

**MINISTRY OF HEALTH OF THE REPUBLIC OF BELARUS**  
Educational Institution  
**BELARUSIAN STATE MEDICAL UNIVERSITY**

**APPROVED**

by Rector of the Educational  
Institution «Belarusian State  
Medical University»

S.P.Rubnikovich

*15.11.2023*

Reg. # UD- *091-049/2324* /edu.

**Контрольный  
экземпляр**

**HISTOLOGY, CYTOLOGY, EMBRYOLOGY**

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

**7-07-0911-01 «General Medicine»**

Curriculum is based on the educational program «Histology, Cytology, Embryology», approved 15.11.2023, registration # УД-091-049/2324/уч; on the educational plan in the specialty 7-07-0911-01 «General Medicine», approved 17.05.2023, registration # 7-07-0911-01/2324/mf.

**COMPILERS:**

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**RECOMMENDED FOR APPROVAL:**

by the Department of Histology, Cytology and Embryology of the educational institution «Belarusian State Medical University»  
(protocol № 3 of 04.10.2023);

by the Scientific Methodical Council of the Educational Institution «Belarusian State Medical University»  
(protocol № 11 of 15.11.2023)

## EXPLANATORY NOTE

«Histology, Cytology, Embryology» is the educational discipline containing systematized scientific knowledge and techniques in the field's histology, cytology, embryology, studying the patterns of development, microscopic structure and activity of the cells, tissues and their interaction in the composition of organs.

The aim of the discipline «Histology, cytology, embryology» is to provide students with the scientific knowledge about the development, the microscopic and submicroscopic organization of the cells, tissues and organs as the structural basis of their functioning in a normal human body. As a result, theoretical prerequisites are laid for mastering and understanding the essence of physiological and pathological processes that contribute to the formation of the conceptual apparatus of medicine, the development of the foundations of clinical thinking and the acquisition of professional competencies.

The knowledge, skills and abilities acquired in the study of academic discipline «Histology, Cytology, Embryology» are necessary for the successful study of the following disciplines: «Normal Physiology», «Pathologic Physiology», «Pathologic Anatomy», «Internal diseases», «Surgical Diseases», «Obstetrics and Gynecology».

Studying the educational discipline «Histology, Cytology, Embryology» should ensure the formation of students' basic professional competency:

BPC-4. While providing medical care use knowledge about the structure of the human body at tissue, cellular and subcellular levels, human embryogenesis and its pathology.

**As a result of studying the discipline «Histology, Cytology, Embryology» the student should**

**know:**

general patterns and stages of human embryonic development;  
sources of development, features of structure and function, age-related changes in the main types of tissues;

features of the tissue composition of the organs of the human body and the spatial relationships of tissues in the organs;

features of the structure, functions and age-related transformations of the cell structure in a living organism;

the basics of tissue regeneration and the limits of their variability;

features of obtaining material for histological examination, methods of tissue fixation;

parts of the microscope, their purpose and rules for using the microscope;

**be able to:**

to differentiate the structural elements of cells and tissues in the composition of organs during microscopic examination of biopsy and surgical material;

recognize electronograms of cells and non-cellular structures of tissues and organs;

**master:**

microscopy technique;

histological terminology.

**Total number** of hours for the study of the discipline is 222 academic hours. Classroom hours according to the types of studies: lectures – 16 hours (including 5 hours supervised independent work), laboratory classes – 122 hours, student independent work (self-study) – 84 hours.

Intermediate assessment is carried out according to the syllabus of the specialty in the form of a credit (2 semester), and examination (3 semester).

Form of higher education – full-time.

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

Code, name of discipline	semester	Number of academic hours						Form of intermediate assessment
		total	in-class	including			out-of-class self-studies	
				lectures	supervised student independent work	laboratory studies (practical classes and seminars)		
7-07-0911-01 «General Medicine»	2	108	68	14	4,5	54	40	credit
	3	114	70	2	0,5	68	44	exam

## THEMATIC PLAN

Section (topic) name	Number of class hours	
	lectures	laboratory
<b>1. Introduction into the discipline «Histology, Cytology, Embryology». Overview of objects and methods used in histology</b>	<b>2</b>	<b>3</b>
<b>2. Cytology</b>		<b>3</b>
<b>3. Embryology</b>		<b>14</b>
<b>4. General histology</b>	<b>12</b>	<b>24</b>
4.1. Overview of tissue	2	2
4.2. Epithelial tissues		1
4.3. Blood and lymph. Hemopoiesis	2	9
4.4. Connective tissue	4	6
4.5. Muscle tissue	2	3
4.6. Nerve tissue	2	3
<b>5. Special histology</b>	<b>2</b>	<b>78</b>
5.1. Nervous system	-	8
5.2. Sense organs	-	4
5.3. Cardiovascular system	-	6
5.4. Organs of hemopoiesis and immunity (lymphoid organs)	-	4
5.5. Endocrine system	-	8
5.6. Digestive system	-	16
5.7. Respiratory system	-	6
5.8. Integumentary system	-	6
5.9. Urinary system	-	4
5.10. Reproductive system	-	12
5.11. Principle of diagnostic of histological slides and electronogramm	2	4
<b>Total hours</b>	<b>16</b>	<b>122</b>

### CONTENT OF THE EDUCATIONAL MATERIAL

#### **1. Introduction into the discipline «Histology, Cytology, Embryology». Overview of objects and methods used in histology**

Appointment, content, place of histology, cytology, embryology in the training system of a doctor. Communications histology with other medical and biological sciences. Development histology as a science. Development of histology in Belarusian. Modern stage of development of histology, cytology, embryology.

Methods of preparing histological slides (preparations) for light microscopy. Principles and methods of taking, fixation, embedding, preparation of section with

microtome of histological objects. Principle and methods of staining. Kinds of preparations – sections, smear, imprint, film.

Special methods of research – histochemistry, autoradiography, immunocytochemistry, cell and organelle separation by differential centrifugation.

Research in light, phase contrast, dark-field, fluorescence microscopy.

Electron microscopy – transmission and scanning electron microscopy.

Techniques preparing micro-objects for transmission electron microscopy.

Quantitative methods research: morphometry, cytophotometry, spectrofluorometry.

Methods research in embryology – peculiarity of fixation and preparation of embryo.

## 2. Cytology

The subject and tasks of cytology, significance for the biological and medical sciences. The main states of cellular theory on the modern stage. Subcellular and postcellular structures. Interaction sizes and shapes of the cells with their functional specialization.

*Cell membrane.* Plasmalemma. Structural chemical feature of plasmalemma. Characteristics of glycocalyx and submembrane layer. Interaction between plasmalemma and glycocalyx and submembrane layer in the functional processes.

Structural basis of barrier, transport, receptor function of plasmalemma.

Cell contacts: anchoring - simple, denticular, desmosome, zonula adherens; tight junction; communicative - gap junction (nexus), synapses.

*Cytoplasm, hyaloplasm.* Properties, chemical composition, participation in cellular metabolism.

*Organelles.* Definition, classification. General and special organelles. Membranous and nonmembranous organelles. Membranous organelles: endoplasmic reticulum, Golgi apparatus, mitochondria, lysosome, peroxisome, structures, functions and interactions in cellular metabolism.

Nonmembranous organelles: ribosomes, structures chemical composition, functions, polysomes. Cytoskeleton. General components of cytoskeleton: microtubules, microfilaments, intermediate filaments, structure, chemical nature. Centrioles, structure, functions in nondividing nuclear and in mitosis.

Special organelles: myofibrils, microvilli, cilia, flagella, structures, functions.

*Inclusion.* Definition, classification, significance. Structures and chemical composition different types of inclusions.

*Nucleus.* Role in storage and transmit genetic information. Shape and number nucleus. Nuclear-cytoplasmic relation. Structure interphase nucleus.

Nucleoplasm: characteristic, chemical composition, significance. Chromatin: structure, chemical composition, characteristic chromatin fibers. Nucleosomes. Euchromatin, heterochromatin, participation in synthetic process.

Nucleolus. Chemical composition, structure, function. Characteristic fibrillary and granular components.

Nuclear membrane, structure, function. Structure-functional characteristics of outer and inner nuclear membrane, perinuclear space. Interaction nuclear membrane with endoplasmic reticulum.

*Synthetic process in cell.* Interaction of the cellular components during anabolism and catabolism. Secretory cycle, uptake mechanism, secretion of product. Intracellular regeneration, general characteristics, biological significance.

*Cell cycle.* Definition, phases of cell cycle.

Mitosis, phases – prophase, metaphase, anaphase, telophase. Biological significance and mechanism of mitosis.

Endomitosis, definition, general forms, biological significance.

Meiosis, mechanism and biological significance.

Cell aging and death. Structural and functional features of the cell aging.

Types of death. Necrosis, definition, mechanism, biological significance.

Apoptosis- program cell death, definition, mechanism, biological significance.

### **3. Embryology**

Basis of general embryology. Basic periods of embryogenesis.

*Progenesis.* Gametes, morphological and functional characteristics. Differences between gametes and somatic cells.

Main processes of embryonic development: proliferation, migration of cells, adhesion, growth, induction, determination, differentiation, cells interaction, physiological death of cells.

*Human embryology.* Stages of human embryonic development, their duration.

*Fertilization.* Definition, biological significance, stages – distant interaction, contact interaction, synkaryon, their significance. Zygote -unicellular organism, its genome, activation of intracellular processes

*Cleavage.* Definition, biological meaning. Morula, blastocyst, formation of embryoblast and trophoblast.

*Implantation.* Stages. Differentiation of the trophoblast. The state of the uterus at the beginning of implantation. Formation of the chorionic plate and primary villi.

*Gastrulation.* Definition, biological significance, stages. The first stage (early stage) of gastrulation – delamination (dividing the embryoblast into epiblast and hypoblast). Formation of extraembryonic mesoderm and secondary villi. Formation of the amnion, yolk sac, allantois.

Second stage (last stage) of gastrulation – immigration. Formation of the primitive streak, primitive node, ectoderm, mesoderm, entoderm, three axial organs.

Differentiation of the embryonic germ layers.

*Organo- and histogenesis.* Definition. The derivatives of the embryonic germ layers.

*Extraembryonic organs.* Amnion, yolk sac, allantois, umbilical cord: their structure, function, duration of existence. Trophoblast, chorion, Placenta structure and function. The fetus and maternal part of placenta. Placental circulation. Placental barrier and its significance. Changes in the endometrium during the development of pregnancy, fetal membranes.

*Critical periods of embryonic development.* The role of exogenous and endogenous factors in the occurrence of anomalies and malformations.

## **4. General histology**

### **4.1. Overview of tissue**

Tissue as one of the levels of body organization. Definition of tissue.

Development and classification of tissues.

Cells and its derivatives (symplasts, syncytia and extracellular matrix). Cellular type, cellular differon. Stem cells, its properties.

Histogenesis and regeneration of tissue.

#### **4.2. Epithelial tissues**

Epithelial tissue. Morphofunctional and histogenesis classifications of epithelia. The sources of development. General morphological characteristic. The main property of epithelial tissue. Functions. Polarity of epithelial cells.

Basement membrane, structure and functions.

*Covering epithelia.* Structural and functional characteristics of its different types: simple (squamous, cuboidal, columnar, pseudostratified) and stratified (keratinized, nonkeratinized, transitional).

*Glandular epithelium.* Structure and classifications of exocrine glands according to the characteristic of the secretory portions and excretory ducts. Properties of endocrine glands. Secretory cycle, phases and their characteristics. Types of secretion: merocrine, apocrine, holocrine.

#### **4.3. Blood and lymph. Hemopoiesis**

Blood. General components of blood as tissue – plasma and cells and their derivatives. Functions of blood. Hemogramme. Sex characteristics of blood.

*Cells of blood*

Erythrocytes. Size, shape, structure, functions, lifespan. Characteristics of erythrocyte membrane organization, cytoskeleton. Kinds of hemoglobin. Reticulocytes.

Leukocytes, general characteristics, classification. Granulocytes (neutrophils, basophils, eosinophils), number, size, shape, lifespan in blood, structure and functions. Structure and chemical nature of specific granule. Agranulocytes – lymphocytes and monocytes, number, size, shape, structure and function. Types of lymphocytes, their functions. Participation of lymphocytes in immune reaction, subpopulation of lymphocytes (memory cells and effector cells). Leukocyte formula.

Thrombocytes (blood plates), number, size, structure, functions.

*Lymph.* Components, relation with blood, recirculation of lymphocytes. Function.

*Hemopoiesis.* Embryonic hemopoiesis, formation blood as a tissue. Stage of embryonic hemopoiesis.

Postembryonic hemopoiesis: physiological regeneration of blood. Hemopoietic stem cell, common progenitor of myelopoiesis and lymphopoiesis (colony-forming unit), unipotential stem cells, their characteristics. Characteristic of cells in the of differons of erythrocytes, granulocytes, monocytes, lymphocytes, thrombocytes. Characteristic of T – and B- lymphopoiesis: antigenindependent and antigendependent lymphopoiesis. Regulation of hemopoiesis and lymphopoiesis, role of microenvironment.

#### **4.4 Connective tissues**

General characteristics of connective tissue, classification. Histogenesis, mesenchyme.

*Connective tissue proper.* Classification.



*Fibrous connective tissue:* general characteristics, classification, regeneration.

Loose connective tissue. Cells of loose connective tissue. Derivatives of mesenchyme: fibroblasts, their kinds (fibrocytes, myofibroblast), structure, participation in fibrillogenesis; adipocytes (lipocytes) of white and brown adipose tissue, their origin, structure, functions; pericytes, adventitial cells, their origin, structure, functions.

Derivatives of stem cell blood. Macrophages, their origin, kinds, structure, role in defense reactions. Concept of the macrophage system (mononuclear phagocyte system). Leukocytes, their role in defense reactions. Plasma cells, their origin, structure, role in immune reactions. Mast cells, their origin, structure, functions.

Pigment cells, their origin, structure, function.

Extracellular matrix, general characteristics, structure. Ground substance, chemical nature, significance. Collagen and elastic fibers, structure, chemical composition, functions. Different types of collagen fibrils, their localization. Reticular fibers. Origin of extracellular matrix.

Dense connective tissues, classification, structure, functions. Ligament as organ.

*Connective tissues with special properties.* Reticular tissue, structure, histophysiology, significance. Adipose tissue, types, structure, significance. Pigment tissue, structure, significance. Mucous tissue, structure.

*Skeletal tissues.* General characteristics of skeleton tissue, classification.

*Cartilage tissues.* General characters. Types of the cartilage – hyaline, elastic, fibrocartilage. Cartilage cells – chondroblasts, chondrocytes. Isogenous groups of cells. Histochemical characteristics and structure of extracellular matrix of different cartilage tissues. Chondrogenesis. Hyaline cartilage of articular joint surfaces.

*Bone tissues.* General characteristics, classification. Cells of bone tissue (osteocytes, osteoblasts, osteoclasts), their characteristics. Extracellular substance of bone tissue, structure and properties. Mineralization of extracellular substance. Types of bone tissue, their localization in the body and morphofunctional characteristics. Bone as organ.

Histogenesis bone tissue: intramembranous and endochondral ossification. Factors influencing the regeneration of bone tissue.

#### **4.5. Muscle tissues**

General characteristics of muscle tissues (classification, sources of development, location in the body, basic structural principles, functions, regeneration, peculiarities of blood supply and innervations).

Comparative characteristics of different types of muscle tissue structural units: morphofunctional units, peculiarities of its structure, principles of location in the tissue and types of intercellular contacts.

*Skeletal muscle tissue.* General plan structure of the muscle fibers, its contractile apparatus. Structure of sarcomere. Mechanism of muscle contraction.

Structure of skeletal muscle as an organ. Myon. Comparative characteristic of different types of skeletal muscular fibers (red, white and intermediate fibers).

*Smooth muscle tissues.* Structure of smooth myocyte, contractile apparatus and molecular mechanism of contraction. Myoepithelial cells, sources of development,

structure and function.

*Cardiac muscular tissue.* Comparative characteristic of different types of cardiomyocytes (contractile, conductive and secretory cardiomyocytes).

#### **4.6. Nerve tissue**

General morphofunctional characteristics of nervous tissue. Sources of development, histogenesis. Regeneration of nervous tissue's structural components.

*Neurons.* Classification (morphological, functional, mediatory). General plan of neuron's structure (perikaryon, axon, dendrites). Transporting processes in nerve cells.

*Neuroglia.* Classification and development. Morphological and functional characteristics of different types of neuroglia (astrocytes, oligodendrocytes, ependimocytes and microglia).

*Nerve fibers.* Classification. Morphological and functional characteristics of myelinated and unmyelinated fibers. Process of myelinisation. Degeneration and regeneration of nerve fibers.

*Nerve endings.* Classification and structure sensory and efferent.

Interneuron synapses. General plan of synapses organization. Classification, structure, transmission of nerve impulse. Reflex arches, its basic structural elements.

### **5. Special histology**

#### **5.1. Nervous system**

General morpho-functional characteristics of nervous system, origin of development. Neuron theory, main statements. Mechanism of neuron integration. Convergence and divergence. Nerve centers, classification of nerve centers (morphological and physiological). Principles of structural organization of nuclear and screen nerve centers. Reflex arches, sensory, motor and associative parts.

*Central nervous system.* Spinal cord. General characteristics, structure. Gray matter: types of neurons, their participation in reflex arches, types of glial cells. Nuclei of gray matter. Rexceed plates. Structure of white matter. Central channel of spinal cord. Morphofunctional characteristics of conductive pathways.

*Brain.* General characteristics, embryogenesis. Gray and white matter. Structure of brain membrane- dura mater, arachnoid layer, pia mater. Subdural and subarachnoid space, vessel plexus. Structure of vessels (sinuses, hemocapillars) of central nervous system.

*Cerebellum:* structure and neurons component of cortex cerebellum: Purkinje, basket, stellate, granular cells. Afferent and efferent nerve fibers. Interneurons connections (cerebellum module). Cerebellum glomerulus. Cerebellum gliocytes.

*Cerebral cortex:* general morphofunctional characteristics. Cytoarchitecture. Neuron component. Layer of cerebrum cortex. Module of cortex. Interneuron connections. Myeloarchitecture. Gliocytes. Blood-brain barrier, structure, significance. Age-related change.

*Peripheral nervous system.* Peripheral nerve, structure, tissue component, reaction on injury, regeneration.

*Sensory nervous ganglia (spinal ganglia),* structure, tissue component. Characteristics of neurons and neuroglia.

*Autonomic (vegetative) nervous system.* General characteristics, structure of central and peripheral parts of parasympathetic and sympathetic nervous system. Structure and neurons component of autonomic ganglia. Pre- and postganglionic nerve fibers. Structure of reflex arches of autonomic nervous system.

## **5.2. Sense organs**

Sensory organs. General morphological and functional characteristics. Conception of analyzer, its structure. Classification, structure and cytophysiology of receptor cells.

*The organ of smell.* Structure, sources of development, cytophysiology of neurosensory receptor cells.

*The organ of vision.* Sources of development and basic stages of embryogenesis. The main functional apparatuses of the eye. Structure of the refractive and accommodative apparatuses of the eye ball.

The receptive apparatus: development, structure, and adaptation of the retina to the level of light. Specialized regions of the retina. Types of neurosensory receptor cells.

*The organ of taste.* Source of development, structure, cytophysiology of taste receptor cells.

### *The organ of hearing and equilibrium*

The organ of hearing: morphological and functional characteristics. Sources of development, structure, cytophysiology of sensoepithelial receptor cells of the spiral organ.

The organ of equilibrium. Sources of development, structure, functions. Morphological and functional characteristics of sensoepithelial receptor cells.

## **5.3. Cardiovascular system**

General morphological and functional description of the cardiovascular system.

*Vessels.* Classification of vessels, their development, general structure and regeneration. Principles of vessel innervations and nourishments.

Arteries. Classification. The dependence of the artery wall structure on haemodynamic conditions.

Veins. Classification. Influence of haemodynamic conditions on the vein wall structure.

Microcirculation bed. The structure and functional description of its vessels. Capillaries: classification, organ specificity. Histochemical barrier. Lymphatic capillaries.

Anastomoses between arterioles and venules: classification, structure, functions.

Lymphatic vessels: classification, morphological and functional description.

*Heart.* Sources and stages of development, structure of cardiac membranes (endocardium, myocardium, epicardium). Structure of heart valves. Morphofunctional and histochemical description of contractile cardiomyocytes.

Conductive cardiac system. Ultrastructural and histochemical description of conductive myocytes. Peculiarities of interaction between conductive cardiac system and contractile cardiomyocytes.

#### 5.4. Organs of hemopoiesis and immunity (lymphoid organs)

General characteristic of organs of hemopoiesis and immunity. Immunity, types. Characteristic of main cells participating in immune reactions – neutrophils, macrophages antigenpresenting cells, T-lymphocytes, B-lymphocytes, plasma cells. Conception of antigens and antibody. Antigendependent and antigenindependent differentiation of lymphocytes. Lymphocytopoiesis in T- and B-zones of secondary lymphoid organs. Conception of circulation and recirculation of T- and B-lymphocytes. Humoral and cellular immunity. Interaction between macrophages, antigenpresenting cells, T- and B-lymphocytes in immune response. Effector cells and memory cells in humeral and cellular immunity. Nature killer. Plasma cells, stage their differentiation. Regulation of immune reactions: cytokine, hormones.

*Primary organs of hemopoiesis and immunity.* Bone marrow. Structure, tissue composition, functions of red bone marrow. Blood supply, structure of capillaries. Microenvironment. Yellow bone marrow.

Thymus, role in lymphocytopoiesis. Structure, tissue composition of cortex and medulla of thymus lobule. Blood supply. Structure and role of blood thymus barrier. Age-related and accidental involution of thymus.

*Secondary organ of hemopoiesis and immunity.* Lymph node, structure and tissue composition. Cortex and medulla, morfofunctional characteristic, cellular composition, T- and B-zone. System of sinuses. Blood supply of lymph node.

Spleen, structure, tissue composition (red and white pulp, T- and B-zone). Blood supply of spleen. Structure and function of venous sinus.

Lymphoid apparatus of the digestive and respiratory systems: structure, development and function of the tonsils.

#### 5.5 Endocrine system

General characteristics of the endocrine system. Hormones, target-cells, receptors. Autocrinia, paracrinia, endocrinia. Classification of endocrine organs. Central and periphery parts of endocrine system. Regulatory mechanisms in endocrine system.

*Central endocrine organ.* Hypothalamus: source of the development, structure, functions. Neurosecretory cells of nucleus of hypothalamus. Releasing hormone, their role in regulation of the endocrine system. Regulation of hypothalamus by central nervous system.

Hypophysis: embryonic development. Structure, functions of adenohypophysis. Morphofunctional characteristics of adenocytes of pars distalis. Pars intermedia of hypophysis. Structure and function of neurohypophysis. Hypothalamoadenohypophyseal and hypothalamo- neurohypophyseal systems. Hypothalamo-hypophysis blood supply, its role in interaction between hypothalamus and hypophysis. Neurohemal organs, neurohemal synapses.

Pineal gland, structure, cell components, functions.

*Peripheral endocrine gland.* Thyroid gland: the origin of development, structure. Follicles – structure and function unit of thyroid gland, wall structure and colloid composition. Thyrocytes, their hormones and phases of secretory cycle. Role thyroid hormones. Structure of follicles in depend on the functional activity. Parafollicular cells, their location, hormones. Regeneration.

Parathyroid gland: the origin of development, structure, cell composition, role in regulation of calcium and phosphate levels in the blood. Regeneration.

Adrenal glands: origin of development. Fetal and definite adrenal cortex. Zones of adrenal cortex, their cell composition. Structure of cortex adrenocytes in connection with synthesis and secretion of glucocorticoids. Role cortex hormones. Adrenal medulla, structure, cell composition, hormones. Peculiarities of the blood supply of the adrenal gland. Regulation of the cortex and medulla.

*Disperse endocrine system.* Origin of development, localization, cell composition. Characteristics of neuroendocrine cells. APUD system.

### **5.6. Digestive system**

General characteristics of digestive system. Sources of development of digestive system's tissues in embryogenesis. The overall plan of the structure of the digestive tube wall (mucosa, submucosa, muscularis externa, serosa or adventitia). Blood and nerve supply. Endocrine apparatus of digestive system. Its lymphoid structures.

*The anterior part of digestive system.* Peculiarities of its different parts, development.

Oral cavity, structural organization of its mucous membrane and function. The lip, gum, cheek, hard and soft palate, tonsils. Their histological and physiological features. Age-related change of the oral mucosa.

Salivary glands, classification, origin of development, structure, functions. Structure of secretory portions and excretory ducts. Endocrine function and regeneration of salivary glands.

Structure of the tongue. Peculiarities of its mucous membrane on the upper and lower surfaces. Characteristics of tongue papillae. Taste buds.

Teeth, sources and basic stages of development. Microscopic structure of dentine, enamel, cementum, its chemical composition and function. Tooth pulp, structure, function, reactive property, and regeneration. Tooth supporting structures. Blood and nerve supply of teeth. Changing of teeth.

Pharynx and esophagus, sources and features of development. Pharyngeal and esophageal membrane structure and their topographic features. Functions. Glands of esophagus, its histophysiology.

*The middle part of digestive tract.* Stomach: sources of development, general characteristics of its membranes, functions. Morphological characteristics of different gastric parts: relief of gastric mucosa, glands (branching, character of secretion, cellular structure), peculiarities of muscular membrane. Main gastric glands: topography, characteristics (degree of branching, form), cellular structure (cell localization, micro- and ultramicroscopic structure, functions). Structural peculiarities of the gastric wall and its glands in the cardiac and pyloric regions. Capability of regeneration of covering epithelium and epithelium of gastric glands. Blood and nerve supply of stomach.

Small intestine: structure and functions. Structural characteristics of different parts of small intestine. Microscopic structure of small intestine villi and crypts, their functions. Ultramicroscopic structure and cytophysiology, regeneration of the small intestine epithelium. Cavernous, membranous and intracellular digestion.

Histophysiology of the «crypt – villus» system. Histophysiology of digestion and absorption. Endocrine system of digestive tract. Blood and nerve supply. Lymphatic apparatus of small intestine.

Large intestine: structure and functions. Structural characteristics of different parts of large intestine. Lymphatic apparatus of its wall. Types of epithelial cells, their cytophysiology. Structural peculiarities of the appendix.

*Posterior part of the digestive tract.* Rectum and anal canal: source of the development, structure of the wall, blood supply.

*Pancreas.* General characteristics, function. Structure of exocrine parts: cytophysiological characteristics of acinocytes, system of the excretory ducts. Structure of endocrine parts: types of endocrinocytes, their morphological and functional characteristics. Blood and nerve supply, regeneration.

*Liver.* General characteristics, functions, blood supply. Structure of classic hepatic lobule as structure-functional unit of liver. Concept of portal lobule, liver acinus. Hepatocytes – main cells of liver, situation in lobules, structure. Structure of intralobular sinusoidal capillaries, cytophysiology of endothelial cells, macrophages. Perisinusoidal spaces, their structure and function. Lipocytes, structure, functions. Liver regeneration

Bile conducting pathways: of bile canaliculus, bile ductuli, interlobular bile duct, their structure. Gallbladder, structure, function.

### **5.7. Respiratory system**

General characteristics of respiratory system. Respiratory and nonrespiratory functions. Conductive pathways (portion), respiratory portion. Pleura.

*Outerpulmonary conducting pathways.* Structure of nasal cavity, pharynx, larynx, trachea, main bronchi. Tissue composition and histophysiological characteristics of membranes. Cell composition of epithelium of mucous membrane.

*Intrapulmonary conducting pathway.* Bronchi, bronchioles, structure of the wall. Structural basis of mucociliated transport.

*Respiratory portion.* Acinus – structure and functional unit of lung. The composition of acinus. Alveolar wall structure. Types of alveolar cells, their features.

Surfactant, structure and chemical composition, functions. Structure of alveolar septum. Air-blood barrier. Macrophages. Blood supply.

### **5.8. Integumentary system**

*Skin.* Morphological and functional characteristics. Sources of development. Regeneration.

Epidermis. The main cell differons of epidermis. Layers of epidermis, its cells. Morphological and functional characteristics of thick and thin skin epidermis. Keratinization and regeneration of skin epidermis. Notion about proliferate units. Morphological and functional characteristics of skin epidermis melanocytes, dendrocytes and Merkel's cells, their development. Local immune system of epidermis.

Dermis. Structure and function of the connective tissue basis of the skin. Papillary and reticular layers, its tissue organization. Skin receptors. Histofunctional characteristic of dermis immune system. Blood supply. Hypodermis.

*Skin derivatives.* Skin glands: morphological and functional characteristics of

eccrine and apocrine sweat glands. Topographic, structural and secretory peculiarities of sebaceous glands. Hair: types, structure, growth and replacement. Nail: development, structure and growth.

### **5.9. Urinary system**

Overview of urinary system.

*Kidney.* The sources of embryonic development and the principal stages of ontogenesis of the kidney: pronephros, mesonephros and metanephros.

Cortical and medullary substances of kidney. The nephron. Types of nephrons, its topography. General organization of the nephron. The structure and function of cortical and juxtamedullary nephrons. Blood supply of the kidney. Characteristics of cortical and juxtamedullary circulation. Histophysiology of the renal corpuscle. Filtering barrier (renal histohematic barrier). Mesangium, its structure and function. Histophysiology of different portions of the nephron (proximal part, thin tubule, distal part) and collecting tubules. Morphofunctional base of regulation of the process of urination.

Endocrine kidney apparatus: rennin – angiotensin system, prostaglandin system and kallikrein – kinin system, its histophysiology.

*The excretory passages.* Calyces, pelvis, ureters, urinary bladder, its structure. Structural peculiarities of the male and female urethra.

### **5.10. Reproductive system**

General morphofunctional characteristics of reproductive system, origin and basis stage of embryonic development. Primary gonocytes, localization, pathways of migration to gonads. Indifferent stage of development. Factors of sex differentiation. Tissue composition of reproductive organs.

*Male reproductive organs.* Origin of development of testis, excurrent duct system.

Testis: structure, Function. Seminiferous tubules, structure. Spermatogenesis, characteristics of its phases. Role of sustentacular cells in spermatogenesis. Blood-testis barrier. Endocrine function, male sex hormone, Leydig cells, their role in regulation in spermatogenesis. Straight ducts, rete testis. Regulation of endocrine and reproductive functions of testis. Regulation of the testis function.

Excurrent duct system: efferent ductuli, epididymis, ductus deferens, structure, functions.

Accessory sex glands: seminal vesicles, bulbourethral glands, prostate gland, structure, functions. Semen fluid, composition, functions.

Penis: structure.

*Female reproductive organs.* Origin of development .

Ovary: general characteristics, structure of cortex and medulla. Oogenesis. Difference between oogenesis and spermatogenesis. Ovarian follicles, structure, development. Ovulation. Development, structure, function of corpus luteum. Ovarian cycle and its regulation. Atretic follicle. Endocrine function of ovaries, female sex hormones.

Uterine tubes: structure, function. Cycle changes.

Uterus: structure, function. Menstrual cycle, its phases. Connection between ovarian and menstrual cycle.

Vagina: structure, functions, cyclic change of mucosa membrane.

Mammary glands: development, structure. Postnatal change. Cyclic changes during the menstrual cycle and pregnancy. Neuroendocrine regulation of mammary glands.

### **5.11. Principle of diagnostic of histological slides and electronogramm**

General principle of diagnostic histological slides, algorithm diagnostic of parenchyma and tubular organs. Basis of microscopic organization of different types of tissue in parenchyma and tubular organs.



## EDUCATIONAL DISCIPLINE CURRICULAR CHART

Section, topic #	Section (topic) name	number of hours			out-of-class self-studies	Forms of control
		lectures (including supervised student independent work)	supervised student independent work	practical		
	<b>2 semester</b>					
1.	<b>Introduction into the discipline «Histology, Cytology, Embryology». Overview of objects and methods used in histology</b>	2	0,5	3	9	
2.	<b>Cytology</b>			3		
3.	<b>Embryology</b>			6		
1-3	Introduction into the discipline «Histology, Cytology, Embryology». Overview of objects and methods used in histology. Embryology	2	0,5	-	1	Interviews
1	Introduction into the course of «Histology, Cytology, Embryology». Overview of objects and methods used in histology	-	-	3	2	Interviews. Completing tasks in the practicum
2	Cytology	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
3	Embryology. Progenesis. The stages of human embryonic development. Fertilization. Cleavage	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
3	Embryology. Gastrulation. Differentiation of the embryonic germ layers	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum

4	<b>General histology</b>	12	4	24	19	
4.1-4.2	Overview of tissue. Epithelial tissue	2	1	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
4.3	Blood and lymph. Hemopoiesis	2	0,5	-	1	Interviews
4.3	Blood and lymph	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
4.3	Blood and lymph. Hemopoiesis.	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
	Final lesson on topics «Methods used in histology», «Cytology», «Embryology», «Overview of tissue», «Epithelial tissue», «Blood and lymph. Hemopoiesis»	-	-	3	4	Colloquium. A control interviews. Control work. Tests. Computer tests.
4.4	Connective tissue. Connective tissue proper	2	0,5	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
4.4	Connective tissue. Skeletal tissue	2	0,5	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
4.5	Muscle tissue	2	0,5	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
4.6	Nerve tissue	2	1	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
<b>5</b>	<b>Special histology</b>			<b>18</b>	<b>12</b>	
5.3	Cardiovascular system. Vessels	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum

5.3	Cardiovascular system. Heart	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.7	Respiratory system	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
	Final lesson on topics «Connective tissue». «Muscle tissue», «Nerve tissue», «Cardiovascular system», «Respiratory system»	-	-	3	2	Colloquium. A control interviews. Control work. Tests. Computer tests. Diagnostics of histological slides
5.8	Integumentary system. Skin	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.8	Integumentary system. Skin derivatives	-	-	3	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum. Credit
	<b>3 semester</b>					
5	<b>Special histology</b>	2	0,5	60	44	
3	<b>Embryology</b>			8		
5.6	Digestive system. Oral cavity	-	-	4	1	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.6	Digestive system. Anterior part	-	-	4	1	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.6	Digestive system. Middle and posterior part	-	-	4	1	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum

5.6	Digestive system. Glands	-	-	4	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum.
5.4	Organs of hemopoiesis and immunity (lymphoid organs)	-	-	4	3	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum.
5.5	Endocrine system	-	-	4	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum.
	Final lesson on topics «Digestive system», «Organs of hemopoiesis and immunity (lymphoid organs) », «Endocrine system»	-	-	4	7	Colloquium. A control interviews. Control work. Tests. Computer tests. Diagnostics of histological slides.
5.1.	Nervous system. Peripheral nervous system. Spinal cord	-	-	4	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.1	Nervous system. Central nervous system	-	-	4	1	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.2	Sense organs	-	-	4	3	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.9	Urinary system	-	-	4	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.10	Reproductive system. Male reproductive system	-	-	4	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
5.10	Reproductive system. Female reproductive system.	-	-	4	3	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum

3.	Embryology. Organo- and histogenesis. Critical periods of development	-	-	4	1	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
3.	Embryology. Implantation. Extraembryonic organs	-	-	4	2	Interviews. Tests. Computer tests. Diagnostics of histological slides. Completing tasks in the practicum
	Final lesson on topics: «Nervous system», «Sense organs», «Urinary system», «Reproductive system», «Embryology»	-	-	4	7	Colloquium. A control interviews. Control work. Tests. Computer tests. Diagnostics of histological slides.
5.11	Principles of the histological slides diagnostics	2	1	4	4	Diagnostic of histological slides. Examination
		<b>16</b>	<b>5</b>	<b>122</b>	<b>84</b>	

## INFORMATION AND INSTRUCTIONAL UNIT

### LITERATURE

#### **Basic (relevant):**

1. Studenikina, T. M., Vylegzhanina, T. A., Ostrovskaya T. I. Histology, cytology, embryology : textbook. – Minsk : Novoe znanie, 2022. – 326 p.

#### **Additional:**

2. Kuznetsov, S. L. Histology, cytology and embryology (a course of lectures) / S. Kuznetsov, T. Boroniknina, N. Gorychkina. – Moscow : Medical Informational Agency, 2019. – 239 p.

3. Eroschenko, V. P. diFiore's Atlas of histology with functional correlations / V. P. Eroschenko. – Lippincott Williams & Wilkins, 2013. – 602 p.

4. Junqueira, L. K. Junqueira's Basic Histology. Text and atlas / L. K. Junqueira. – Antony L. Mescher. International edition, 2013. – 694 p.

5. Ross, M. Histology: a text and atlas / M. Ross, W. Pawlina. J.B. Lippincott Company, 2020. – 974 p.

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

The time allotted for independent work can be used by students for:

- preparation for lectures and laboratory classes;
- preparation for the test and exam in the academic discipline;
- study of thematic video lectures on the academic discipline;
- elaboration of topics (questions) submitted for independent study;
- solving situational tasks and tests for self-training in an academic discipline;
- performing research and creative tasks;
- preparation of thematic reports, abstracts, presentations;
- performing practical tasks;
- taking notes of educational literature;
- compilation of a review of scientific literature on a given topic;
- compilation of a thematic selection of literary sources, Internet sources.

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

Main forms of supervised student independent work:

- learning of the lectures' material: presentations or video lectures;
- preparation for practical classes;
- preparation and presentation of abstracts;
- presentation of reports;
- 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 testing;  
preparation of tests for the organization of mutual assessment.

Control of supervised student independent work is carried out in the forms of:  
test paper;  
colloquium in the form of a written work or a testing;  
discussion of abstracts;  
assessment of an oral reply to a question, presentation, report or problem solving;  
checking up abstracts, written reports,  
checking up videolecture or lecture's presentation viewing;  
checking up notes of original sources, monographs and articles;  
individual interview.

#### **LIST OF AVAILABLE DIAGNOSTIC TOOLS**

The following forms are used for competences assessment:

##### **Oral form:**

interviews;  
colloquiums;  
diagnostics of histological slides.

##### **Written form:**

tests,  
control interviews;  
control works;  
abstracts;  
completing tasks in the workshop

##### **Oral-written form:**

credits;  
examinations;  
diagnostic of histological slides.

##### **Technical form:**

computer tests.

#### **LIST OF AVAILABLE TEACHING METHODS**

Linear (traditional) method (lecture, practical lessons);

Active (interactive) methods:

Problem-Based Learning (PBL);  
Research-Based Learning (RBL).

#### **LIST OF PRACTICAL SKILLS**

1. Microscopy technique.
2. Histological slides diagnostic.

### LIST OF USED EQUIPMENT

1. Light microscope.
2. Video camera.
3. TV set.
4. Computers.
5. Practicum.
6. Atlases.

### LIST OF LECTURES

#### 2<sup>nd</sup> semester

1. Introduction into the discipline «Histology, Cytology, Embryology». Overview of objects and methods used in histology. Embryology.
2. Overview of tissue. Epithelial tissue.
3. Blood and lymph. Hemopoiesis.
4. Connective tissue. Connective tissue proper.
5. Connective tissue. Skeletal tissue.
6. Muscle tissue.
7. Nerve tissue.

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

1. Principles of the histological slides diagnostics.

### LIST OF PRACTICAL STUDIES

#### 2<sup>nd</sup> semester

1. Introduction into the discipline «Histology, Cytology, Embryology». Overview of objects and methods used in histology.
2. Cytology.
3. Embryology. Progenesis. The stages of human embryonic development. Fertilization. Cleavage.
4. Embryology. Gastrulation. Differentiation of the embryonic germ layers.
5. Overview of tissue. Epithelial tissue.
6. Blood and lymph.
7. Blood and lymph. Hemopoiesis.
8. Final lesson on topics «Methods used in histology», «Cytology, «Embryology», «Overview of tissue», «Epithelial tissue», «Blood and lymph. Hemopoiesis».
9. Connective tissue. Connective tissue proper.
10. Connective tissue. Skeletal tissue.
11. Muscle tissue.
12. Nerve tissue.
13. Cardiovascular system. Vessels.
14. Cardiovascular system. Heart.
15. Respiratory system.



16. Final lesson on topics «Connective tissue». «Muscle tissue», «Nerve tissue», «Cardiovascular system», «Respiratory system»
17. Integumentary system. Skin.
18. Integumentary system. Skin derivatives.

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

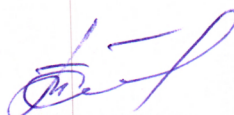
1. Digestive system. Oral cavity.
2. Digestive system. Anterior part
3. Digestive system. Middle and posterior part.
4. Digestive system. Glands.
5. Organs of hemopoiesis and immunity (lymphoid organ)
6. Endocrine system.
7. Final lesson on topics «Digestive system», «Organs of hemopoiesis and immunity (lymphoid organ)», «Endocrine system».
8. Nervous system. Peripheral nervous system. Spinal cord.
9. Nervous system. Central nervous system.
10. Sense organs.
11. Urinary system.
12. Reproductive system. Male reproductive system.
13. Reproductive system. Female reproductive system.
14. Human embryology. Organo- and histogenesis. Critical periods of development.
15. Human embryology. Implantation. Extraembryonic organs.
16. Final lesson on topics: «Nervous system», «Sense organs», «Urinary system», «Reproductive system», «Embryology»
17. Principles of the histological slides diagnostics.

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

Title of the discipline requiring approval	Department	Amendments to the curriculum of the academic discipline	Decision of the department, which designed the curriculum (date, protocol # )
Medical Biology and General Genetics	Department of Biology	No changes are added	Protocol № N 3 of 04.10 2023
Human Anatomy	Department of Normal Anatomy	No changes are added	Protocol № N 3 of 04.10 2023
Medical and Biological Physics	Department of Medical and Biological Physics	No changes are added	Protocol № N 3 of 04.10 2023
Bioorganic Chemistry	Department of Bioorganic Chemistry	No changes are added	Protocol № N 3 of 04.10 2023

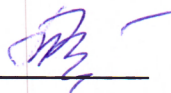
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Curriculum content, composition and accompanying documents comply with  
established requirements.

Dean of the Medical Faculty of  
International Students of the  
educational institution «Belarusian  
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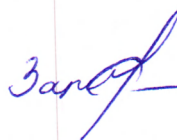
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