of functioning of the human body. The course includes 10 themes, each theme discusses functioning processes from the level of individual cells to the level on the entire system of organs.

During this course students will improve their skills that facilitate understanding the processes of functioning of healthy human body, study the laboratory techniques and practice to make a proper experiment reports with discussion and conclusion, learn to think critically and participate in scientific discussion.

Each main topic consists of laboratory classes and seminars.

Laboratory classes contain laboratory experiments which have to be submitted as handwritten laboratory reports. Seminars are performed as oral discussion of given questions.

Semester scores:

20 points for lab reports.

20 points for seminars

10 points for control works on lectures or practical classes.

1 <sup>st</sup> semester (2 <sup>nd</sup> year of study)
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<p><b>Lecture (4 hours):</b> The structure of the cell membrane of excitable cells. Excitability. The membrane potential. Parameters of excitability. The action potential, ionic mechanisms of its occurrence. The analysis of phases of the action potential. Refractory period, its phases. Chemical and electrical synapses. The structure of myofibrils as a functional unit of the muscle fiber. The mechanism of muscle contraction in striated muscle sarcomere.</p>
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<p><b>Practical class 1.</b> Physiology of excitable tissues. Laboratory experiments.</p>
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<p><b>Practical class 2.</b> Physiology of excitable tissues. Laboratory experiments:</p>
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<p><b>Practical class 3.</b> Seminar of physiology of excitable tissues.</p>
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<p><b>Practical class 4.</b> Lab reports submissions.</p>
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<b>Section 2. Physiology of central nervous system</b>
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<p><b>Lecture (4 hours):</b> Reflex as a general principle of regulation of body functions. The reflex arc</p>
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and its components. Spinal cord. Motor function of the spinal cord. Monosynaptic and polysynaptic reflexes. Motor function of the brain stem. Static and statokinetic reflexes. The cerebellum and its basic functions. Reticular formation, its structure and function of neural organization. Thalamus as a collector of sensitive information. Hypothalamus and its functions. The value of the basal ganglia in the coordination of motor activity as an intermediary between associative and motor areas of the cortex. Motor areas of the cerebral cortex. The role of the pyramidal and extra pyramidal pathways in the organization of locomotion. The limbic system, its structure, and its basic physiological functions. The cerebral cortex of the brain, its structure. Sympathetic and parasympathetic divisions of the autonomic nervous system.

**Practical class 5.** Physiology of central nervous system. Laboratory experiments.

**Practical class 6** Physiology of central nervous system. Laboratory experiments.

**Practical class 7.** Seminar of physiology of central nervous system.

**Practical class 8.** Lab reports submissions.

**Lecture (2 hours)** The subject of physiology of cognitive functions, relationship with psychology. Contribution of works of I.M. Sechenov and I.P. Pavlov to the physiology of cognitive functions. Basic principles of the reflex theory. General characteristics of the conditioned reflex. Neurophysiological features of the memory. Short-term memory organization. Structural and functional basis of learning and memory.

**Lesson 9.** Physiology of cognitive functions. Laboratory experiments.

**Lesson 10.** Seminar of physiology of cognitive functions.

**Lesson 11.** Lab reports submissions.

#### Section 4. **Physiology of sensory system**

**Lecture (4 hours):** The concept of sensation. General properties of receptors. Classification of receptors and their types. Classification of the sensory receptors. Primarily and secondary-sensory receptor cells. The mechanism of the receptors excitation. The receptor potential. Adaptation of the receptors. The optical system of the eye. Refractive abnormalities of the eye (nearsightedness, farsightedness, astigmatism). The structure of the retina. Photoreceptors. Blind Spot. Photochemical reactions in the receptors of the retina. Electrical phenomena in the retina and optic nerve. Receptive fields of neurons. Electroretinogram. Processing of visual information in the thalamus. The transformation of the visual sensory stimulation in the thalamus. Analysis of visual sensory stimulation of the visual cortex neurons.

**Lecture (4 hours):** Structure and function of the outer, middle and inner ear. The organ of Corti, its structure and mechanism of excitation. The perception of sounds of different frequencies. The mechanism of genesis of receptor potential in the hair cells of the spiral ganglion. The vestibular system. The central part of the vestibular system. Olfactory and taste systems. The sensitivity of the receptors to different kinds of taste stimuli. Central processing of gustatory and olfactory information. Somato-visceral sensitivity. Cutaneous mechanoreceptors, their classification, histology, functional significance. Afferent innervation of the skin, the receptor field. Proprioception and its quality. Thermoreception. Static and dynamic senses. Nociception. Neurophysiological basis of pain: the theory of pain perception

**Lesson 12.** Physiology of sensory system. Laboratory experiments. Visual and auditory perception.

**Lesson 13.** Seminar of physiology of visual and auditory perception.

**Lesson 14.** Physiology of sensory system. Laboratory experiments. Gustatory and olfactory system. Somatosensory system

**Lesson 15** Seminar of physiology of gustatory, olfactory and somatosensory systems.

**Lesson 16.** Lab reports submissions.

**Lesson17.** Test preparation and consultation

**I semester's test**

**2<sup>nd</sup> semester (2<sup>nd</sup> year of study)**

**Physiology of blood**

**Lectures (2 hours):** Physico-chemical characteristics of blood, the blood buffer systems. The concept of osmotic pressure. Composition and functions of plasma. Red blood cells (RBC, Erythrocytes). Hemoglobin. Hemoglobin function and structure. Iron Metabolism. Structure and types of White Blood Cells (leukocytes). Genesis of the White Blood Cells. Inflammation: Role of Neutrophils and Macrophages. Non-specific (innate) immunity: humoral and cellular. Specific (acquired) immunity. Lymphocytes, their types. Role in cellular and humoral immunity. Hemostasis and Blood Coagulation. Blood groups. ABO system.

**Lesson 1.** Physiology of blood. Laboratory experiments.

**Lesson 2.** Seminar of physiology of blood. Lab reports submissions.

**Lectures (4 hours):** The structure of the human heart. The role of the heart in the circulatory system. Physiological parameters of the heart. Cardiac cycle, characteristics of different phases of the cardiac cycle and their duration. The typical and atypical (modified, pacemaker) cardiomyocytes. Autorhythmicity of the heart. Ionic mechanisms of the origin of the action potential in pacemakers. HCN-channels and its role in the generation of pacemaker potentials. Morphological and physiological characteristics of the typical cardiomyocytes. Analysis of action potential phases. The velocity of conduction of excitation in different parts of the heart. Atrioventricular delay and its role in the cardiac cycle. Refractory period of the heart muscle, its phases. Excitation-contraction coupling in the heart muscle. The nature of the effects of the vagus nerves (chrono-, ino-, and dromotropic) on cardiac function. The nature of the action of the sympathetic nerves and their mediators on the parameters of the heart muscle contraction. Intracardiac mechanisms of regulation of cardiac activity, associated with the physiological characteristics of the heart. Extracardiac reflex mechanisms of regulation of the heart activity. The role of the centers of the medulla oblongata and the hypothalamus in the regulation of the heart work. Humoral regulation of cardiac activity. The mechanism of action of the hormones and metabolic factors in the cardiomyocytes.

**Lectures (2 hours):** Morpho-functional classification of the blood vessels. The main hemodynamic parameters (pressure, flow and resistance). Blood pressure, its magnitude in different areas of the vascular bed. Factors determining the blood pressure value. Regular

fluctuations in blood pressure (1,2,3 order of waves), the mechanism of their occurrence. Characteristics of systolic, diastolic, and pulse pressure. The concept of average pressure. Venous pressure, its characteristics. Features of the movement of blood through the veins. Factors that ensure venous return of blood to the heart. Microcirculatory bed. Classification of capillaries. The regulation of capillary blood flow. The lymphatic system. Mechanism of lymph formation. The composition of the lymph. The role of the lymph nodes. Regulation of lymph circulation.

Vasomotor center, its departments. Vasoconstrictor innervation. Tonus of vasoconstrictor nerves. Neurogenic and myogenic components of the vascular tone, their nature. The mechanism of the effect of the sympathetic neurotransmitters to the vascular smooth muscle cells. The role of the vasoconstrictor center in regulation of blood pressure and redistribution reactions in the vascular system. Vasodilator innervation, its types.

**Lesson 3.** Physiology of Cardiovascular system. Laboratory experiments.

**Lesson 4.** Physiology of Cardiovascular system. Laboratory experiments.

**Lesson 5.** Physiology of Cardiovascular system. Laboratory experiments.

**Lesson 6** Seminar of physiology of cardiovascular system.

**Lesson 7.** Lab reports submissions.

### **Physiology of Respiration**

**Lectures (4 hours):** The exchange of gases between the lungs and the blood. Tissue gas exchange, dissolving gases in the plasma and formed elements, the transport of O<sub>2</sub> and CO<sub>2</sub>. External respiration. Mechanics of inspiration and expiration. The pleural space, its significance. The negative pressure in the pleural cavity, its causes. Changes of the pleural pressure during inhaling and exhaling. Pulmonary and alveolar ventilation. The anatomical and alveolar dead space. Pulmonary volumes and capacities: respiratory capacity, reserve volume of inhalation and exhalation, the vital lung capacity, residual volume, respiratory rate, minute respiratory volume at rest and during exercise. Methods for determination of respiratory volumes. Transport of carbon dioxide in the blood. Transport of carbon dioxide in solution. The pressure of carbon dioxide in arterial and venous blood. Regulation of respiration. The role of the peripheral and central chemoreceptors in the regulation of respiration. Effects of hypoxemia and hypercapnia on breathing. The role of the vagus nerve. Respiratory center, its location. Inspiratory and expiratory neurons. Pneumotaxic center. The role of the pons as a regulator of the duration of inhalation and exhalation acts.

The role of the hypothalamus, limbic system, cerebral cortex in the regulation of respiration.

Conditioned reflex and the voluntary regulation of breathing.

**Lesson 8.** Physiology of respiration. Laboratory experiments.

**Lesson 9.** Seminar of physiology of respiration.

**Lesson 10** Lab reports submissions.

### **Physiology of digestion. Metabolism and Thermoregulation**

**Lectures (2 hours):** The main functions of the digestive system. Types of digestion. Digestion in the mouth. Digestion in the stomach. Gastric glands. The amount and composition of the gastric juice. Phases of gastric secretion, their characteristics. Humoral regulation of gastric secretion (acetylcholine, histamine, gastrin, secretin). Enterogastric reflex. Digestion in the duodenum. Pancreatic juice, its quantity, and composition. The physiology of the liver. Bile Formation, its quantity, and composition. Digestion in the small intestine. Digestion of proteins in different parts of the gastrointestinal tract. Digestion of carbohydrates. The digestion and absorption of fats. The mechanisms of absorption. The role of the bile acids. Conversion of fat in enterocytes. Absorption of vitamins, water, minerals, and microelements in the digestive tract. Gastric motility. Regulation of intestinal motor function by sympathetic and parasympathetic nerves. The role of the intramural nerve plexus. The motor function of the colon and its features. The act of defecation.

**Lectures (2 hours):** The metabolism, concept of anabolism and catabolism. Methods for determining basal metabolic rate. Direct and indirect calorimetry. "Surface law" of metabolic rate by Rubner. Energy consumption for different types of physical and mental labor. Work exchange. Work exchange for persons engaged in various activities. Normal food intake. Caloric value of nutrients. The digestibility of the food. Human body temperature, its daily fluctuations. Chemical and physical thermoregulation. Mechanisms of maintenance of a constant internal environment of the body temperature. Thermoregulatory centers.

**Lesson 11.** Physiology of digestion. Laboratory experiments:

**Lesson 12.** Physiology of metabolism and thermoregulation. Laboratory experiments.

**Lesson 13** Seminar of physiology of digestion. Lab reports submissions.

**Lesson 14.** Seminar of physiology of metabolism and thermoregulation. Lab reports submissions.

Physiology of excretion. Endocrinology.

**Lectures (2 hours):** Excretory organs. Kidney, its functions. Types of nephrons, their

function. Juxtaglomerular complex, its role. Blood circulation in the kidney. The mechanism of formation of primary urine. Glomerular filtration rate, factors affecting it. Tubular reabsorption. The mechanism of selective reabsorption of substances in different parts of the nephron. Tubular secretion and its mechanism. The role of the nervous system and hormones in the regulation of urine formation (antidiuretic hormone, aldosterone, catecholamines, natriuretic hormone, calcitonin, parathyroid hormone, renin-angiotensin system, etc.).

Hypothalamic-pituitary system. Neurosecretory cells of the hypothalamus. Characteristics of releasing hormones. Hormones of the adenohypophysis: synthesis and secretion, and their targets. Hormones of the neurohypophysis: synthesis and secretion, and their targets. Feedback regulation. Hormones of the thyroid and parathyroid glands. The regulation of glucose in the blood (pancreas, pituitary, and adrenal glands). Functions of adrenal cortex hormones. Catecholamine hormones and neurotransmitters. Female and male sex hormones and their functions.

**Lesson 15.** Physiology of excretion. Laboratory experiments.

**Lesson 16** Seminar of physiology of excretion.

**Lesson 17** Seminar of endocrinology.

**Lesson 18.** Exam preparation and consultation

**EXAM**