**DEPARTMENT OF HISTOLOGY AND EMBRYOLOGY**
**POMERANIAN MEDICAL UNIVERSITY IN SZCZECIN**
**COURSE IN HISTOLOGY WITH EMBRYOLOGY AND CYTOPHYSIOLOGY**
**FOR STUDENTS OF FACULTY OF MEDICINE**

*The name of Unit in which the subject is realized*

**Department of Histology and Embryology**

**Head**
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**Professor**

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**Total hours:**

- **150 hours** include:
  - **60 h of seminars**
  - **90 h classes**

**ECTS:** 18

The purpose of histology course is to provide the sufficient information regarding the types of human tissues and morphology of human organs. The goal is also to explain the connection between the morphology of particular cells and their function.

The seminars in cytophysiology are to describe the principal information on molecular mechanisms that control the cell metabolism and are responsible for cell specificity.

The embryology seminars explain the prenatal development of human organism starting from conception (fertilization) through formation of blastocyst, gastrulation and organogenesis to the time of birth. The subject also includes the phases of human embryological development, sensitivity of embryo and fetus to the most common teratogenic factors, capability of survival in comparison to gestational age.

Theoretical background provided during two semesters of histology, embryology and cytophysiology course is necessary for students of medicine faculty and may be very helpful to understand etiology of diseases.

**FORMS OF ACTIVITIES**

Subject of **Histology with Embryology and Cytophysiology** is carried out in II and III terms in forms classes, seminars, colloquiums, and examination. There are no lectures.

1. **Seminars** are conducted during 15 h in II term on histology and 45 h in III term on histology, embryology and cytophysiology.

2. **Classes with histology** include 45 h in II term and 45 h in III term and are devoted to know the normal morphology of cells, tissues, organs and systems together with their function. The morphology is studied in histological slides under light microscope. The classes are carried out in 10-12 group of students per tutor. Classes are lasting 4 h and are preceded one hour of seminar presenting theory of following subjects and showing pictures watched slides. During the classes students are controlled by tutor with acquaintance of subject theory. Twice a term during the classes practical tests are carried out to recognize the tissue and organs in histological slides before the written tests.
3. **Seminars with cytophysiology and embryology** are conducted during 15 h in III term. They include the cell structure, histologically methods and chosen subject with cytophysiology (7 h) and embryo and fetus development, fetal membranes structures, organogenesis and teratology. The seminars are carried out in group of 20-30 students a one tutor.

4. The students skills in histology, embryology and cytophysiology are verified with four colloquiums (two in II term and two in III term) as written tests containing uni- and multi-choice questions. Each test has two re-sits.

5. **The final exam** on histology, embryology and cytophysiology is carried out as a written test (uni- and multichoice questions). Additionally, each student is obligated to pass practical examination – to recognize and discus chosen by tutor slides. The exam has two re-takes. For student wish, the 2-re-sit can be carried out in oral form.

**PROGRAM OF HISTOLOGY, CYTOPHYSIOLOGY AND EMBRYOLOGY**

**HISTOLOGY**

1. Epithelial tissue
   - Main characteristics of the basic types of tissues in human body
   - The forms and characteristics of epithelial cells
     - Basal lamina and basement membrane
     - Intercellular adhesion and intercellular junctions
   - Specializations of the cell surface
   - Type of epithelia
     - Covering epithelia
     - Glandular epithelia
   - Types of glandular epithelia
   - General biology of epithelial tissue
   - Origin of epithelia
   - Cell Adhesion Molecules (CAMs) – the role in physiology and pathology

2. Connective tissue and adipose tissue
   - General characteristics of connective tissue
   - The cells of connective tissue
   - Fibroblasts and fibrocytes – structure and functions
   - Cells temporary reside in connective tissue – structure and functions
   - Extracellular matrix
   - Fibers: collagen, elastic and reticular fibers
     - Biosynthesis of collagen and collagen types
     - The elastic fiber system
     - Reticular fibers – localization
   - Ground substances
     - Glycosaminoglycans (GAGs)
     - Proteoglicans
     - Multiadhesive glycoproteins
   - Types of connective tissue
     - Connective tissue proper
     - Connective tissue with special properties
   - Adipose tissue
     - Uniocular adipose tissue – morphology, functions, distribution
3. Cartilage and bone
- General characteristics of cartilage
- Hyaline cartilage
- Elastic cartilage
- Fibrocartilage
- General characteristics of cartilage bone
  - Bone cells
  - Bone matrix
  - Periosteum and endosteum
- Types of bone
  - Primary bone
  - Secondary bone
- Histogenesis of bone
- Bone growth and remodeling

4. Nerve tissue and the nervous system
- General characteristic of nervous tissue
- Neuron
  - Perykarion dendrites and axon
  - Anterograde and retrograde flow
  - Principles of electrophysiology: membrane resting and action potential
  - Synapse and neurotransmitters
  - Glial cells: classification, morphology and function
- Embryogenesis of nerve tissue
- Division of nervous system
  - Central and peripheral nervous system
  - Somatic and autonomic nervous system
- White and gray matter
  - Components and localization
- Meninges and spaces
- Cerebrospinal fluid circulation
- Blood brain barrier
- Nerves classification and structure
  - Myelinated and unmyelinated fibers
  - Afferent and efferent fibers
- Ganglia classification and structure
  - Sensory and autonomic ganglia
- Autonomic nervous system
  - General structure – pre and postganglionic neuron
  - Comparison of sympathetic and parasympathetic system
  - Distribution
- Degeneration and regeneration in nervous system

5. Muscle tissue
- General characteristics of muscle tissue
• Types of muscles
  ✓ Skeletal muscle
  ✓ Cardiac muscle
  ✓ Smooth muscle
• Connective tissue associated with muscles
• The mechanism of contraction in different kinds of muscle tissue
• Innervation of skeletal, cardiac and smooth muscle tissue
• Regeneration of muscles

6. Circulatory system
• General organization of the circulatory system, division on the functions.
  ✓ Structure of arteries and veins – composition of the vascular wall, vasa vasorum, inervation.
  ✓ Arteries – types (elastic, muscular, small arteries, arterioles, metaarterioles), differences in structure and function, distribution.
  ✓ Veins – types (large, medium small veins, postcapillary venules), morphology, functions.
  ✓ Capillaries – structure, types (continuous, fenestrated, discontinuous), correlation of structure and functions, distribution
  ✓atriovenous anastomoses structure and function
• Endothelium – morphology, distribution, functions, pathologic changes and clinical correlation
• Lymphatic vessels
  ✓ Heart- structure of the wall (layers - endocardium, myocardium, epicardium).
  ✓ Impulse-generating and conducting systems – structure and their role.
  ✓ Myoendocrine cells-structure, localization, function.

7. Blood and the bone marrow
• Composition of plasma
• Blood cells
• Stem cells
• Bone marrow
  ✓ Maturation of erythrocytes
  ✓ Granulopoiesis
  ✓ Maturation of lymphocytes and monocytes
  ✓ Origin of platelets

8. Lymphoid organs
• Classification of lymphocytes. Primary and secondary lymphatic organs and tissues.
• Antigens, antibodies. Classes of antibodies, actions of antibodies.
• Responses to antigens – non-specific and specific cellular and humoral immune responses.
• Cells of the lymphatic system – B-lymphocytes, T-lymphocytes. Lymphokines and interleukins. Macrophages and the immune response.
• Major Histocompatibility Complex (MHC). Organ transplantation.
• Antigen-Presenting Cells system (APCs).
• Mucosa-associated lymphoid tissue (MALT). Diffuse lymphatic tissue and lymphatic nodules - tonsils – morphology and function. Appendix and cecum, Peyer’s patches.
Thymus – role in T cell differentiation, vascularization, blood-thymus barrier, secretion by the thymus.

Lymph node – morphology of the cortex, paracortex and medulla, functions. Lymph circulation, role in the immune response, recirculation of lymphocytes.

Spleen – general structure, splenic pulps, close and open circulation, functions.

9. Digestive tract
- General structure of digestive tract
- Oral cavity
- Tongue
  - Papillae
  - Taste buds
- Teeth and associated structures
- Tooth development:
  - Stages of tooth development (bud, cap, bell)
  - Crown and root formation
  - Mineralization of dentin and enamel
  - Tooth eruption
- Pharynx
- Esophagus
- Stomach – general layers of the wall. Structure of the mucosa, submucosa, muscularis, serosa.
- Surface epithelium, gastric pits. Gastric glands – their morphology, distribution (regional differences), function. Glandular epithelium – the morphology of cells, functions, clinical correlation.
- Small intestine - features of the wall, morphological differences of the particular segments. Elements of the wall, which increase absorptive surface – plicae circulares (Kerckrings valves), villi, microvilli.
  - Villi and crypts– structure and function, cellular composition of the epithelium of villi and crypts.
  - Enteroendocrine cells of the gastrointestinal tract.
- Large intestine- specific features of the wall, crypts – morphology, cells of the epithelium. Innervation.
- Appendix – features of the wall.
- Defense mechanisms - gut-associated lymphoid tissue (GALT).

10. Organs associated with the digestive tract
- Types of secretory cells
- Salivary glands (histological structure of secreting portion and ducts)
- Saliva: Source and Composition
- Liver (classic lobule, portal lobule, liver accinus)
  - Cells of liver (structure and function)
  - Liver sinusoids
- Gallbladder
- Pancreas (structure, duct system)

11. Respiratory system
- General organization of the respiratory system and their subdivision on the conducting and respiratory portion
• Upper portion of the conducting portion: nasal cavity (vestibule and nasal fossae) and characteristic features of mucus membrane covered by the olfactory epithelium; nasopharynx, larynx and trachea
• Bronchial tree (bronchi and bronchioles) and type of covering epithelium (respiratory epithelium – structure, function and type of the epithelial cells)
• Respiratory portion of the lungs – respiratory bronchiole, alveolar duct and alveoli
  ✓  Arrangement of the lungs’ parenchyma
  ✓  Alveoli – structure, pneumocytes type I and type II and their function
  ✓  Structure of blood-air barrier.
  ✓  Surfactant and their role
  ✓  Lung macrophages
• Pulmonary blood vessels
• Development of the respiratory system

12. Skin
• General structure of the skin
  ✓  Populations of the cells in the epidermis
  ✓  Layers of epidermis, specific features of keratinocytes
  ✓  Epidermal barrier – structure and function
  ✓  Specific features of melanocytes – structure and function
  ✓  Specific features of Langerhans cells – composition and function of Skin Associated Lymphoid Tissue (SALT)
  ✓  Specific features of Merckel’s cells
  ✓  Basal lamina – structure and function
  ✓  Functions of the skin
  ✓  Layers of the dermis: papillary layer and reticular layer
• Structure of epidermal derivatives:
  ✓  The hair follicles and hair
  ✓  Nails
  ✓  Sebaceous glands
  ✓  Sweat glans

13. The urinary system
• Composition and function of the urinary system
• Functions of the kidneys
• Histological structure of the kidney
  ✓  Structure of the nephron
  ✓  Renal corpuscle
  ✓  Filtration barrier
  ✓  Henle’s loop structure
  ✓  Juxtaglomerular apparatus
• Blood circulation in the kidney
• Histological structure of the ureter, urinary bladder, urethra.

14. Endocrine gland
• The principles of endocrine glands
  ✓  Hormones classification
  ✓  Receptors and signal transduction
• The neuro-endocrine system
✓ Hypothalamus, nuclei micro- and macrocellulare
✓ Inhibitory and realizing hormones

• Adenohypophysis and neurohypophysis
  ✓ Embryonic development
  ✓ Division and morphology
  ✓ Hypophyseal portal system
  ✓ Pituitary hormones

• Thyroid gland
  ✓ Morphology, follicles, stroma, and parafollicular cells
  ✓ Follicular cells stages: hormones synthesis, accumulation and secretion

• Parathyroid glands, morphology and function

• Adrenal (Suprarenal) glands:
  ✓ Embryonic development
  ✓ Cortex: zones division, morphology, steroid synthesis and function
  ✓ Medulla: morphology, catecholamines synthesis, function
  ✓ Blood circulation in suprarenal glands

• Langerhans islets
  ✓ Cells classification, localization, functions

• Pineal body, morphology and function

15. The male reproductive system
• General characteristics of the male reproductive system
• Testes-structure and functions
  ✓ Seminiferous (Germinal) epithelium
  ✓ Sertoli cells and their role in spermatogenesis
  ✓ Intratesticular genital ducts
  ✓ The blood-testis barrier
  ✓ Interstitial (Leydig) cells
• Spermatogenesis and spermiogenesis
• Excretory genital ducts
  ✓ Ductus epididymidis
  ✓ Vas deferens
  ✓ Urethra
• Accessory genital glands
  ✓ Prostate
  ✓ Seminal vesicles
  ✓ Bulbourethral glands

16. The female reproductive system
• General characteristics of the female reproductive system
• Ovaries-structure and functions
  ✓ Ovarian follicles
  ✓ Follicular atresia
  ✓ Interstitial cells
  ✓ Oogenesis
  ✓ Ovulation
  ✓ Corpus luteum
• Uterus
  ✓ Endometrium
- Myometrium
- Uterine cervix
- Menstrual cycle
  - Menstrual phase
  - Proliferative phase
  - Secretory (luteal) phase
- Vagina
  - External genitalia

17. **Photoreceptor and audioreceptor systems**
- Receptor definition and classification
- Neuronal circuit – signal input
- Exteroceptors and interoreceptors
  - Nociceptors, free endings, Ruffini, Krause, Meissner, Pacinian bodies
  - Chemoreceptors, taste bud, olfactory cells
- Proprioreceptors
  - Muscle spindle, Golgi tendon organ
- Photoreception: eye
  - Eye bulb tunics structure
  - Retina layers: sensitive and blind portion, rod and cones,
  - Basis of photophysiology: visual pigments
  - Accessory structures of eye
- Auditory receptor system
  - External, middle and inner ears
  - Tympanic cavity: lining, auditory ossicles, auditory tube
  - Bony and membranous labyrinth – composition, structure, endo- and perilymph circulation
  - Vestibulum: maculae saccule and utricule, cristae ampullares, receptor cells and equilibrium
  - Cochlea: scalae, organ of Corti, receptor and supporting cells, auditory

**CYTOPHYSIOLOGY**

1. **The cell**
- Cell components
  - Plasma membrane-fluid mosaic model
  - Cytoplasm
  - Nucleus
  - Endoplasmic reticulum
  - Ribosomes
  - Mitochondria
  - Golgi apparatus
  - Lysosomes
  - Proteasomes
  - Peroxisomes
- Cellular transport

2. **Methods of study in histology**
- Types of microscopes used in histology
• General structure of light microscope (mechanical and optical part; resolution and resolving power of light microscope)
• Preparation of tissue for light microscopy (fixation and fixatives, dehydration and clearing, embedding media, staining and type of dyes)
• Different method of staining depending on sample content and structures of cells/tissues – histochemistry/cytochemistry; immunohistochemistry
• Cell and tissue culture- how to make and what for?

3. Cytoskeleton
• Microtubules
• Microfilaments
• Intermediate filaments

4. Cell cycle
• Phases of cell cycle
• Control of cell cycle
• Cell division

5. Cell growth and differentiation,
• Hypertrophy, hyperplasia, regulation of cell growth, growth factors
• Types of cellular populations
• Cell differentiation
• Cell to cell interaction and its impact to differentiation..

6. Ageing of cells and apoptosis
• Definition of ageing
• Theories of ageing
• Sublethal and lethal cell injury
  ✓ Cellular mechanism of injuring factors activity
  ✓ Molecular mechanism of cell regeneration and recovery
  ✓ Stages of anoxic cell injury
• Necrosis morphological features and examples
• Apoptosis morphological features and examples in embryonic and postnatal live

7. Receptors
• General definition of cell signaling
• Types of cell signaling
  ✓ Autocrine signaling
  ✓ Paracrine signaling
  ✓ Endocrine signaling
  ✓ Nerve signaling
• Types of answer in cell signaling
• Types of signaling molecules
• Receptors
  ✓ Ion-channel- linked
  ✓ G-protein- linked
  ✓ Enzyme-linked
  ✓ Cytoplasmic or nuclear
EMBRIOLOGY

1. Fertilization
   • Capacitation
   • Acrosomal reaction
   • Fusion of germ cells
   • Completion of second meiotic division

2. The embryonic period
   • Preimplantation development: fertilization to implantation
   • Second week of development: bilaminar germ disc
   • Third week of development: trilaminar germ disc
   • Third to eight week

3. Ninth week to birth
   • Fetus and placenta
   • Organogenesis – detailed embryology

4. Fetal membranes and placenta
   • Types of fetal membranes
   • Formation of fetal membranes
   • Phases of placenta development
   • Structure of human placenta

5. Birth defects and prenatal diagnosis
   • Birth defects – types of abnormalities
   • Principles of teratology
   ✓ Teratogens associated with human malformation

Textbooks

Histology & Cytophysiology

2. Ross M., Kaye GI., Pawlina W. Histology, a text and atlas.
or
3. Philip Deakin, Barbara Young et al. : Wheather’s Functional Histology

Embriology

Skills and competences of the student who completed the course in histology, embryology and cytophysiology.
Each student is required to:
   • be able to recognize tissues and organs under light microscopy
   • be able to describe and explain the morphology of human tissues, organs and their function
• be able to describe the embryonic and fetal human development
• know the basic mechanisms responsible for birth defects
• understand the mechanisms regulating the cell cycle, process of the proliferation and differentiation of cells
• understand importance of apoptosis in the embryogenesis
• know the principles on the participation of cell adhesion molecules in physiological and pathological processes