Course of study: Medicine and Surgery
Teaching: Histology and Embryology
Scientific disciplinary sector: BIO/17
Number CFU: 10

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PREREQUISITES

Although there are no propaedeutic requirements, basic concepts of cell biology are required.

LEARNING OBJECTIVES

Aim of the integrated course of Histology and Embryology is to provide students with knowledge on the physiological organization and development of cells and tissues. During the Histology lectures fundamentals of cytology are discussed for the full understanding of the organization of tissues and their development. The organization of cells and extracellular matrix and their association in the organization of the different tissues is illustrated and discussed, together with the standard histological procedures, including microscopy approaches (optics, fluorescence and electronics), as a tool for the study of structure and development of the human organism.

LEARNING OUTCOMES

Knowledge and understanding

At the end of the course of Histology and Embryology the student should have acquired:

- Knowledge on the structure of the various tissues forming the human organism
- Knowledge on the histological organization of the various human organs
- Knowledge on the developmental process of the human organism and the main apparatus
- Ability to recognize the morphology of tissues and the cells that compose them, from a morphological and functional point of view
- Ability to recognize and describe the microscopic organization of tissues and organs, and the processes leading to their formation during development
- Ability to synthesize and correlate the various topics.

Applying knowledge and understanding

At the end of the course the student should be able to:

- Recognize and contextualize microscopic information.
- Understand the relationship between cells and the extracellular matrix underlying the organization of the different tissues of the multicellular organism.
- Apply the knowledge of histology and embryology to the subsequent study of physiology, anatomy, pathological anatomy and clinical disciplines.

Communication skills

At the end of the course the student should be able to:

- Use a correct scientific terminology to identify, at the microscopic level, the different types of cells and tissues present in the human body and the mechanisms of their formation during embryonic development.

Making judgements

At the end of the course the student should:

- Autonomously interpret histological slides and describe the processes of embryogenesis and organogenesis.

COURSE SYLLABUS

CITOLOGY

METHODS TO STUDY CELLS AND TISSUES

Notes on the use of optical (bright field, phase contrast, interference, fluorescence, confocal) and electronic (TEM and SEM) microscopes; unit of measurement and resolving power (Abbe's formula). Procedures for preparing of specimens for optical (paraffin and freezing) and electron microscopy. Cell cultures. Autoradiography and electrophoresis. Main histo- morphological and histochemical staining procedure. Principles of immunolocalization of cellular molecules and organelles. The fractional centrifugation.

THE PLASMA MEMBRANE

Molecular structure and organization of the plasma membrane: the fluid mosaic model; membrane lipids and their properties; extrinsic and intrinsic proteins: antigenic properties, function as adhesive proteins, function as receptors and their role in signal transduction. Transport of small molecules and water across the plasma membrane: simple diffusion, facilitated diffusion, active transport and osmosis. Principal morphological ((freeze-fracture) and molecular (immunolocalization and electrophoresis of proteins) study methods. Composition and functions of the glycocalyx.

THE CYTOPLASMIC ORGANELLES

Composition of the cytosol and of the various cytoplasmic inclusions (glycogen granules

and lipid droplets). The smooth endoplasmic reticulum: structure, role in lipid metabolism, detoxification processes, in glycogenolysis and in the accumulation of calcium. Ultrastructural organization and function of the rough endoplasmic reticulum. Main steps in the translation process and differences between the synthesis of proteins destined for the cytosol and of secretory, membrane or lysosomal proteins. Post-translational modifications of proteins: glycosylation, hydroxylation and role of molecular chaperones. COP protein- coated transport vesicles. Specificity of vesicular transport and fusion processes: v-SNARE and t-SNARE proteins. Golgi complex: ultrastructure, biosynthetic processes and sorting of the molecules synthesized in the endoplasmic reticulum. Constitutive and regulated cell secretion: regulatory mechanisms. Endocytosis. Internalization of soluble molecules by caveole: pinocytosis, transcytosis, interactions of caveolins with signal molecules. Receptor Mediated Endocytosis: Clathrin-coated vesicles. Endosomes and the different sorting pathways of specific ligands. Lysosomes: biogenesis, morphology, hydrolytic enzymes. Phagocytosis and autophagy. The peroxisomes: structure and functions
Mechanisms for the degradation of cytoplasmic proteins: the ubiquitin-proteasome system and the aggresome.

Mitochondria: morphology, distribution and replication. Mitochondrial genome. Localization and function of mitochondrial enzymatic complexes: main aspects of the Krebs cycle and oxidative phosphorylation. Role of mitochondria in calcium homeostasis, in apoptosis and in the synthesis of steroid hormones.
The cytoskeleton. Microtubules, microfilaments and intermediate filaments: molecular organization, distribution in the cell and in the different cell types. The function of the cytoskeleton in specific processes such as cell motility, phagocytosis, endocytosis, exocytosis, vesicle movement. Proteins associated with microtubules (kinesins and dyneins) and microfilaments (proteins that bind actin). The centrosome. The membrane cytoskeleton. Vibrating lashes: structure and function. The primary edge.

THE NUCLEUS
Structure of the interphase nucleus. Exchanges between nucleus and cytoplasm. Composition of interphase chromatin and nuclear matrix. Euchromatin and heterochromatin. The nucleosomes. Histones, non-histone regulatory proteins. The nucleolus: molecular structure and organization; the synthesis of rRNA and the assembly of ribosomal subunits. The nuclear envelope: differences between the cytoplasmic and nuclear surfaces, structure and function of nuclear pores, importins and exports, associated regulatory molecules, the nuclear lamina.
Notes on cell division and the phases of the cell cycle. Notes on the formation of chromosomes (their structure) and the mitotic apparatus. Notes on the stages of mitosis.

CELLULAR INTERACTIONS

General principles of paracrine, autocrine, endocrine and justacrine cellular interactions. Cell- cell and cell-matrix adhesive systems. The intercellular junction structures: structural and molecular organization of the occluding junctions, of the anchoring junctions (adherent zonules and desmosomes) and of the communicating junctions (gap junctions). The integrins. Podosomes and focal adhesions. Hemidesmosomes.

HISTOLOGY

METHODS FOR THE MORPHOLOGICAL STUDY OF TISSUES

Optical microscopes (transmitted light, phase contrast, interferential, fluorescence and confocal optical microscopes) and electronic microscopes (TEM and SEM); unit of measurement and resolution power (Abbe formula). Procedures for histological preparation for the optical (paraffin preparation and freezing) and electronic microscope. The cell cultures. Autoradiography and electrophoresis. Main histo-morphological and histochemical staining. Principles of immunolocalization of molecules and cellular organelles. Fractional centrifugation.

THE STEM CELLS

Notes on cellular differentiation. Stem cells (general characteristics of embryonic stem cells, adult tissues, and induced pluripotent stem cells). Stem niches. Cloning. Tissue regeneration.

THE EPITHELIAL TISSUES

Generalities (organization, vascularization and innervation) and embryonic derivation. Characteristics of epithelial cells [shape, polarity, specializations of the apical surface (common cilia and primary cilia (notes on ciliopathies), microvilli, stereocilia], specializations of the lateral surface [adhesive molecules and junction complexes (ultrastructural and molecular organization of the occluding junction, adherent, desmosome), the gap junctions], specializations of the basal surface (structural and molecular organization, function of the basal lamina), the cytoskeleton, epithelial stem cells (general characteristics of stem cells of adult tissues).
Classification of epithelial tissues (lining and glandular; notes on sensory and special epithelia).

Surface epithelia. General characteristics, classification, distribution and hints of functions. Mucous membranes (intestinal epithelium, airway epithelium, bladder epithelium), serosa, skin and endothelium [notes on the structure of capillaries (continuous, fenestrated and sinusoid capillaries, passage of molecules and cells through the endothelium) and of blood vessels].
Epidermis (keratinocytes and corneification, melanocytes and melanogenesis, Langherans cells and Merkel cells).

Clinical links: celiac disease, primary ciliary dysnesia (PCD) or immotile cilia syndrome, Bardet-Biedl syndrome (BBS), pemphigus, Harlequin-type ichthyosis, melanoma.

Glandular epithelia. Embryonic derivation and histological organization of the exocrine and endocrine glands (parenchyma and stroma). *Exocrine glands* (position, organization, types of adenomeres and excretory ducts), classification and secretions (serous, mucous, mixed). Myoepithelial cells. Examples of exocrine glands: skin glands (sebaceous, sweat and mammary glands), major salivary glands(parotide, sublingual and sub-mandible), pancreas, digestive glands, goblet cells. *Endocrine glands*. General characteristics (concept of cellular signalling, autocrine, paracrine, endocrine, exosomes) and histological organization (cordonal, follicular and interstitial). Hormones (polypeptides, amino acids and steroids). Examples of histological organization and functions of endocrine glands: pituitary, thyroid, adrenal, pancreas.

THE CONNECTIVE TISSUES

General characteristics, embryonic origin, classification, distribution and functions.

The connective tissues proper (classification, distribution and functions): loose (areolar) and dense (regular and irregular). Mesenchymal stem cells. Resident cells (fibroblasts, reticular cells, macrophages [phagocytosis (opsonins, Toll-type receptors, complement, such as APC cells, the macrophage system), mast cells, adipocytes]. Integrins and interactions with molecules of the intercellular substance. Intercellular substance (amorphous matrix and protein fibers). Amorphous matrix (GAGs, proteoglycans and glycoproteins) and interstitial fluid. Protein fibers. Collagens (fibrillar, laminar/reticular and FACIT and their molecular organization in particular of collagen I, synthesis and fibrillogenesis). Elastin and elastic fibers (molecular characteristics of elastin, fibrillins and their synthesis). Connective tissues proper with special properties [adipose (white and brown), reticular, elastic, pigmented, mucous].
Clinical links: notes on some pathologies due to proteoglycans, collagenopathies and elastinopathies; degenerative arthritis, myxoedema, Graves' disease, collagenopathies, scurvy, Ehlers-Danlos syndrome (EDS), Marphan syndrome.

The supporting connective tissues.
Cartilage tissues. Hyaline cartilage (embryonic origin, histological organization, distribution and growth, staining, perichondrium, chondroblasts / chondrocytes, intercellular substance and aggrecans, collagen fibers). Special types of hyaline cartilage (metaphyseal/conjugation and articular cartilage). Elastic cartilage (embryonic origin, histological organization, distribution and growth, staining, perichondrium, chondroblasts / chondrocytes, intercellular substance). Fibrous cartilage (embryonic origin, histological organization, distribution and growth, staining, perichondrium,

chondroblasts / chondrocytes, intercellular substance).

Bone tissues.

1. General characteristics of their histological composition and organization (types of bones, vascularity, innervation). Cells (osteoprogenitors, osteoblasts, osteocytes, osteoclasts). Intercellular substance (mineralized matrix, collagen fibers, glycoproteins). Lamellar (compact or spongy) and not lamellar bone tissue. Preparation of a histological preparation of bone tissue (demineralization or section due to wear). Periosteum and endosteum. Osteoblasts (synthesis of molecules of the intercellular substance, their role in the formation of osteoclasts-RANK / RANKL, in maintaining the "niche" of hematopoietic stem cells and in mineralization). Osteocytes. Osteoclasts: origin, cytological (podosome) and functional (hydrogen ion pump, lysosome) characteristics. Role of osteoblasts and osteoclasts in calcium metabolism (parathyroid hormone, calcitonin). Notes on osteoporosis (estrogens, RANKL and OPG).

2. Ossification. Direct ossification. Indirect ossification. Example of ossification of the bones of the face and skull (chondrocranium and neurocranium). Example of indirect ossification of a long bone of the axial skeleton (primary ossification center and secondary ossification centers). Growth in length (metaphyseal cartilage) and width and ossification of a bone. Formation of an osteone. Mechanisms of mineralization (role of osteoblasts, mineralization vesicles, collagen fibers and proteoglycans).

Clinical correlations: Osteoarthritis, rheumatoid arthritis, dwarfism, osteogenesis imperfecta, osteopetrosis, Osteoporosis

Blood and lymph

Blood (composition and functions). Plasma (serum) and corpuscular elements (hematocrit, buffy coat, blood smear). Red blood cells [structural (size, shape and cytoskeleton) and functional characteristics (numbers, hemoglobin, transport of oxygen and carbon dioxide, hemolysis processes, notes on blood groups]. Platelets [structural characteristics (size, chromomer, hyalomer, shape and cytoskeleton, granules) and functional characteristics (numbers, plug and thrombus)]. Activation of platelets (adhesion to collagen, exocytosis granules, exposure of phospholipids and thrombin and fibrinogen receptors, aggregation). White blood cells (types and numbers, the leukocyte formula, diapedesis). Neutrophils (how to recognize them in a blood smear, MO and TEM characteristics; "kamikaze" and "effect

functions" spiderman ", the" respiratory burst "). Eosinophils (how to recognize them in a blood smear, characteristics at MO and TEM; functions, the basic protein ica major). Basophils (how to recognize them in a blood smear, OM and TEM characteristics; functions). Monocytes (how to recognize them in a blood smear, characteristics at OM and TEM). Lymphocytes (how to recognize them in a blood smear, characteristics at OM and TEM; functions).
Notes on haemolytic pathologies (cytoskeletal anomalies, favism and sickle cell anemia). Notes on the intrinsic and extrinsic blood coagulation.
Lymph (composition and function).
Lympho-hematopoietic tissues. Lymphoid tissues (notes on the structure and functions of the thymus, lymph nodes, spleen and bone marrow).
Hemopoiesis [the hematopoietic stem cell, hematopoietic cytokines, progenitors and precursors of differentiative cell lines, erythropoiesis, granulocytopoiesis, monocytopoiesis, thrombopoiesis (mechanisms of platelet release), lymphopoiesis].
The immune system. Innate and acquired immunity. Notes on the functions of B, T and NK lymphocytes (concept of antigen, antibodies, complement, clonal selection, gene rearrangement, immune memory, APC cells, the HLA system, the different classes of T lymphocytes).
Clinical correlations: Microcytosis, macrocytosis, red blood cell membrane defects, anaemias, red blood cell enzymopathies, red blood cell haemoglobinopathies, allergies, inflammation.

Tooth tissues

Mineralized tissues: enamel, dentin, cement. Soft tissues: paradontium and pulp.

MUSCLE TISSUES

General characteristics, embryonic origin, classification, distribution.
Skeletal muscle tissue. General organization of a muscle. Muscle fibers cytological (shape and size, colorability, bands and striae) and ultrastructural characteristics. Myofibrils and contractile myofilaments, the sarcomere. The actin filaments (molecular organization); myosin filaments (molecular organization); filaments and accessory proteins of the sarcomere (titin, nebulin, oscurin, protein C, myomesin); the dystrophin and the costamer. The triads and the sarcoplasmic reticulum. Neuromuscular synapse, motor plate, functioning of a cholinergic synapse. The molecular mechanism of muscle contraction (action potential, T tubules, DHPR and ryanodine receptors, calcium ions and troponins / tropomyosin, the myosin heads interaction cycle, ATP, binding sites on actin filaments). Satellite cells. Structural, metabolic and functional heterogeneity of muscle fibers (type I, type IIa, IIb and IIx fibers). Outline of muscle fiber growth factors IGF-1 and myostatin, testosterone and anabolic steroids.
Smooth muscle tissue. General organization of the tissue (laminae, small muscles, myoepithelial cells). Cytological (shape and size) and ultrastructural characteristics of the smooth muscle cell (caveole, gap junctions, dense bodies, contractile filaments).

Organization of contractile filaments (caldesmone, calponina, dense bodies, intermediate filaments of the cytoskeleton). Characteristics and stimuli (nervous, hormonal, mechanical, NO) of the contraction. Unitary and multi-unit musculature. Synapses "en passant". Molecular mechanism of contraction (calmodulin, MLCK, myosin light chain phosphorylation, caldesmone / calponin).

Cardiac muscle tissue. General tissue organization, cardiomyocyte network and intercalated discs. Cytological (shape and size) and ultrastructural characteristics of the cardiomyocyte (intercalated discs, contractile filaments, sarcomere, dyads, mitochondria). Characteristics of cardiomyocyte contraction (sodium channels and spontaneous onset of action potential, DHPR and ryanodine channels, calcium ion and sarcomere). Special cardiomyocytes of the sinoatrial node and Purkinje cells.

NERVOUS TISSUE

General characteristics, embryonic origin, classification, distribution. CNS and SNP. The autonomic nervous system.
General organization of the tissue (neuronal networks, synapses, glia, gray matter and white matter). Connective lining (the meninges) and vascularization (the blood-brain barrier). Special histological methods for the study of nervous tissue from "black" Golgi to "Clarity" staining.
Cytological (shape and size, plates of Nissl, cytoskeleton, Golgi) and ultrastructural characteristics (neurotubules and neurofilaments, actin filaments, REG) of the neuron. Morphological and functional classification of neurons. Dendrites. The axon and its coatings (the myelin sheath and the concept of nerve fiber). Structure, ultrastructure and molecular organization of the myelin sheath. The axoplasmic flow. Regenerative capacity of the axon. General principles of the functioning of a neuron (the resting potential, the action potential and the propagation of the nerve impulse). The electrical and chemical synapses. Interneuronal chemical synapses (synaptogenesis, types and structure, pre- and postsynaptic density, neurotransmitters, neuropeptides). Histological structure of the nerves and ganglia. The glia (astrocytes, oligodendrocytes, ependyma, microglia, Schwann cells, satellite cells). Notes on neuronal stem cells.

EMBRYOLOGY

SPERMATOGENESIS, OOGENESIS AND FERTILIZATION

The meiotic division. Timing and modalities of meiosis in spermatogenesis and ovogenesis. Aneuploidy. Testis structure: albuginea tunic, lobules, seminiferous tubules, rectus tubules and rete testis. Localization and function of Sertoli cells, Leydig cells and myodid cells. Male genital tract and related glands. The seminiferous epithelium. Spermatogenesis: the mitotic phase, the meiotic phase and spermiogenesis. Structure of spermatozoa. Cycle and wave of the seminiferous epithelium. The Immune Privilege of the Testis. Hormonal control of spermatogenesis. Testicular tumors.
Structure of the ovary: cortical area and medullary area. Folliculogenesis: the primordial,

primary, secondary, antral, dominant, ovulatory follicle. The zona pellucida. The cells of the theca. Ovulation. The corpus luteum. Ovarian cycle and uterine cycle. Hormonal control of the ovarian cycle and follicular selection. Mutual influence between somatic cells and the oocyte: growth and maturation of the oocyte and proliferation and maturation of follicular cells. The sperm. Capacitation and acrosomal reaction of spermatozoa. Fertilization. Activation of the oocyte: calcium, cortical reaction, completion of meiosis (MPF and cytostatic factor). Parthenogenesis and imprinting. Birth control methods. Assisted reproduction techniques. Generalities of prenatal development: embryonic and fetal period and sensitivity to teratogenic agents. Diagnosis and prenatal therapy.

FIRST WEEK OF DEVELOPMENT

The segmentation. Cloning. Embryonic stem cells (ES), adult stem cells and induced pluripotent cells (iPSCs). Preimplantation genetic diagnosis. IVF and ICSI. Activation of the embryo genome. Inactivation of the X chromosome. Imprinting and hydatiform mole.

SECOND WEEK OF DEVELOPMENT

Embryonic implantation. Differentiation of the trophoblast: cytotrophoblast, syncytium trophoblast and lacunar system. HCG and pregnancy test. Amniotic cavity and yolk sac. Formation of the extraembryonic mesoderm. Chorionic or extra-embryonic coelomic cavity. Decidual reaction. Ectopic implant.

THIRD WEEK OF DEVELOPMENT

Gastrulation and formation of the three embryonic sheets. Primary epithelial-mesenchymal transition. Buccopharyngeal and cloacal membrane. Allantoid diverticulum. Development of the notochord, induction of the neural plaque (BMP inhibitors: cord, noggin and follistatin) and neurulation. Neural tube and neural crest. The paraxial, intermediate and lateral mesoderm. The intra-embryonic coelom. Formation of extra- and intra-embryonic angioblastic islands. Cardiogenic area and transverse septum. Regression of the primitive line and the sacro-coccygeal teratoma. Determination of the body axes: AVE, Hensen's node, notochord, primitive line and postero-anterior, dorso-ventral and left-right decreasing gradient of factors of the TGFbeta family (nodal and BMP). Differentiation of neural crests and importance of BMP, WNT and FGF.

FOURTH WEEK OF DEVELOPMENT

Lateral and cephalo-caudal folding and cylindrical definition of the body. Development of the ectoderm, mesoderm and endoderm. Homeotic genes and the body pattern along the anterior-posterior axis. Molecular mechanisms of somitogenesis (clock and wavefront model).

ORGANOGENESIS

The ectoderm: epidermis and attached glands. Origin of melanoblasts, Merkel cells and

Langherans cells. Development of placodes and neogenesis of hairs. Malformations: bullous epidermis, harlequin fetus, ectopic dysplasia, albinism.

The neuroectoderm: development of the neural tube. Eminence or caudal gem. Three to five brain vesicles. Derivatives of the walls and cavities of the five vesicles. Development of the pituitary gland. The spinal cord and the formation of the equine tail. Derivatives of the neuroepithelium: neurons and glia of the central nervous system. Radial glial cells. Differentiation of microglia cells. The peripheral nervous system and other derivatives of neural crest cells. Importance of BMP and SHH in the differential development of neurons in the spinal cord. NGF and neurotrophic factors. Malformations: rachisisis, spina bifida occulta, meningocele, meningomyelocele.

Development of ***the face and neck****.* Development and derivatives of the frontal process, arches, clefts and pharyngeal pouches. Stomodeum and buccopharyngeal membrane. Embryonic derivation of the cartilages, bones, muscles and nerves of the face. Development of the primitive and definitive palate, tongue and thyroid. Tooth development: four stages.

Malformations: cervical sinus, cleft lip (cleft lip), cleft palate, cleft lip and palate *The endoderm and the formation of the primitive intestine*. Mesentery and peritoneal, retro peritoneal and secondarily retro peritoneal organs.

Anterior intestine: vascularization and development. Pharyngeal intestine, oesophagus, stomach, omentum, upper duodenum, liver, gallbladder, pancreas. Spleen. Development of the respiratory system. Formation of the pericardial, pleural, and peritoneal cavities. The diaphragm. Malformations: tracheal oesophagus fistula, atresia of the oesophagus, diaphragmatic hernia, stenosis and atresia of the duodenum, annular pancreas.

The middle intestine*:* small intestine, cecum, ascending colon, and two thirds of the transverse colon. Rotations and vascularization. Malformations: Meckel's diverticulum, omphalocele, rotational and volcanic defects.

The primitive posterior intestine*:* the cloaca and its burial. Formation of the last third of the transverse colon, descending colon, sigmoid colon, rectum, upper part of the anal canal. Proctodeo. Bladder and urethra.

Development of the ***urogenital system****.* Hormonal and genetic formation and regulation (SRY, SOX9, FGF9) of the male and female gonads, genital tracts and external genitalia. Differentiation of PGCs. Egg reserve. Malformations: pseudohermaphroditism, hypospadias, cryptorchidism, bicornuate uterus, tumors of germline origin.

Formation of ***the urinary system.*** Development of the ureters and kidneys: pronephros, mesonephros, metanephros. The mesonephric duct and the ureteral gem. Metanephric blastema. Functional maturation and ascent of the kidneys. Endodermal derivation of the bladder and urethra. The bladder trine. Molecular processes of the development of the collector system and nephrons (WNT1, GDNF, WNT4). Malformations: renal agenesis, supernumerary ureters and kidneys.

Outline of the development of the ***circulatory system****.* Angioblastic islands. Hematopoietic stem cells of the yolk sac and of the aorta-gonadal-mesonefric region. Locations of hematopoiesis before and after birth. The development of the heart. Foldings and expansions in the fourth week. Subdivision of the primitive atrium. Formation of endocardial cushions

and signalling pathways involved. The heart at the end of the eighth week. FGF, VEGF and ANG1 in vasculogenesis. Outline of the arterial and venous system development. Fetal circulation and birth changes.

Development of ***the locomotor system.*** Somites development: sclerotome, dermatome, myotome. Derivation of the axial and appendicular skeleton and of the head and related muscles. Limb training. The ectodermal crest, the proliferation zone and the polarizing zone and the development of the limb in the three Cartesian axes. Malformations: polydactyly, phocomelia.

The embryonic appendages: placenta, allantoid, yolk sac, umbilical cord. Development, structure and function of the placenta. Placental hormones. The placental circulation. Decidual reaction: basal, capsular, parietal decidua. Angiogenesis and changes in the vascular wall. Immunological tolerance. Amnios and amniotic fluid. The dizygotic and monozygotic twins. Malformations: Polyhydramnios and oligohydramnios. Fetal erythroblastosis and the Rh factor.

PRACTICAL HISTOLOGY

Through the use of the optic microscope students will have to identify histological specimens, describe their organisation, and correlate structure with function, at cellular and tissue level. Histological specimens to be studied are:

- Simple boundary epithelium: squamous (mesothelium, endothelium), cuboidal (glandular ducts) and columnar (intestine) epithelia.
- Stratified boundary epithelium: squamous (oesophagus) and keratinized squamous (epidermis) epithelia
- Pseudostratified epithelium (trachea)
- Transitional epithelium (ureter)
- Glandular epithelium: intraepithelial, unicellular glands (the goblet cell); examples of exocrine (salivary glands) and endocrine (thyroid, parathyroids) glands; exo/endocrine gland: the pancreas.
- Connective tissue: loose connective tissue (trachea, intestine and oesophagus); dense
  irregular connective tissue (the skin); dense regular connective tissue (tendons).
- Supportive connective tissues: tracheal cartilage and compact bone (ground and H&E)
- Blood smear
- Lympho-epithelial tissue of the thymus
- Skeletal, cardiac and smooth muscle tissues
- Nerve tissue: section of the spinal cord

COURSE STRUCTURE

The Histology and Embryology course is structured in 75 hours of frontal teaching (divided into lessons of 2 or 4 hours according to the academic calendar) and 25 hours of lab practice, consisting of microscopic analysis of several histologic preparations, including sections of epithelium, lining and glandular, connective tissue proper, adipose tissue, cartilage, bone, blood and lymphatic organs, muscle tissues (skeletal, cardiac and smooth muscles) and nervous tissue (nerve and spinal cord).

COURSE GRADE DETERMINATION

The acquisition of the expected learning results is evaluated through the exam. The exam consists in a written test, followed by an oral examination. The written test consists of about 60 multiple choice questions. Each correct answer corresponds to a score of +1 and each wrong or not given answer corresponds to a score of -0.2. Only students who answer 40% of the questions correctly in the written test are admitted to the oral exam. The oral exam includes the identification of one/two histologic slides and questions on cytology, histology and embryology.

LEARNING VERIFICATION METHODS

The acquisition of the expected learning outcomes is verified through the exam, which is based on a written test, a practical test and an oral test. The final exam aims to assess the achievement of the following educational objectives:

- knowledge of the structure of the cytotypes that make up the tissues of the human body
- knowledge of the classification and sub-classifications of these tissues
- understanding of the correlations between the various tissues, knowing their

morphofunctional aspects and the mechanisms that govern their development during the embryo-fetal period.

The written test consists of about 40 multiple choice questions. Each correct answer corresponds to a score of +1 and each wrong or missing answer corresponds to a score of -0.2. The oral exam is accessed if 40% of the questions are answered correctly. The oral part includes the practical test, i.e. the recognition of one/two histological preparations and questions on cytology, histology and embryology. During the recognition of the histological section, the student must describe in the appropriate terms the microscopic preparation that is proposed to him. The student is not asked for an organ diagnosis, but for a correct and exhaustive description of the preparation, which will consequently lead him to a tissue diagnosis. Each exam is aimed at verifying the degree of knowledge of the notions of the subjects being studied and the ability to relate and interpret the acquired concepts. In particular, the written test aims to verify the level of knowledge of both basic and more in- depth notions and the ability to connect concepts in a logical way. In the practical test, the student will have to demonstrate a good knowledge of the optical microscope, to know the histological characteristics of the tissues and to be able to apply this knowledge for the recognition of the different cytotypes and tissues in the preparations observed under the microscope. The oral test is aimed at verifying what the student demonstrated in the previous tests, as well as ascertaining his ability to understand and explain concepts with language properties.

Overall, the exam will be evaluated according to the following criteria:

Unsuitable: Poor or lacking knowledge and understanding of the topics; limited capacity for analysis and synthesis, frequent generalizations of the required contents; inability to use technical language.

18-20: Just enough knowledge and understanding of topics, with obvious imperfections; just sufficient capacity for analysis, synthesis and independent judgement; poor ability to use technical language.

21-23: Sufficient knowledge and understanding of topics; sufficient capacity for analysis and synthesis with the ability to logically and coherently argue the required contents; sufficient ability to use technical language.

24-26: Fair knowledge and understanding of the topics; discrete capacity for analysis and synthesis with the ability to rigorously argue the required contents; Good ability to use technical language.

27-29: Good knowledge and understanding of required content; good capacity for analysis and synthesis with the ability to rigorously argue the required contents; good ability to use technical language.

30-30L: Excellent level of knowledge and understanding of the requested contents with an excellent capacity for analysis and synthesis with the ability to argue the requested contents in a rigorous, innovative and original way; Excellent ability to use technical language.

OPTIONAL ACTIVITIES

In addition to the didactic activity, the student will be given the opportunity to take advantage of tutoring activities, upon request, and to attend seminars.

READING MATERIALS

- Pawlina W.: Histology a text and atlas, eighth edition. Wolters Kluwer/Lippincott Williams and Wilkins.
- Abraham L Kierszenbaum, Laura Tres. Histology and Cell Biology: An Introduction to Pathology. Elsevier
- Schoenwolf, Bleyl, Bauer and Francis-West: Larsen's Human Embryology, fifth edition.
- Moore, Persaud, Torchia. The Developing Human: Clinically Orientend Embryology. Elsevier.