

THE MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
BLACK SEA STATE UNIVERSITY OF A NAME OF PETRO MOHYLA

MEDICAL INSTITUTE

Department of Medical Biology and Physics, Microbiology, Histology, Physiology and Pathophysiology



Course Description

HISTOLOGY, CYTOLOGY AND EMBRYOLOGY

field of knowledge 22 «Health care»
in the specialty 222 «Medicine»

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1. DESCRIPTION OF EDUCATIONAL DISCIPLINE

Characteristic	Characteristics of the discipline	
Name of the discipline	Histology, cytology and embryology	
Branch of knowledge	22 «HealthCare»	
Specialty	222 «Medicine»	
Specialization (if any)		
Educational program	Medicine	
High education level	Master	
Status of discipline	Normative	
Course of Study	I, II	
Academic year	2020	
Semester numbers:	Full-time	Correspondence form
	II, III	
Total ECTS credits / hours	11.5 credits (7,0 / 4,5) / 345 hours	
<ul style="list-style-type: none"> – Course structure: – - lectures – - seminars (practical, laboratory, semigroup) – - hours of independent work of students 	Full-time	Correspondence form
	40 hours (20/20)	
	120 hours (70/50) 185 hours (120/65)	
Percent age of classroom load	46%	
Language of instruction	English	
Interim control form (if any)	Total Modular Control (TMC)	
Form of final control	2nd semester - credit, 3rd semester - exam	

2. Purpose, tasks and planned learning outcomes

Purpose: Histology, cytology and embryology aims to study the microscopic and ultramicroscopic structure of the structures of the human body, their development and changes in various living conditions, students acquire deep knowledge of histology and use this knowledge in the process of further training and in professional activities to solve clinical problems, create a theoretical basis for students to master clinical disciplines (internal diseases, surgery, clinical pharmacology, pathological anatomy, etc.), integrate teaching with the main clinical disciplines, development of professional abilities for clinical thinking in students.

Task:

*study of the cellular and tissue levels of organization of the human body and prenatal human ontogenesis; • study of the morphofunctional organization of the main tissues;

*study of the structural organization of life processes and the possibilities of purposeful influence on them;

*study of the molecular and structural foundations of cell function and repair and their derivatives;

*determination of adaptive and regenerative capabilities of organs, taking into account their tissue composition, regulatory features and age-related changes;

*interpretation of patterns of human embryonic development, regulation of morphogenesis processes;

*determination of critical periods of embryogenesis, malformations and abnormalities of human development

Prerequisites for studying the academic discipline (interdisciplinary connections)

Histology, cytology and embryology as a discipline:

a) is based on the study of students of anatomy and physiology, medical biology, medical and biological physics, biological and bioorganic chemistry, foreign language and integrates with these disciplines;

b) lays the foundations for the study of clinical disciplines by students, which provides for the integration of teaching with these disciplines and the formation of skills to apply knowledge of histology, cytology and human embryology in the process of further study and professional activities;

c) lays the foundations of microscopic research to ensure a healthy lifestyle and prevention of dysfunction of cells, tissues and organs in the process of life.

Expected learning outcomes

As a result of studying the discipline, students have:

know:

- subject area of histology, cytology and embryology;
- patterns of cyto- and histogenesis, the structure and function of cells and tissues at the microscopic and submicroscopic level, the purpose of individual components of the cell;
- molecular and structural bases of functioning and restoration of cells and their derivatives;
- basics of adaptation, reactivity and maintenance of homeostasis;
- organization of tissues and features of their interaction in the composition of organs, conditions and mechanisms of tissue regeneration;
- adaptive and regenerative capabilities of organs;
- tissue composition of organs, features of regulation;
- age-related changes in cells, tissues, organs;

- structure of gametes, periods of embryogenesis and their patterns, critical periods of embryogenesis;
- patterns of tissue differentiation and regeneration;
- the role of the nervous, endocrine, immune systems of the body in the regulation of morphogenesis of cells, tissues and organs;
- processes of morphogenesis, patterns of human embryonic development;
- critical periods of embryogenesis, defects and anomalies of human development;

be able to:

- determine the adaptive and regenerative capabilities of organs, taking into account their tissue composition, features of regulation and age-related changes;
- interpret the laws of human embryonic development, regulation of morphogenesis;
- determine the critical periods of embryogenesis, defects and anomalies of human development;
- interpret the microscopic and submicroscopic structure of cells;
- to interpret the microscopic structure of various human organs in terms of the relationship of tissues that are part of them at different ages, as well as in terms of physiological and reparative regeneration;
- interpret the patterns of human embryonic development;
- explain the features of embryonic development of tissues (histogenesis) and organs (organogenesis);
- explain the basic principles of organization of different tissues, their interaction.

HAVE COMPETENCIES

- on the application of knowledge of histology, cytology and embryology to promote a healthy lifestyle, as well as to prevent the occurrence and development of diseases;
- about the main perspective directions of development of histology, cytology and embryology.

The developed program corresponds to the educational-professional program (EPP) and is focused on the formation of competencies:

general (GC) - GC1-GC10 EPP:

Ability to abstract thinking, analysis and synthesis, the ability to learn and be modernly trained

professional (PC) - PC 2, PC 3, PC 5 EPP:

PC2. Ability to determine the required list of laboratory and instrumental studies and evaluate their results

PC3. Ability to establish a preliminary and clinical diagnosis of the disease

PC5. Ability to determine the nature of nutrition in the treatment of diseases

According to the educational-professional program, the expected **program learning outcomes (PLO)** include the skills of **PLO1, PLO 4, PLO12 EPP:**

- Know the methods of analysis, synthesis and further modern learning. Be able to analyze information, make informed decisions, be able to acquire modern knowledge. Establish appropriate connections to achieve goals. Be responsible for the timely acquisition of modern knowledge.

- Know the types and methods of adaptation, principles of action in a new situation. Be able to apply the means of self-regulation, be able to adapt to new situations (circumstances) of life and activity. Establish appropriate connections to achieve results. Establish appropriate connections to achieve results. Be responsible for the timely use of self-regulatory methods.

- Evaluate information about the diagnosis in the health care facility, its unit, using a standard procedure, using knowledge about the person, his organs and systems, based on the results of laboratory and instrumental studies (according to list 4).

3. PROGRAM OF EDUCATIONAL DISCIPLINE

The educational process is organized according to the European credit transfer and accumulation system (ECTS).

The program of the discipline consists of three information blocks:

INFORMATION BLOCK 1

Topic 1. Introduction to the course of Histology, Cytology and Embryology. History of development of science

The emergence of histology, cytology and embryology as independent sciences. The value of the works of R. Hooke, A. Levenhuk, J. Purkinje, R. Brown, M. Schleiden for the creation of cell theory. T. Schwann's research. Cell theory as a fundamental generalization of biology. Elucidation of the microscopic structure of tissues and organs, creation of tissue classification.

Development of histology, cytology and embryology in Ukraine. Organization of independent departments (PI Peremeshko, NL Hrzhonshchewsky). The value of the research of MK Kulchytsky, V. Ya. Rubashkin, VV Alyoshin, MI Zazybin, MF Kashchenko, BI Khvatov.

The current stage of development of histology, cytology and embryology. Connection of histology with other sciences of medical and biological profile.

Basic principles of manufacturing specimen for light and electron microscopy, obtaining material (biopsy, needle puncture biopsy, autopsy). Fixation, dehydration, compaction of objects, making sections on microtomes and ultramicrotomes. Types of micropreparations are cut, smear, imprint, film, section. Coloring and contrasting of drugs. The concept of histological dyes.

Technique of microscopy in light microscopes. Special methods of light microscopy - phase contrast, dark field, luminescent, interference, laser scanning. Transmission and scanning electron microscopy. The concept of histochemistry, radioautography, immunocytochemistry. Congratulatory research methods.

Quantitative research methods are morphometry, densitometry, cytophotometry, spectrofluorometry.

The concept of the cell as an elementary living system. Eukaryotic cell as the basis of structure, function, reproduction, development, adaptation and regeneration of multicellular organisms. Cell derivatives as tissue components of multicellular organisms.

The purpose and objectives of cytology, its significance for medicine. The main provisions of cell theory at the present stage of development of science.

General plan of eukaryotic cell structure. Relationship between the shape and size of cells and their functional specialization in animals and humans.

Topic 2. Cytology

The main components of the cytoplasm are hyaloplasm, organelles, inclusions. Hyaloplasm - definition, cytosol and cytomatrix, physicochemical properties, chemical composition, significance for cellular metabolism.

Organelles - definition, classification. General and special purpose organelles. Membrane organelles (granular and non-granular endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes, mitochondria). Non-membrane organelles (ribosomes, centrioles, microtubules, microfilaments and intermediate filaments). Synthetic processes in the cell. Interaction of structural components of the cell in the synthesis of proteins and non-protein substances.

Inclusion - definition, classification, meaning. The importance of the nucleus in the life of the eukaryotic cell, storage and transmission of genetic information. Shape, size, number of

nuclei and nuclear-cytoplasmic ratio in different cell types. The main components of the nucleus: nuclear envelope, chromatin, nucleolus, karyoplasm.

Nuclear shell. Its structure and functions. Nuclear membrane membranes, perinuclear space, nuclear pores.

Chromatin. Structure and chemical composition. Euchromatin and heterochromatin. Sex chromatin. Chromatin as a form of chromosome existence in the interphase nucleus. Composition of chromosomes: DNA, RNA, histone and non-histone proteins. Structure and function of chromosomes during cell division. Karyotype, ploidy.

Nucleolus as a derivative of chromosomes. Nuclear organizers. The structure of the nucleolus and its role in the formation of ribosomes.

Karyoplasm, physicochemical properties, chemical composition, importance in the life of the nucleus

Life and cell cycles, their characteristics. Types of cells derived from the cell cycle.

Mitosis. Biological significance. Phases of mitosis. Rearrangement of structural components of the cell during different phases of mitosis. Endomitosis. Polyploidy.

Intracellular regeneration. General morphofunctional characteristics, biological significance.

Cell reactions to damaging effects. Reversible and irreversible cell changes. Their morphological manifestations. Adaptation of cells, its importance for the preservation of cell life in altered conditions of existence. Apoptosis and its biological and medical significance. Aging and cell death.

Topic 3. General and comparative embryology

Periodization of animal development. Progenesis. Fertilization. The main stages of embryonic development. Crusting, gastrulation, histo- and organogenesis. Features of the structure of vertebrate embryos at different stages of development. The concept of biological processes underlying the development of the embryo: induction, determination, division, cell migration, growth, differentiation, cell interaction, destruction. Provisional bodies, their role and structure. Cloning of animals.

Subject and tasks of human embryology. Medical embryology. The ratio of onto- and phylogeny. Periodization of human embryogenesis.

Germ cells. Structure and functions of male and female germ cells, the main stages of their development. Meiosis as a mechanism of germ cell formation. Its serving.

Fertilization in humans, its biological significance, phases. Conditions necessary for normal fertilization, the phenomenon of capacitation, acrosomal reaction, penetration of sperm, the formation of the male pronucleus. Cortical reaction of the oocyte, completion of meiosis, formation of the female pronucleus. The concept of in vitro fertilization. Its medical and social significance. Zygote as a unicellular organism.

Crusting of the human embryo, its characteristics. Structure and localization of the embryo during fragmentation. Types of blastomeres. Morula. Blastocyst formation. Embryo and trophoblast. Implantation. Its mechanisms, stages, chronology, features in humans.

Delamination. Structures formed as a result of delamination. Presumptive rudiments of provisional organs, epiblast, hypoblast. Gastrulation. Formation of embryonic mesoderm. Neurolation and formation of the axial complex of rudiments of organs.

Differentiation of embryonic leaves and their derivatives.

Provisional organs: chorion, amnion, yolk sac, allantois, umbilical cord. Human placenta, its development, structure and functions. Changes in the endometrium during pregnancy, amniotic membranes. The mother-fetus system. The concept of critical periods of embryogenesis and ontogenesis.

Topic 4. Practical skills and testing on the topics of block 1

Topic 5. Final control work on block 1.

INFORMATION BLOCK 2

Topic 6. Epithelial tissue. The structure of intercellular contacts. Types of secretion

The concept of tissue. A systematic approach in defining the concept of tissue as a multicellular organism.

Cells and cellular derivatives as tissue elements.

Tissue formation based on cell differentiation of embryonic rudiments. Mechanisms of histogenesis. Patterns of origin and evolution of tissues, the theory of parallelism and divergent evolution. The concept of cell populations. Stem cells, their properties. Determination and differentiation of cells, their molecular genetic basis. The concept of histogenetic series (differon).

Tissue classification. Types of physiological regeneration. The concept of reparative regeneration and metaplasia.

General morphofunctional characteristics of the epithelium. Organization of the epithelial layer. Cytokeratins as markers of different types of epithelial tissues. Modern ideas about the structure, origin and function of the basement membrane. Epithelial nutrition. Histogenesis of epithelial tissues. Genetic and morphofunctional classification.

The structure of different types of integumentary epithelium.

Glandular epithelium. Structure and classification of glands. Secretory cycle. Types of secretion.

Features of physiological and reparative regeneration of epithelial tissues.

Topic 7. Actually connective tissues

General characteristics. Classification.

Fibrous connective tissue. Their varieties are loose and dense.

Characteristics of loose fibrous connective tissue. Cellular composition of loose fibrous connective tissue (fibroblasts, macrophagocytes, plasma cells, tissue basophils, lipocytes, pigment and adventitial cells). Intercellular substance of loose fibrous connective tissue, fibrous structures (collagen, reticular, elastic fibers) and amorphous substance. Macrophage system of the organism. Interaction of blood cells and connective tissue in inflammation.

Dense fibrous connective tissues, their varieties - decorated and unformed, their location, structure and functions. The structure of the tendon.

Topic 8. Connective tissues with special properties.

Connective tissues with special properties: reticular, adipose (white and brown), pigmented, mucous, their localization, structure and functions.

Topic 9. Tissues of the internal environment. Structural and functional characteristics of the blood system. Modern ideas about hematopoiesis

Morphofunctional characteristics. Origin. Mesenchyme. Classification of connective tissues. The system of connective tissues as the internal environment of the organism.

Blood composition, plasma and shaped elements, function. Plasma characteristics. Structure and functions of erythrocytes, leukocytes, thrombocytes. Classification of leukocytes, their participation in the body's protective reactions. Hemogram and leukocyte formula, their features in newborns and children of different ages. Characteristics of lymph. The concept of physiological regeneration of blood and lymph.

Postnatal hematopoiesis as physiological blood regeneration. Myeloid and lymphoid tissues. Modern theory of hematopoiesis. Hematopoietic stem cell, its properties. Semi-stem cells. The concept of colony-forming units. Unipotent progenitor cells, morphologically recognizable proliferating progenitor cells, maturing and mature blood cells. Histogenetic series: erythropoiesis, granulocytopoiesis, monocytopenoiesis, thrombocytopoiesis, lymphopoiesis.

Embryonic hematopoiesis (development of blood as a tissue), its stages (mesoblastic, hepatothymolienal and medulothymolymphoid).

Topic 10. Muscle tissue

Mechanism of muscle contraction. General morphofunctional characteristics of muscle tissues, genetic and morphological classification. Unstriated muscle tissue of mesenchymal origin. Histogenesis, structure, morpho-functional and histochemical characteristics. Myocyte. Organization of the contractile apparatus. Regeneration of unstriated muscle tissue. Unstriated muscle tissue of epidermal and neural origin. Striped skeletal muscle tissue (somatic type). Localization, histogenesis, functional features. Muscle fiber as a structural and functional unit of tissue. The structure of the muscle fiber. Myosatellitocytes. Sarcoplasmic reticulum. T-system. Types of muscle fibers, the relationship between excitation and contraction of muscle fibers. Muscle as an organ. Mion. Endomysia, perimysia, epimysia. Regeneration of skeletal muscle tissue.

Topic 11. Nervous tissue: neurocytes, gliocytes, nerve fibers, nerve endings, synapses

General morphofunctional characteristics. Histogenesis.

Neurocytes (neurons). Morphological and functional classification. Structure of perikaryon, axon, dendrites. General and special purpose organelles. Processes of transport of substances in a neuron. The concept of neurotransmitters. Secretory neurons.

The most horny. General characteristics, main varieties. Central gliocytes. Macroglia (ependymocytes, astrocytes, oligodendrocytes). Microglia. Peripheral gliocytes.

Nerve fibers. General characteristics, classification. Myelin and myelin-free nerve fibers. De- and regeneration of nerve fibers.

Nerve endings. General morphofunctional characteristics. Receptors and effectors, their classification and structure. The concept of synapse. Interneuronal synapses (classification, structure, mediators). The mechanism of excitation transmission in synapses. Morphological substrate of reflex activity of the nervous system (the concept of simple and complex reflex arcs). Neural theory.

Topic 12. Practical skills and testing on the topics of block 2

Topic 13. Final control work on block 2

INFORMATION BLOCK 3

Topic 14. Nervous system

General morphofunctional characteristics. Embryogenesis. Classification (anatomical and functional).

Central nervous system. Gray and white matter. Nerve centers. Meninges.

Spinal cord. General morphofunctional characteristics. The structure of gray matter. Neural composition. Nuclei. Own apparatus of reflex activity. Anterior and posterior roots. White matter. Leading paths.

Brain. General characteristics, development. Brain stem. The medulla oblongata. The most important associative nuclei. Reticular formation. Diencephalon. The nucleus of the thalamus. Hypothalamus, main nuclei. Functions of the diencephalon.

Cerebellum. Structure and functions. Gray and white matter. Layers of the cerebellar cortex, their neural composition. Interneuronal connections. Afferent and efferent fibers. Cerebellar gliocytes.

The cortex of the cerebral hemispheres. General morphofunctional characteristics. Cytoarchitectonics: neural composition, layers of the cortex of large hemispheres. The concept of brain modules (barrels, speakers). Interneuronal connections. Myeloarchitectonics. Gliocytes.

Hematoencephalic barrier, structure, significance.

Peripheral nervous system. Sensitive nerve nodes (spinal cord and skull). Sources of development Tissue composition. Building. Position of nodes in the reflex arc. The structure of nerve trunks. Features of their reaction to damage, recovery processes. Nerve endings (see section "Nerve tissue"). Somatic and autonomic (autonomic) nervous system. General

morphofunctional characteristics of the autonomic nervous system, division into sympathetic and parasympathetic systems. The concept of metasympathetic nervous system. The nuclei of the central parts of the autonomic nervous system. The structure of the ganglia of the autonomic nervous system.

Topic 15. Sensory systems: visual, olfactory, taste, auditory and gravitational analyzers.

General characteristics of the senses. The doctrine of sensory systems. Classification of sense organs by origin and structure of receptor cells.

The organ of sight. General characteristics. Embryogenesis. General plan of the structure of the eyeball. Shells, their divisions and derivatives. The main functional devices: dioptric, accommodation, receptor. Photoreceptor cells. Retinal neurons and gliocytes. The structure of the yellow and blind spots of the retina. Optic nerve. Hematoophthalmic barrier. Auxiliary apparatus of the eye. Age changes.

The sense of smell. General characteristics. Embryogenesis. Localization. Olfactory cells. Supporting and basal cells. Histophysiology of the olfactory organ. Vomero-nasal organ.

The organ of taste. General morphofunctional characteristics and embryogenesis. Taste buds, their localization and structure. Taste, support and basal cells. Histophysiology of the taste organ.

Hearing and balance. General morphofunctional characteristics. Outer, middle and inner ear. Bone and membranous labyrinths. Vestibular part of the cross-frequent labyrinth: pistil, sac and semicircular ducts, their receptor sections: spots and ampullary combs. Hair and supporting cells. Otolith membrane and dome. Curly (auditory) part of the membranous labyrinth. Spiral organ. Hair and supporting cells. Histophysiology of the vestibular and auditory apparatus. Embryogenesis of hearing and balance. Age changes.

Topic 16. Endocrine system

General morphofunctional characteristics. The concept of hormones and their significance for the body. Hormone receptors. The mechanism of action of hormones. The principle of feedback. Classification of endocrine glands. Central and peripheral parts of the endocrine system.

Neuroendocrine system of regulation of body functions. Hypothalamus. Large and small cell nuclei of the hypothalamus as the central link of the endocrine system. Structure and functions of neurosecretory cells. Hypothalamic-neurohypophyseal and hypothalamic-adenohypophyseal systems and their neurohemal organs (neurohypophysis and medial eminence). Liberins and statins.

The pineal gland. Structure, cell composition, connection with other endocrine glands. Hormones and their action. Development, age changes.

Pituitary. Embryogenesis of the adeno- and neurohypophysis. Structure, cellular composition of the adeno- and neurohypophysis. Morphofunctional characteristics of endocrinocytes, their changes in hormonal imbalances. Hypothalamic-adenohypophyseal vascular system, its role in hormone transport. The structure and functions of the neurohypophysis, its role in the excretion of hormones of the anterior hypothalamus. Age changes.

Thyroid. Development, structure, cell composition. Follicles. Folliculogenesis. Morphofunctional characteristics of follicular endocrinocytes. Structure, hormones and their action. Features of the secretory cycle. Restructuring of follicles due to different functional activity. Parafollicular endocrinocytes, sources of development, localization, hormones and their action.

Thyroid glands. Development, structure and cell composition. Parathyroid, its role in the regulation of mineral metabolism.

Adrenal glands. Embryogenesis. Fetal and definitive adrenal cortex. Zones of the cortex, their structure, morphofunctional characteristics of their endocrinocytes. The role of adrenal

cortex hormones in the development of general adaptation syndrome. Brain substance of the adrenal gland (structure, cell composition, hormones, their action).

Single hormone-producing cells of non-endocrine organs. Classification by origin. Cells of the ARUD system, localization, hormones and their action.

Topic 17. Cardiovascular system

General characteristics. Sources and course of embryonic development. Classification of vessels. Dependence of the structure of the vascular wall on the conditions of hemodynamics. Age changes.

General plan of the structure of the vascular wall. Artery. Types of arteries (elastic, muscular-elastic, muscular). Organ features of arteries.

Hemomicrocircular bed. Hemocapillaries. The structure of the endothelium. Arteriolo-venular anastomoses.

Veins, features of a structure in comparison with arteries. Classification of veins. The structure of venous valves. Organ features of veins.

Lymphatic vessels. Classification, structure of lymphatic vessels of different types. Features of the structure of lymphatic capillaries and postcapillaries, participation in microcirculation.

Heart. Embryogenesis. The general structure of the heart wall. Endocardium, heart valves.

Myocardium. Features of the structure and function of cardiac muscle tissue. Source of development, features of histogenesis. Morphofunctional characteristics of contractile, conducting and secretory cardiomyocytes. Leading system of the heart. Possibilities of regeneration of cardiac muscle tissue.

The structure of the epicardium and pericardium.

Newborn heart. Restructuring, development and age-related changes in the heart after birth.

Topic 18. Hematopoietic organs and immune defense

General morphofunctional characteristics and classification.

Red bone marrow. Localization, structure and functions: stroma, parenchyma, vascularization. Yellow bone marrow. Age changes. Regeneration.

Thymus (thymus gland) as the central organ of T-lymphocytopoiesis. Particles: cortical and cerebral substances, thymic bodies. Features of vascularization. Age and accident involution, thymic-lymphatic status.

Spleen. Structure and functions: stroma and parenchyma, white and red pulp. T- and B-zones of white pulp. Features of blood supply. Structure and function of venous sinuses of the spleen. Possibilities of spleen regeneration.

Lymph nodes. Structure and functions: stroma and parenchyma, cortical and cerebral matter. T- and B-zones. Paracortical area. Sinus system. Histophysiology of lymph nodes. Regeneration.

Hemolymph nodes. Features of structure and value.

The only immune system of mucous membranes: lymph nodes in the wall of the airways, digestive tract and other organs.

Topic 19. Respiratory system and general cover

General morphofunctional characteristics. Airways and respiratory department. The structure of the membranes of the wall of the airways: mucous membrane, submucosal base, fibro-cartilage membrane, outer (adventitial) membrane.

Departments of the airways: nasal cavity, larynx, trachea, bronchi (main, large, medium and small caliber), terminal bronchioles, their structure and function. The concept of broncho-associated lymphoid tissue, its significance for the body.

General plan of the structure of the lungs. The concept of the lobe of the lung. Acinus as a structural and functional unit of the respiratory lung. The structure of the alveoli, the cellular composition of its lining. Surfactant complex. Airtight barrier. Pleura.

Regenerative potencies of the respiratory system. Age changes.

Skin. General morphofunctional characteristics. Tissue composition of the skin. Regeneration.

Epidermis. Its layers, features of the structure of "thick" and "thin" skin. Keratinocytes. Processes of keratinization in the epidermis. Macrophage and melanocyte dendrites of the epidermis. Tactile epitheliocytes.

Derma. Papillary and reticular layers. Features of the structure of the dermis in different areas of the skin.

Glands of skin: sebaceous, sweat, dairy (structure, histophysiology).

Hair. Development, structure, growth, hair change

Nails. Development, structure, growth

Topic 20. Digestive system: gastrointestinal tract

General morphofunctional characteristics. Embryogenesis. Division into departments by development, structure and functions. General plan of the structure of the wall of the digestive tract. Characteristics of membranes, their tissue composition and features in different parts of the digestive tract. Innervation and vascularization of the digestive tract. Digestive glands, their location, structure and functions. The concept of gastroenteropancreatic endocrine system, its significance for the body.

Oral cavity. Features of the mucous membrane in connection with the functions. Lips, cheeks, gums, hard and soft palate, tonsils, tongue.

Teeth. Tooth tissues, their distribution by anatomical parts. Enamel, dentin, cement - structure, chemical composition, function. Tooth pulp, structure, function. Periodontist. Tooth development. Milk and permanent teeth. Age-related changes in teeth.

Pharynx and esophagus. Features of the structure of the mucous membrane. Esophageal glands, localization, histophysiology. Features of the structure of the esophageal wall at different levels. Age changes.

Stomach. The structure of the wall, its tissue composition. Features of the relief of the mucous membrane and its epithelial lining, differences in different parts of the body. Localization, structure and cellular composition of glands. Exo- and endocrinocytes of different types. Histophysiology of secretory cells. Regeneration of the gastric epithelium. Age changes.

Small intestine. General characteristics of different anatomical departments, wall structure. Features of the relief of the mucous membrane. Crypt-villi system. Varieties of epitheliocytes, their structure and function. Histophysiology of digestion. The role of microvilli of columnar epitheliocytes in parietal digestion. Features of the structure of the duodenum, jejunum and ileum. . Aggregated lymphatic follicles in the ileum. Regeneration of the epithelium of the small intestine. Age changes.

Colon. The structure of the wall. Features of the relief of the mucous membrane. Histophysiology of the colon. The appendix, its structure, function. Rectum, departments, their morphofunctional features. Age changes.

Topic 21. Digestive glands

Large salivary glands. Structure, histophysiology, exo- and endocrine functions. Pancreas. General morphofunctional characteristics. Structure of exocrine and endocrine parts. Acinus as a structural and functional unit of exocrine purity of the pancreas. Features of morphology and function of adenocytes. Centroacinous cells. The structure of the excretory ducts. Types of pancreatic islet cells, their morphofunctional characteristics. Acinar-islet cells. Age changes. Liver. Morphofunctional characteristics. Features of blood supply. The structure of the classical lobe of the liver. Intrapartic hemocapillaries. Liver beams. Hepatocyte, its structure and function. Bile capillaries. Perisinusoid space, perisinusoid lipocytes, their structure and

function. The concept of hepatic acinus and portal lobe. Gallbladder and biliary tract. Regenerative potencies of the digestive system. Age changes.

Topic 22. Urinary system

Urinary organs. General morphofunctional characteristics. Embryogenesis. Age changes.

Kidneys. Cortical and cerebral matter. Nephron as a structural and functional unit of the kidney. Types of nephrons. Departments of the nephron and their histophysiology. Structure of the renal corpuscle, renal filtration barrier. Features of renal blood circulation - cortical and south-medullary blood supply systems. Endocrine apparatus of the kidney. Juxtaglomerular complex, its structure and functions. Regenerative potencies of the kidney.

Urinary tract, structure of renal pelvis, cups, bladder ureters, urethra.

Topic 23. Male reproductive system

General characteristics. Embryogenesis. The testicle, its structure and function. Tortuous seminal tubules, the structure of its wall. Spermatogenesis. Testicular endocrinocytes, their function. Hematotesticular barrier. Age changes.

Family pathways. Testicular appendage. The vas deferens. Family bubbles. Ejaculatory duct. Prostate. Age changes. Penis, its structure, vascularization and innervation.

Topic 24. Female reproductive system, medical embryology

Ovary, development of its generative and endocrine function. Cortical and cerebral matter. Oogenesis, its differences from spermatogenesis. Development and structure of follicles. Ovulation. Development of the corpus luteum, its types. Ovarian cycle and its regulation. Follicle atresia. Age features of the ovary.

Uterine tubes, structure and functions.

Uterus. The structure of the wall (endometrium, myometrium, perimetrium). Menstrual cycle and its phases. The structure of the endometrium in different phases of the cycle. Relationship of the menstrual cycle with the ovarian. Influence of pituitary hormones and action of hypothalamic centers of regulation of ovarian-menstrual cycle. Restructuring of the uterus during pregnancy and after childbirth. Age changes.

Vagina. The structure of the wall, a change in structure in connection with the menstrual cycle.

Mammary gland.

Topic 25 Practical skills and testing on the topics of block 3

Topic 26 Final control work on block 3

Structure of the academic discipline

Topic	Lectures	Laboratory classes	Student independent work
Information block 1. Updates of cytology and general embryology			
1. Introduction. History of development of histology, cytology and embryology. Methods of histological, cytological and embryological research	2	4	8
2. Cytology	2	16	20
3. General and comparative embryology.	2	8	20
4. Practical skills and testing on the topics of block	-	4	-
5. The final module for the control 1		4	-
Total hours – 90. ECTS credits – 3,0	6	36	48
Information block 2. Updates of general histology			
1. Epithelial tissue. The structure of intercellular contacts. Types of secretion	2	4	6
2. Own connective tissue	2	8	7
3. Connective tissue with special properties	2	2	2
4. Fabrics of the internal environment. Structural and functional characteristics of the blood system. Modern ideas about hematopoiesis	4	6	15
5. Muscle tissue. Mechanism of muscle contraction	2	2	15
6. Nervous tissue: neurocytes, glyocytes, nerve fibers, nerve endings, synapses.	2	4	15
7. Practical skills and testing on the topics of block 2		4	
8. The final module for the control 2	-	4	
Total hours – 108. ECTS credits – 3,5	14	34	60
Information block 3. Special histology			
9. Nervous System	2	6	8
10. Sensory systems: visual, olfactory, taste, auditory and gravitational analyzers.	2	6	10
11. Endocrine system	2	4	7
12. Cardiovascular system	2	4	5
13. Bodies of hematopoiesis and immune protection	2	2	10
14. Respiratory system and general cover	2	4	10
15. Digestive system: gastrointestinal tract	2	8	5
16. The digestive glands	2	4	5
17. Urinary system	2	2	5
18. Male sexual system	2	2	5
19. Female reproductive system		4	10
21. Practical skills and testing on the topics of block 3	-	2	
22 The final module for the control 3.	-	2	-

Individual work - a review of the scientific literature or experimental research

Total hours – 150. ECTS credits – 5,0	20	50	80	-
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4. The content of the discipline

4.1. Lecture plan

INFORMATION BLOCK 1

№	Topic	Number of hours
1	Topic 1. Introduction. History of histology, cytology and embryology. 1) Subject and tasks of histology, cytology and embryology. 2) Methods of histological, cytological and embryological examinations. 3) The doctrine of disease, etiology and pathogenesis.	2
2	Topic 2. Cytology. 1) Cell theory as a fundamental generalization of biology. 2) General plan of eukaryotic cell structure. 3) Life (cell) cycle, its periods.	2
3	Topic 3. General and comparative embryology. 1) The subject and objectives of human embryology. Medical embryology. 2) The concept of periods of ontogenesis. Periods of embryonic development. Types of oocytes, essence and mechanisms of periods of development 3) Progenesis. Periods of human embryogenesis	2
Total hours		6

INFORMATION BLOCK 2

№	Topic	Number of hours
1	Topic 4. Epithelial tissue. Structure of intercellular contacts. Types of secretion. 1) Epithelial tissues. Histogenesis, morphofunctional characteristics, genetic and morphofunctional classifications. 2) Integumentary epithelium. Basement membrane. Features of physiological and reparative regeneration of epithelial tissues. 3). Glands. Classification principles. End sections and excretory ducts. Phases of the secretory cycle and their histological characteristics. Types of secretion.	2
2	Topic 5. Own connective tissues 1) General characteristics of connective tissues. 2) Classification of the actual connective tissue. 3) Features of physiological and reparative regeneration of the own connective tissue.	2
3	Topic 6. Connective tissues with special properties 1) Reticular, adipose (white and brown) tissue. Localization, structure and functions 2) Pigmented tissue. Localization, structure and functions 3) Mucous tissue. Localization, structure and functions	2
4	Topic 7. Tissues of the internal environment. Structural and functional characteristics of the blood system. Modern ideas about hematopoiesis 1) The concept of tissues of the internal environment. Morphofunctional characteristics, origin 2) Blood. Blood composition (plasma and shaped elements), properties and	4

	functions of plasma. 3) Modern theory of hematopoiesis. Hematopoietic stem cell, its properties	
5	Topic 8. Muscle tissue. Mechanism of muscle contraction 1) Classification and general characteristics of muscle tissues 2) The mechanism of muscle fiber contraction 3) Features of physiological and reparative regeneration of muscle fiber	2
6	Topic 9. Nervous tissue: neurons, gliocytes, nerve fibers, nerve endings, synapses 1) Classification and general characteristics of nervous tissue. 2) Synapse structure. 3) Modern theory of nerve impulse conduction.	2
Total hours		14

INFORMATION BLOCK 3

№	Topic	Number of hours
1	Topic 10. Nervous system 1) Features of the structure of the spinal cord. Neural composition. 2) The medulla oblongata. The most important associative nuclei. Reticular formation. The midbrain. The nucleus of the thalamus. Hypothalamus, main nuclei. Cerebellum. Cytoarchitectonics of the layers of the cortex of the large hemispheres. Neural composition. Plates (layers) of the cortex of large hemispheres. 3). Sensitive nerve nodes (spinal cord and cranial). Structure, functions of nerve trunks, ganglia. Fabric composition.	2
2	Topic 11. Sensory systems: visual, olfactory, taste, auditory and gravitational analyzers. 1) The doctrine of sensory systems. Classification by origin and structure of receptor cells. 2) General characteristics of the senses. 3). Histophysiology of sense organs.	2
3	Topic 12. Endocrine system. 1) Endocrine system. Morphofunctional characteristics. Classification. The concept of target cells and hormone receptors. 2) Central endocrine glands. 3) Peripheral endocrine glands.	2
4	Topic 13. Cardiovascular system. 1) Heart. Myocardium. Features of the structure and function of muscle tissue. Sources of development, features of histogenesis. 2) Classification of vessels. General plan of the structure of the vascular wall. Dependence of the structure of the vessel wall on the conditions of hemodynamics. 3) Lymphatic vessels. Classification, structure of lymphatic vessels of different types. Peculiarities of the structure of lymphatic capillaries and postcapillaries, participation in microcirculation.	2
5	Topic 14. Hematopoietic organs and immune defense. 1) General morphofunctional characteristics of hematopoietic organs. 2) Red bone marrow, localization, development, structure and function. Thymus is the central organ of T-lymphopoiesis. 3) General characteristics of peripheral organs of hematopoiesis and immunogenesis	2
6	Topic 15. Respiratory system and general cover.	2

	1) The respiratory system. Airways and respiratory department. 2) The structure of the alveoli. Surfactant complex. Air barrier. Pleura. 3) Regenerative capabilities of the respiratory system. Age changes.	
7	Topic 16. Digestive system: gastrointestinal tract. 1) Pharynx, esophagus. Stomach. 2) Small and large intestines. 3 Gallbladder and bile ducts.	2
8	Topic 17. Digestive glands. 1) The liver. Hepatocytes, their structure and functions. 2) Pancreas: morphofunctional characteristics. 3). Histophysiology of digestive glands.	2
9	Topic 18. Urinary system. 1) Juxtaglomerular complex, structure and functions. 2) Urinary tract, the structure of the renal pelvis, cups, bladder, ureter, urethra. 3) Endocrine apparatus of the kidney.	2
10	Topic 19-20 Reproductive system 1). General plan of histological structure of the testis. 2) The seminiferous tract. 3) Additional glands. 4) The ovary. Ovarian cycle. Development and structure of follicles (folliculogenesis). Ovulation. Menstrual cycle and its phases. 5) Female genital tract. Uterine tubes: structure, functions. Uterus. Vagina. Mammary glands. 6) The placenta. Hematoplacental barrier. Functions. Endocrine functions of the placenta	2
Total hours		20

4.2. Plan of practical classes

INFORMATION BLOCK 1

№	Topic	Number of hours
1.	Topic 1. Optical devices. Rules for working with a microscope	2
2.	Topic 2. Special methods of research in cytology, embryology, histology	2
3.	Topic 3. Basics of cytology. The overall organization of the cell. Plasmolemma. Intercellular contacts	2
4.	Topic 4. Cytoplasm. Cell metabolism. Synthetic cell apparatus	2
5.	Topic 5. Organelles	2
6.	Topic 6. Inclusion	2
7.	Topic 7. Cell nucleus	2
8.	Topic 8. Reproduction of cells. Cell cycle. Mitosis	2
9.	Topic 9. Cell life cycle. Differentiation. Aging. Cell death	2
10.	Topic 10. Cell anomalies	2
11.	Topic 11. Practical skills on «Fundamentals of Cytology»	2
12.	Topic 12. Fundamentals of embryology. Progenesis	2
13.	Tema 13. Fertilization. Implantation. Formation of extra-embryonic organs	2
14.	Topic 14. Early stages of development of embryo.	2
15.	Topic 15. Provisional organs. Placenta. Umbilical cord	2
16.	Topic 16. Practical skills on «Fundamentals of General Embryology».	2

17.	Topic 17. FINAL TEST WORK ON THE BLOCK 1	4
Total hours		36

INFORMATION BLOCK 2

№	Topic	Number of hours
1.	Topic 18. Epithelial tissues. General morphology	2
2.	Topic 19. Glandular epithelium. Exocrine glands	2
3.	Topic 20. Loose and dense connective tissue.	2
4.	Topic 21. Connective tissue with special properties	2
5.	Topic 22. Supporting connective tissues: cartilage	2
6.	Topic 23. Supporting connective tissues: bone tissue	2
7.	Topic 24. Fabrics of the internal environment. Blood. Erythrocytes and platelets. Hemogram	2
8.	Topic 25. Leukocytes. Leukocytic formula.	2
9.	Topic 26. Hemopoiesis	2
10.	Topic 27. Practical skills on «Epithelial tissues» and «Connective tissues»	2
11.	Topic 28. Muscle tissue	2
12.	Topic 29. Nervous tissue. Neurons and neuroglia.	2
13.	Topic 30. Nervous tissue. Nerve fibers and nerve endings. Regeneration of nerve fibers	2
14.	Topic 31. Practical skills on «Muscle tissue» and «Nerve tissue».	4
15.	Topic 32. FINAL TEST WORK ON BLOCK 2	4
Total hours		34

INFORMATION BLOCK 3

№	Topic	Number of hours
1.	Topic 33. Nervous system	6
2.	Topic 34. Sensory systems: visual, olfactory, taste, auditory and gravitational analyzers	6
3.	Topic 35. Central and peripheral endocrine organs	4
4.	Topic 36. Cardiovascular system: heart, blood vessels and microcirculatory bed	4
5.	Topic 37. Central and peripheral organs of hematopoiesis and immune defense	2
6.	Topic 38. Respiratory system	4
7.	Topic 39. Common cover and its derivatives	2
8.	Topic 40. Digestive System: Oral Organs	4
9.	Topic 41. Digestive system: pharynx, esophagus, stomach	2
10.	Topic 42. Digestive system: small and large intestine	2
11.	Topic 43. Glands of the digestive tract: salivary glands, endocrine structures, pancreas, liver.	4
12.	Topic 44. Urinary system	2
13.	Topic 45. Male sexual system	2
14.	Topic 46. Female reproductive system	2
15.	Topic 47. Practical skills and testing on the topics of block 3	2
16.	Topic 48. The final module for the control 3	2
Total hours		50

Note. * Plan of each practical lesson:

- 1) Written solution of test problems "Step-1" on the topic.
- 2) Group work on errors, at the same time an oral interview on all material of the topic.
- 3) Assessment of knowledge.

4.3. Tasks for independent work

№	Topic	Number of hours
INFORMATION BLOCK 1: Fundamentals of cytology and general embryology		
1.	Preparation for practical classes (theoretical training, development of practical skills)	10
2.	Taking online courses and online testing	10
3.	Independent study of topics that are not included in the classroom plan Block 1 (the list is attached)	24
4.	Individual work	2
5.	Preparation for the final control work	2
Total hours		48
INFORMATION BLOCK 2: Fundamentals of general histology		
1.	Preparation for practical classes (theoretical training, development of practical skills)	14
2.	Taking online courses and online testing	14
3.	Independent study of topics that are not included in the classroom plan Block 2 (the list is attached)	26
4.	Individual work	4
5.	Preparation for the final control work	2
Total hours		60
INFORMATION BLOCK 3: Special histology		
Preparation for practical classes (theoretical training, development of practical skills)		16
Taking online courses and online testing		18
Independent study of topics that are not included in the classroom plan Block 3 (the list is attached)		31
Individual work		6
Preparation for the final control work		9
Total hours		80

INFORMATION BLOCK 1

Histology in Ukraine
 Methods of research in histology. Technology of manufacturing of histological preparations.
 Structural basis of transport through the plasmolemma.
 Mechanisms of reception
 Structural bases of cytoprotection
 Mytosis and meiosis
 Cell reaction to external stimuli

INFORMATION BLOCK 2

General principles of tissue organization
 Epithelium as a leading component of histohemic barriers
 Glandular epithelium. Secretory cycle
 Epithelial stem cells.
 Thrombosis. Stages and Mechanisms.

Leukocytes. Mechanisms of adhesion, migration, and killing of microorganisms.

Interaction of blood cells and connective tissue with inflammation

Repair of loose fibrous connective tissue. Regulation of the volume and composition of the matrix of the connective tissue.

Articular cartilage

Bone as an organ.

Bone remodeling. Regeneration of bone tissue

Muscle as an organ. Muscle regeneration.

Nerve endings. Nerve-muscle spindle.

Histophysiology of locomotive apparatus

INFORMATION BLOCK 3

Development of the cardiovascular system.

Morphological basis of neurohumoral regulation of blood vessels activity.

Development of endocrine glands.

Diffuse endocrine system.

Trans- and parathyroid regulation.

Embryogenesis of the hematopoiesis.

Cellular basis of non-specific immunity.

Cellular basis of reactions of cellular and humoral immunity.

Development of the nervous system.

Regeneration of nerves.

Eye development.

Development of the ear.

Nerve endings of the skin, their role in the work of the statokinetic system.

Development of the oral cavity and organs of the digestive system.

Structural bases of digestion.

Neurohumoral regulation of digestion.

Intestinal-associated lymphoid tissue.

Development of digestive glands.

Regulation of secretory activity and regeneration of digestive glands.

Development of the respiratory system.

Neurohumoral regulation of mucociliary apparatus and bronchial tone.

Development of the urinary system.

Structural bases of urine concentration.

Development of organs of the male reproductive system.

Structural and molecular criteria for the diagnosis of male infertility.

Development of organs of the female genital system.

Regulating the ovarian-menstrual cycle.

Uterus.

Retroactivity of the endometrium and mechanisms of implantation.

Mechanisms of placental development.

Regularities of organogenesis.

Individual tasks

The individual task is chosen by the student at the beginning of studying of the module and is specified together with the teacher. Executed during study module. If necessary, the teacher provides counseling and makes corrections to the work. Completed task is given to the teacher before the beginning of the final module control. The evaluation of the work is conducted by the teacher in accordance with the distribution of the maximum number of points

Note: An individual modular task is not required.

Typical test problems to be solved in practical classes:

1. During the staining of specimens, various acidic and basic dyes are used. By origin they are divided into plant, animal, synthetic. Determine which of the following dyes by origin belongs to the animal?

- A. Carmine
- B. Azur
- C. Fuchsin
- D. Hematoxylin
- E. Methylene blue.

2. In a 50-year-old woman, new tissue regenerated at the site of the extracted tooth. Which organelles of blood cells, based on their function, are most active in tissue repair?

- A. Centrosomes
- B. Ribosomes
- C. Lysosomes
- D. Microtubules
- E. Postlysosomes.

3. In the experiment, the micromanipulator damaged the mesodermal pedicle connecting the somites and ventral mesoderm. The development of which body systems will be disrupted?

- A. Digestive
- B. Hematopoietic
- S. Endocrine
- D. Urinary
- E. Respiratory.

4. In the early stages of mammalian development, the yolk sac is damaged. What are the functions of the yolk sac in mammals?

- A. Trophic
- B. Respiratory
- S. Allocation
- D. Hematopoietic
- E. Protective.

5. During the study of the biopstat of the mucous membrane of the bronchus of the child revealed a defect of the cilia of the ciliated epithelium. What epithelial function is affected?

- A. Endocrine
- B. Secretarial
- C. Evacuation
- D. Excretory
- E. Protective.

4.4. Ensuring the educational process

Optical devices:

Micromed 2 - 7 pc

Biolam - 1 pc

Binocular Micromed - 1 pc

In total - 9 pcs

Micropreparations (100 pieces) according to the list
Slides on the topics of practical classes - 1 set.
Tables on the topics of practical classes and lectures - 1 set.
Demonstration screens, laptops, files in Power Point and Word with
tasks "Step-1" for practical and final classes.
Exam tickets

5. Final control

List of final control (exam) questions

INFORMATION BLOCK 1. Fundamentals of cytology and general embryology.

OVERVIEW

1. Histology. Definition, content and tasks of modern history. Its sections are important for biology and medicine.
2. Basic principles and stages of preparation of histological preparations.

CYTOLOGY

1. Cytology. Definition, tasks, importance for biology and medicine
2. Cell theory. The history of the problem Substantive provisions
3. Cell surface complex. Membrane, suprimembranous and diaphragm components Their structure and functions. Intercellular contacts, their types, structure and functions.
4. Cell as an elemental living system of a multicellular organism. Definition. The superficial complex of the cell. Its structure and functions
5. Metabolic apparatus of the cell. Its structural composition. Organelles of general importance Classification, structure and general characteristics
6. Cell nuclear apparatus, its value. Main components of the kernel, their structural and functional characteristics. Nuclear-cytoplasmic relationships as an indicator of the cell's functional state
7. Cell membranes. Modern understanding of their structure, properties and functional significance
8. Cell as elemental living system. Definition. Membrane organelles. Golgi Complex. Structure and Functional Value
9. Eukaryotic cells. General structure. Granular and non-granular endoplasmic reticulum. Structure and functions
10. Cell as elemental living system. Definition. General-purpose organelles. Mitochondria, structure, functional value
11. Cell is an elementary living system. Definition. The general plan of structure. Lysosomes. Structure, functional value
12. Cell as elemental living system. Definition. General plan for the construction of eukaryotic cells. Non-membrane organelles of the cytoplasm. Structure, functional value
13. Cell as elemental living system. Non-membrane organelles. Centrosome (cell center). Structure, functional value
14. Cell as an elemental living system. Exercise. The general plan of structure. Inclusion of the cytoplasm. Their classification and value
15. Cell cycle: its stages, morphofunctional characteristics, features in different cell types.
16. Methods of cell reproduction. Their morphological characteristics. Values for biology and medicine
17. Mitosis. Its importance, phases and regulation. Mitotic and interphase chromosomes
18. Mitosis. Its regulation. The value of mitosis for the biology of medicine
19. Mitosis. General characteristics of the different phases. The concept of endoreproduction and polyploidy

20. Meiosis. Its significance. Difference from mitosis
21. Cell growth, differentiation, aging and death. Response of cells to external influences

GENERAL EMBRYOLOGY

1. Embryology. Content. Scientific directions. Values for biology and medicine
 2. Types of eggs, the nature of their crushing after fertilization.
 3. Gastrulation. Definition of the concept. The biological significance of the first and second stages gastrulation.Characterization of different types of gastrulation
 4. Stages of embryogenesis. Gastrulation, its value. Comparative characteristic of gastrulation in chordates and humans
 5. Embryonic leaves. Definition of the concept. Mesoderm and mesenchyme, their derivatives
 6. Embryonic leaves. Definition of the concept. Ectoderm and endoderm, their derivatives
 7. Features of development of higher vertebrates (for example, birds)
 8. Axial complex of organs in vertebrates and its development
 9. The germ cells. Morphological and functional characteristics of sperm and oocytes.
- Fertilization
10. Early stages of human development. Features of crushing. Morula, blastocyst and its implantation
 11. Early human embryogenesis. Formation of germinal leaves. The concept of germinal rudiments
 12. Early human embryogenesis. Formation of transient organs (chorion, yolk and amniotic vesicles, allantois)
 13. Yolk sac, amnion and allantois. Their formation and functions in human embryonic development.
 14. Human embryo at 4 weeks of development. Formation of nerve tube, somites and intestinal tube
 15. The system «mother-fruit». Features of placental circulation. The structure of the umbilical cord
 16. Implantation. Placenta. Mammalian placental types
 17. Relationship of the human embryo with the maternal organism. Placenta and umbilical cor
 18. The placenta and its formation, structure and function
 19. The concept of critical periods of human embryo development
 20. The main stages of human embryonic development. Embryonic induction as one of the regulating mechanisms of embryogenesis

INFORMATION BLOCK 2: Fundamentals of general histology

TISSUES

1. Tissues. Definition of the concept. Classification. Contribution by O.O. Zavarzin and M.G.Khlopinin the development of the doctrine of tissue
2. Tissues as one of the levels of living organization. Definition. Classification of types. The concept of tissue determination and differentiation
3. The concept of diferons and stem cells.
4. Tissues as one of the levels of living organization. Definition. Cellular derivatives (syncytia and symplasts, intercellular substance)
5. Tissues. Definition. Physiological and reparative regeneration of different tissue types.

EPITHELIAL TISSUES

1. Epithelial tissues. General characteristics. Morphofunctional and genetic classification of their types

2. Epithelial tissues. Morphofunctional characterization of different types of epithelial cover
3. Glandular epithelium. Classification and structure of glands. Morphology of the secretory cycle. Types of glandular secretion

BLOOD AND HEMOPOIESIS

1. Embryonic hemocytopoiesis. Blood development as a tissue. Features of yolk and hepatic hematopoiesis
2. Postembryonic hematopoiesis. Modern scheme of hematopoiesis
3. Hemopoiesis in the post-embryonic period. The relationship of stromal and hematopoietic elements
4. Hemogram. Leukocyte formula, its value for the clinic. Erythrocytes, structure and functional value
5. Hemogram and leukocyte formula. Platelets, their number, function, duration of existence
6. Thrombocytopoiesis. Structure and function of platelets
7. Leucocyte formula. Leukocytopoiesis in embryonic and post-embryonic periods.
8. Leukocytes. Classification, morphofunctional characteristics. Leukocyte formula and its features at different stages of ontogeny
9. Blood leukocytes. Basophilic and eosinophilic granulocytes
10. Leucocyte formula. Morphofunctional characterization of monocytes. The concept of the system of mononuclear phagocytes
11. Macrophages and lymphocytes. Their structure, histochemical characteristics and participation in immune response
12. Characterization of immunocompetent cells. T and B lymphocytes. Their development, proliferation and differentiation

CONNECTIVE TISSUE

1. Fibrous connective tissue. Its structure, varieties and functional significance. Intercellular substance formation (for example collagen synthesis)
2. Intercellular substance of connective tissue (fibers, basic substance), structure, value
3. Intercellular substance of connective tissue. Collagen and elastic fibers. Their structure and functions
4. Connective tissue cells. Structure, functional value
5. Loose fibrous connective tissue. Morphofunctional characteristics. Macrophagocytes: structure and sources of development. The concept of the system of mononuclear phagocytes
6. Dense fibrous connective tissue. Morphofunctional characteristics. Structure of dense fibrous connective tissue (for example tendon)
7. Macrophagocytes: morphofunctional characteristics, their participation in natural and acquired immunity. The concept of the system of mononuclear phagocytes
8. Cellular elements of connective tissue. Macrophagocytes, plasma cells and their participation in the body's protective reactions
9. Connective tissues with special properties (reticular, fat, pigment, mucous). Structure and Functional Value

SUPPORTING TISSUE

Cartilage and bone tissue

1. Cartilage, their classification, structure and function. Cartilage development, their regeneration and age-related changes
2. Bone tissue. Classification of types. Morphofunctional characteristics
3. Reticulofibrous bone tissue. Its histogenesis, structure, regeneration and age changes
4. Plate bone tissue. Tubular bone. Structure, development, regeneration

5. Plate bone tissue. General Morphofunctional characteristics. Tubular bone regeneration and factors that affect bone structure

HEMOPOIETIC AND IMMUNE DEFENSE BODIES

1. The concept of the immune system and its tissue components. Classification and characterization of immunocytes and their interaction in humoral and cellular immunity responses

2. Hemopoiesis. The concept of stem and semi-stem cells of hematopoietic tissue. Modern scheme of hematopoiesis

3. Red and yellow bone marrow. Structure and functions. Characterization of postembryonic hematopoiesis in the red bone marrow. Interaction of stromal and hematopoietic elements

4. Organs of hematopoiesis and immune protection. Thymus gland. Structure and Functional Value. Characterization of postembryonic hematopoiesis in the thymus. The concept of age and accidental involution of the thymus

5. Organs of hematopoiesis and immune protection. Spleen. Structure and Functional Value. Features of embryonic and post-embryonic hematopoiesis in the spleen. T- and B-zones

6. Organs of hematopoiesis and immune protection. Lymph nodes. Structure and functional value of T- and B-zones of lymph nodes

MUSCLE TISSUES

1. Muscle tissue. Sources of development. General morphofunctional characteristics. Non-stained muscle tissue. Histogenesis, structure, regeneration

2. Muscle tissue. Sources of development, general morphofunctional characteristics. Striped muscle tissue. Structure, innervation, structural basis of reduction. Regeneration

3. Skeletal muscular tissue. The concept of red and white muscle fibers. Muscle structure as an organ.

4. Cardiac muscle tissue. Development, microscopic and ultramicroscopic structure

NERVE TISSUE

1. Nerve tissue. Morphofunctional characteristics. Sources of development. Neurons. Morphological and functional classification

2. Neuroglia. Classification, structure and significance of different types of neuroglia

3. Nerve fibers. Morphofunctional characteristics of myelin and demyelinated nerve fibers

4. Nerve endings. Classification of types. Morphofunctional characteristics of motor nerve endings

5. Nerve endings. Morphofunctional characterization of sensitive nerve endings

6. Nerve tissue. General characteristics. Interneural synapses, their structure and functions

7. Nerve tissue. Sources of development. Morphofunctional characteristics. The concept of simple and complex reflex arcs

INFORMATION BLOCK 3: Special histology

NERVOUS SYSTEM

1. The nervous system. General morphofunctional characteristics. Classification. Sources of development

2. Spinal cord. Morphofunctional characteristics. Development. The structure of gray and white matter. Neural composition. The ascending and descending leading pathways of the spinal cord

3. Sensitive nerve nodes. Structure, functions and connections

4. Autonomous (autonomic) nervous system. The structure of extra- and intramural ganglia. Classification of neurocytes by O.S. Dogel
5. Peripheral nerve. Structure, degeneration and regeneration after damage
6. The cerebellum. Structure and functional characteristics. Neuronal composition and gliocytes of cerebral cortex
7. The brain. General Morphofunctional characteristics. Cyto- and myeloarchitectonics of the cortex. Age changes
8. The brain. The bark of the large hemispheres. Morphofunctional principle of neocortex organization

SENSORY SYSTEMS (SENSORY ORGANS)

1. The senses. General morphofunctional characteristics. The organ of taste. Structure, development and cytophysiology
2. The senses. General morphofunctional characteristics. The sense of smell. Structure, development and cytophysiology
3. The eye. Embryonic development. The general plan of structure. Morphofunctional characteristics of the cornea and lens
4. The eye. Embryonic development. Dioptic apparatus of the eye (cornea, lens, vitreous body)
5. The eye. Embryonic development. The structure of the retina. Histophysiological characteristics of photoreceptor cells
6. The eye. Embryonic development. The retina of the visual, ciliary and iris parts. Histophysiological characteristics of photoreceptor cells
7. Hearing organ. Development, structure and histophysiology
8. Hearing organ. Sources of development. The structure of the outer, middle and inner ear. Histophysiology of the spiral organ
9. Body of balance and vibration. Sources of development. Structure and histophysiology

SKIN AND ITS DERIVATIVES

1. Skin. structure and sources of development. Features of the structure of thin skin
2. Skin. Sources of development. Structure and functions. Physiological regeneration of the epidermis. Features of the structure of oily skin
3. Derived skin (hair, nails, glands). Hair structure and function. Hair change.

CARDIOVASCULAR SYSTEM

1. Cardiovascular system. Morphofunctional characteristics. Classification of vessels. Relationship of hemodynamic conditions with the structure of blood vessels
2. The artery. Classification of types and their morphofunctional characteristics. Arteries of the muscular type
3. Arteries. Classification of types and their morphofunctional characteristics. Arteries of elastic and muscular-elastic types. Age changes
4. Vessels of hemomicrocirculatory bed. Morphofunctional characteristics of its links.
5. Arterio-venular anastomoses. Classification, structure of different types of anastomoses. their functions
6. Blood capillaries. The structure. The main types of capillaries. The concept of histogematic barriers
7. Veins. Classification. Development, structure, functions. Structure dependence on hemodynamic conditions
8. Lymphatic vessels. Morphofunctional characteristics. Sources of development
9. Heart. The general plan of structure of a wall. Myocardium. Morphofunctional characterization of contractile and conductive cardiomyocytes

10. Heart. Sources of development. Histogenesis. The general plan of structure of a wall. Endocardium

THE ENDOCRINE SYSTEM

1. Endocrine system. Classification of endocrine glands. The concept of target cells and hormone receptors
2. The endocrine system. Classification of endocrine glands. Characterization of single hormone-producing cells
3. The hypothalamus. Neurosecretory nuclei of the hypothalamus, features of the structure and function of neurosecretory cells. Hypothalamo-adenohypophyseal and hypothalamo-pituitary system themes
4. Pituitary gland. Development, structure, blood supply, histophysiology. Relationship of the pituitary gland with the hypothalamus
5. The pituitary gland. Development. The general plan of structure. Adenohypophysis, its blood supply, communication with the hypothalamus, functional significance
6. Pituitary gland. Development. The general plan of structure. Neurohypophysis, its blood supply, communication with the hypothalamus, functional significance.
7. The epiphysis. Sources of development. The structure. Secretarial functions
8. Thyroid gland. Development, structure, histophysiology, functional value. Age changes
9. Thyroid gland. Development, structure and functional value. Age changes
10. Adrenal glands. Sources of development. Structure, histophysiology of cortical and brain matter. Adrenal connection with the pituitary and central nervous system. Age changes

THE DIGESTIVE SYSTEM

1. The digestive canal. The general plan of structure of a wall. Innervation and vascularization. Morphofunctional characteristics of the lymphoid apparatus
2. The oral cavity. Features of the structure of the mucous membrane of various organs of the oral cavity
3. Oral cavity. General characteristics of the mucous membrane. Lip and cheek. Development, structure, functions
4. Hard and soft palate. Development. General structure. Morphological features of the mucous membrane on different surfaces
5. Language. Development. The general plan of structure. Features of the structure of the mucous membrane on different surfaces
6. Large salivary glands, their classification, development. Parotid salivary gland, structure, functions.
7. The large salivary glands. General characteristics. Submaxillary and sublingual salivary glands
8. Teeth. The general plan of structure. Dentine. Development, structure, functions. The concept of transparent dentin and interglobular spaces
9. Teeth. The general plan of structure. Enamel. Structure, functions, development.
10. Teeth. The general plan of structure. Enamel. Structure, functions, development
11. Teeth. The general plan of structure. Pulp and periodontium. Structure, functions, development
12. Tooth development. Cutting and replacement of teeth
13. The digestive canal. The general plan of structure of a wall. Throat and esophagus. Its structure and functions
14. The stomach. General morphofunctional characteristics. Sources of development. Features of the structure of different departments. Innervation and vascularization. Regeneration. Age changes
15. Gastric glands, their morphofunctional features in different parts of the body

16. The small intestine. Development. General morphofunctional characteristics. Histophysiology of the crypt-villus system
17. The colon. General morphofunctional characteristics. Sources of development. Structure, regeneration, age changes
18. The digestive canal. The general plan of structure of a wall. Morphofunctional characteristics of the endocrine apparatus
19. Worm-shaped process. General morphofunctional characteristics
20. Liver. General morphofunctional characteristic. Structure of hepatocytes, perisinusoidlipocytes and sinusoid wall
21. Liver. General morphofunctional characteristics. Sources of development. The structure of the classic liver lobe. Imagery of portal lobes and acinus. Regeneration. Age changes
22. Pancreas. Development. The general plan of structure. Histophysiology, regeneration, age-related changes
23. Pancreas. Development, general layout of the structure. The exocrine part, its structure and functions.

RESPIRATORY SYSTEM

1. Respiratory system. Morphofunctional characteristics. Respiratory and nonrespiratory functions, airways. Structure and function of the nasal cavity lining
2. Respiratory system. Morphofunctional characteristics. Airways. Sources of development. The structure and functions of the trachea and bronchi of different caliber
3. Lungs. Morphofunctional characteristics. Sources of development. The structure of the respiratory department. Aerogematic barrier. Particularly blood supply. Age changes
4. Structure and histophysiology of the lung acinus

URINARY SYSTEM

1. Urinary system, its morphofunctional characteristics. The kidneys. Sources and main stages of development. Structure and features of blood supply
2. The kidneys. Structure and functional significance of cortical nephrons
3. The kidneys. The general plan of structure. The endocrine apparatus of the kidney. Structure and function
4. Urinary tract. Development. Structure and Functional Value. Mucous epithelium (urothelium)

GENDER SYSTEM

1. The testicle. The structure. Embryonic and post-embryonic histogenesis. Functions. Spermatogenesis and its regulation
2. The testicle. The structure. Embryonic and post-embryonic histogenesis. The concept of hematotesticular barrier
3. The uterine tract and accessory glands of the male reproductive system. Appendix of the testicle. Family bubbles. The prostate gland. Structure, functions. Age changes
4. The ovary. Embryonic and post-embryonic histogenesis. Structure and function. Ovogenesis and its regulation
5. The ovary. Embryonic and post-embryonic histogenesis. Common rail structure. Endocrinal function of the ovary. Age changes
6. The uterus. Development. Structure and functions. Cyclic changes, hormonal regulation. Age changes
7. Organs of the female genital system. Fallopian tubes and vagina. Changes during the ovarian menstrual cycle, their hormonal regulation
8. Breast. Development, structure and functions. Hormonal regulation of the breast

«0» version of the exam ticket

BLACK SEA STATE UNIVERSITY OF A NAME OF PETRO MOHYLA

Educational qualification level - master

Branch of knowledge: 22 Health

Specialty 222 Medicine

**EDUCATIONAL DISCIPLINE - HISTOLOGY, CYTOLOGY AND
EMBRYOLOGY**

Option № 0

Theoretical part:

1. Non-membrane organelles **The maximum number of points is 20.**

2. Sensory systems: visual, auditory and gravitational analyzers. **The maximum number of points is 20.**

Practical part:

3 Identify the proposed histological preparation. **The maximum number of points is 20.**

Approved at the meeting of the Department of Medical Biology and Physics, Microbiology, Histology, Physiology and Pathophysiology №__ from __ 2020

Head of the Department _____ Prof. Korolova O.V

Examiner _____ Pshychenko V.V

An example of the final control work on block 1

Solving problems Step-1

1. During the postsynthetic period of the mitotic cycle, tubulin protein synthesis was disrupted. What consequences can this lead to?

- A. Violation of chromosome spiralization
- B. Cytokinesis disorders
- C. Reducing the duration of mitosis
- D. Violation of the formation of the division spindle
- E. Violation of DNA repair

2. In the blood test, the laboratory assistant found non-nuclear shaped elements in the form of biconcave disks. Name them:

- A. Monocytes
- B. Eosinophils
- C. Lymphocytes
- D. Red blood cells
- E. Netrophiles

3. The process of crushing the zygote ends with the formation of a blastula. What type of blastula is typical for humans?

- A. Blastocyst.
- B. Celoblastula.
- C. Discoblastula.
- D. Amphiblastula.
- E. Morula.

And so 20 problems with the subsequent analysis of typical errors

**Example of the final control work for Block 2
Solving problems Step-2**

1. In the preparation of human red bone marrow, clusters of giant cells located in close contact with sinusoidal capillaries are detected. Name The shaped blood elements that are formed from these cells.

- A. Blood plates
- B. Red Blood Cells
- C. White Blood Cells
- D Monocytes
- E. Lymphocytes

2. In the histological specimen of the tubular bone, signs of a regenerative process are detected at the site of the fracture. What tissue forms this structure?

- A. Coarse-fibrous bone structure
- B. Loose binder
- C. Reticular.
- D Epithelial
- E. Lamellar bone structure

3. With age, a person's skin undergoes changes, which can be manifested by a decrease in its elasticity. What elements of connective tissue most provide its elasticity?

- A. Collagen and elastic fibers
- B. The main substance
- C. Epidermal cells
- D. Connective tissue cells
- E. Reticular fibers

And so 20 tasks with subsequent analysis of typical errors

**Example of the final control work for Block 3
Solving problems Step-3**

1. A specimen of pia mater includes a vessel whose wall doesn't have the tunica media, the tunica externa is adherent to the surrounding tissues, the intima is composed of a basement membrane and endothelium. What vessel is it?

- A Nonmuscular vein
- B Muscular vein with underdeveloped muscular elements
- C Muscular artery
- D Arteriole
- E Artery of mixed type

2. The specimens present sections of haemopoetic and immunogenetic organs. Organ has lymph tissue forming different structures (lymph nodes, lobules, bars). In what organ does antigen-independent proliferation and differantiation take place?

- A Thymus
- B Lymphatic nodes
- C Spleen
- D Hemolymph nodes
- E Tonsil

3. 50 years old patient complains about enlargement of ears, nose and hands size. Hyperfunction of which gland does these symptoms give?

- A. Hypophysis
- B. Thyroid gland
- C. Sex glands
- D. Adrenal glands
- E. Pineal gland

And so 20 tasks with subsequent analysis of typical errors

6. Criteria for evaluation and tools for diagnosing learning outcomes

№	Type of activity (task)	Maximum number of points
1	Test control on tasks of the MLI format "Step-1". Number of tests - 30. Time to complete the entire stage - 30 minutes.	The weight of each correct answer is 1 point. The maximum number of points per stage is 30 points.
2	Written theoretical work on program questions. Number of questions - 2. Time to complete the entire stage - 60 minutes.	The weight of each correct answer is 25 points. The maximum number of points per stage is 50 points.
	Total	80

Control methods

- Survey (testing of theoretical knowledge and practical skills).
- Test control.
- Writing a review of scientific literature (abstracts), performing individual tasks, their defense.

Current control. Testing in practical classes of theoretical knowledge and the acquisition of practical skills, as well as the results of independent work of students. Supervised by teachers according to the specific purpose of the curriculum. Assessment of the level of students' training is carried out by: interviewing students, solving and analyzing situational tasks and test tasks, interpreting the results of experimental and clinical and laboratory research, monitoring the acquisition of practical skills.

Intermediate control. Checking the possibility of students using for clinical and diagnostic analysis of theoretical knowledge and practical skills on all topics studied, as well as the results of independent work of students. Carried out in the last lesson by section by passing practical skills, solving situational problems and testing.

The final control is carried out at the last practical lesson after the completion of the content module. The control of theoretical knowledge, acquired practical skills and abilities is carried out. The maximum number of points of the modular final control is 80. The module is considered credited if the student has scored at least 50 points. Carried out in 3 stages:

Distribution of points received by students

The grade for the discipline is set as the average of the grades for the topics of the three blocks on which the discipline is structured, only for those students who have all the blocks.

During the assessment of mastering each topic of the block the student is given grades on a 4-point (traditional) scale and on a 200-point scale using the accepted and approved assessment criteria for the respective discipline. This takes into account all types of work provided by the methodological development for the study of the topic. The student must receive a grade on each topic.

The grade for each block is determined taking into account the grades of current control and the final grade, which is set when assessing theoretical knowledge and practical skills in accordance with the lists defined by the program of the discipline. The maximum number of points in the study of the unit - 200, including for current educational activities - 120 points, according to the results of the final control - 80 points.

In order to assess the results of training in Histology, Cytology and Embryology, the final control is carried out in the form of an exam, which is recommended for academic disciplines that are part of the integrated test examinations EDKI and "Step-2". Only students who have passed both final tests (blocks 1-3) in the discipline are admitted to the exam.

Distribution of points awarded to students:

INFORMATION BLOCK 1	Number of points
Topic 1	8,0
Topic 2	8,0
Topic 3	8,0
Topic 4	8,0
Topic 5	8,0
Topic 6	8,0
Topic 7	8,0
Topic 8	8,0
Topic 9	8,0
Topic 10	8,0
Topic 11	8,0
Topic 12	8,0
Topic 13	8,0
Topic 14	8,0
Topic 15	8,0
The final module for the control 1.	80
Total sum of points	120
Total for Block 1	200
INFORMATION BLOCK 2	Number of points
Topic 1	10,0
Topic 2	10,0
Topic 3	10,0
Topic 4	10,0
Topic 5	10,0
Topic 6	10,0
Topic 7	10,0
Topic 8	10,0
Topic 9	10,0
Topic 10	10,0
Topic 11	10,0

Topic 12	10,0
The final module for the control 2	80
Total sum of points	120
Total for Block 2	200

INFORMATION BLOCK 3	Number of points
Topic 1	8,0
Topic 2	8,0
Topic 3	8,0
Topic 4	8,0
Topic 5	8,0
Topic 6	8,0
Topic 7	8,0
Topic 8	8,0
Topic 9	8,0
Topic 10	8,0
Topic 11	8,0
Topic 12	8,0
Topic 13	8,0
Topic 14	8,0
Topic 15	8,0
The final module for the control 3.	80
Total sum of points	120
Total for Block 3	200

Assessment in the discipline "Histology, Cytology and Embryology" is given only to students who have enrolled in all topics of the discipline. It is determined by the total number of points scored by the student in all practical and 2 final classes. The amount obtained is divided by 2, and the points scored are converted into a 4-point scale as follows:

Assessment of independent work is carried out during the current control of the topic in the relevant classroom.

Assessment of mastering the topics that are submitted only for independent work and are not included in the topics of classroom training, is controlled during the final control.

7. Recommended sources of information

7.1. Basic

- 1 Pawlina W, Ross M. Histology: a Text and Atlas with Correlated Cell and Molecular Biology. 8th edition. Wolters Kluwer. 2019. –928 p.
2. Junqueira LC, Carneiro J. Basic histology. 11 edition. 2005.
3. Carlson BM. Human Embryology and Developmental Biology. 5th edition, Saunders Elsevier. 2013.
4. Gartner LP, Hiatt JL. Color Atlas and Text of Histology. 6th edition. Wolters Kluwer. 2014.

Additional:

1. Young B, O'Dowd G, Woodford P. Wheater's Functional Histology: a Text and Colour Atlas. 6th edition, Elsevier Health Sciences. 2013.
2. Cochard L. Netter's Atlas of Human Embryology, 1st edition, Saunders Elsevier. 2012.

3. Dongmei Cui, John P. Naftel, Jonathan D. Fratkin, William Daley, James C. Lynch. Atlas of Histology: With Functional and Clinical Correlations, Lippincott Williams and Wilkins. 2010.
4. Lowe J., Anderson P. Stevens & Lowe's Human Histology, 4th Edition. Elsevier Health Sciences. 2014.
5. Moore KL, Persaud T.V.N, Torchia MG. The Developing Human: Clinically Oriented Embryology. 10th Edition, Elsevier, Philadelphia. 2016.
6. Sadler T. Langman's Medical Embryology. 13th edition. Wolters Kluwer. 2014.
7. Slípka J. Outlines of embryology. Karolinum, 2012
8. Slípka J. Outlines of histology. Karolinum. 2004
8. Kierszenbaum A.L., Tres L.L. Histology and Cell Biology. An introduction to pathology. 3rd ed. Elsevier, Philadelphia. 2012. 701 p.
9. Mescher A.L. Junqueira's basic histology. Text and atlas. 13th. Ed. New York, Mack Graw Hill. 2013. 559 p.
10. Ovalle W.K., Nahirney P.C. Netter's essential histology. Philadelphia, Saunders Elsevier, 2008. 493 p

7.3. Information resources on the Internet

1. <http://www.slideshare.net/mohammadanassirn/preparation-of-histological-slide>
2. <http://library.med.utah.edu/WebPath/HISTHTML/HISTOTCH/HISTOTCH.html>
3. <http://www.leicabiosystems.com/pathologyleaders/an-introduction-to-specimen-preparation/>
4. <http://www.kasem.info/histology-lectures/dental-histology-lectures/cell-nucleus>
5. <http://www.gettyimages.com/photos/nucleus>
6. <https://embryology.med.unsw.edu.au/embryology/index.php/Histology>
7. <https://quizlet.com/108067553/types-of-connective-tissue-flash-cards/>
8. <https://www.pinterest.com/kaiser254/1-hematopoiesis-and-bone-marrow/>
9. <http://www.proteinlounge.com/Pathway/Hematopoiesis%20from%20Pluripotent%20Stem%20Cell%20to%20Erythrocyte>
10. <http://study.com/academy/lesson/what-is-cartilage-function-definition-types.html>
11. <http://www.slideshare.net/Firedemon13/cartilage-9007184>
12. <http://www.lab.anhb.uwa.edu.au/mb140/CorePages/Bone/Bone.htm>
13. <http://www.slideshare.net/AnaRitaRamos1/human-bone-tissue>
14. <http://www.slideshare.net/AddisuAlemu/histology-of-bone>
15. <http://www2.sunysuffolk.edu/kennym/Ch7.pdf>
16. <https://opentextbc.ca/anatomyandphysiology/chapter/6-4-bone-formation-and-development/>
17. <http://lyceum.algonquincollege.com/lts/onlineCourses/anatomy/content/module7-3.htm>
18. <http://philschatz.com/anatomy-book/contents/m46509.html>
19. <https://www.britannica.com/science/nerve-ending>
20. <http://study.com/academy/lesson/sensory->
21. <http://veteriankey.com/introduction-to-the-nervous-system-2/>
22. <http://www.slideshare.net/Firedemon13/4-smooth-muscle-tissue>