



Degree Programme in Medicine and Surgery

Academic Year 2026 / 2027

INTEGRATED COURSE (I.C.): Histology and Embryology

NUMBER OF CFU (ECTS credits): 10 (100 hours)

SSD (Academic Discipline Code): BIOS-13/A (formerly BIO/17)

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PREREQUISITE COURSES

None required.

PREREQUISITES

Although there are no formal prerequisites, students are expected to have a basic knowledge of cell biology, with particular reference to the structure and main functions of the eukaryotic cell.

LEARNING OBJECTIVES

The integrated Histology and Embryology course unit aims to provide students with the knowledge required to describe the morpho-functional organisation of the cells and tissues of the human body and the main processes underlying embryonic development. It also aims to provide the methodological foundations for observing and interpreting histological specimens, with reference to the principal preparation procedures and to light, fluorescence and electron microscopy techniques. Particular emphasis is placed on the relationship between structure, function and embryonic origin as a basis for the subsequent study of physiology, pathological anatomy and clinical disciplines. Practical sessions, conducted using light

microscopes and digital virtual microscopy platforms, develop the ability to recognise, describe and interpret histological specimens by relating structure, function and development.

EXPECTED LEARNING OUTCOMES

DD1: Knowledge and understanding

By the end of the course unit, students will be able to:

- describe the structural and functional organisation of the eukaryotic cell and its main compartments;
- classify the tissues of the human body and explain their composition, microscopic organisation, distribution and functions;
- describe the histological organisation of the principal organs and systems and relate it to their function;
- explain the fundamental stages of gametogenesis, fertilisation, early embryonic development and organogenesis;
- explain the principles of the main histological and microscopic techniques used to study cells and tissues.

DD2: Applying knowledge and understanding

By the end of the course unit, students will be able to:

- recognise and classify cells, tissues and the main microscopic structures in histological specimens and digital images;
- interpret the morphological features observed by relating cells, extracellular matrix, tissue organisation and function;
- apply knowledge of cytology, histology and embryology to the understanding of subsequent biomedical and clinical disciplines.

DD3: Making judgements

By the end of the course unit, students will be able to:

- independently analyse a histological specimen, select the relevant morphological features and provide a reasoned identification of the tissue by integrating structure, function and embryonic origin.

DD4: Communication skills

By the end of the course unit, students will be able to:

- describe cells, tissues, microscopic specimens and developmental processes using appropriate scientific terminology, and present the content clearly, logically and coherently.

DD5: Learning skills

By the end of the course unit, students will be able to:

- independently use textbooks, histological atlases, microscopic images and teaching materials to consolidate and update the knowledge acquired;
- organise and connect concepts in cytology, histology and embryology, recognising their role in medical education and future professional practice.

SYLLABUS

CYTOLOGY

METHODS FOR STUDYING CELLS AND TISSUES

Overview of the use of light microscopes (bright-field, phase-contrast, interference, fluorescence and confocal) and electron microscopes (TEM and SEM); units of measurement and resolving power (Abbe's formula). Procedures for preparing specimens for light microscopy (paraffin embedding and frozen sections) and electron microscopy. Cell cultures. Main histomorphological and histochemical staining techniques. Principles of immunolocalization of molecules and cell organelles. Differential centrifugation.

THE PLASMA MEMBRANE

Structure and molecular organisation of the plasma membrane: the fluid mosaic model; membrane lipids and their properties; peripheral and integral proteins: antigenic properties, function as adhesion proteins, function as receptors and 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 protein electrophoresis) methods of study. Composition and functions of the glycocalyx.

CYTOPLASMIC ORGANELLES

Composition of the cytosol and the various cytoplasmic inclusions (glycogen granules and lipid droplets).

The smooth endoplasmic reticulum: structure and role in lipid metabolism, detoxification processes, glycogenolysis and calcium storage.

Ultrastructural organisation and function of the rough endoplasmic reticulum. Main stages of translation and differences between the synthesis of proteins destined for the cytosol and that of secreted, membrane or lysosomal proteins. Post-translational protein modifications: glycosylation, hydroxylation and the role of molecular chaperones.

Transport vesicles coated with COP proteins. Specificity of vesicular transport and fusion processes: Rab proteins, v-SNAREs and t-SNAREs.

Golgi apparatus: ultrastructure, biosynthetic processes and sorting of molecules synthesised in the endoplasmic reticulum.

Constitutive and regulated cell secretion: regulatory mechanisms.

Endocytosis. Internalisation of soluble molecules via caveolae: pinocytosis, transcytosis and interactions between caveolins and signalling molecules. Receptor-mediated endocytosis: clathrin-coated vesicles.

Endosomes and the different sorting pathways of specific ligands.

Lysosomes: biogenesis, morphology and hydrolytic enzymes. Phagocytosis and autophagy.

Peroxisomes: structure and functions.

Mechanisms for the degradation of cytoplasmic proteins: the ubiquitin-proteasome system and the aggresome.

Mitochondria: morphology, distribution and replication. The mitochondrial genome. Location and function of mitochondrial enzyme complexes: main aspects of the Krebs cycle and oxidative phosphorylation. Role of mitochondria in calcium homeostasis, apoptosis, steroid hormone synthesis and thermoregulation.

The cytoskeleton. Microtubules, microfilaments and intermediate filaments: molecular organisation and distribution within the cell and among different cell types. The role of the cytoskeleton in specific processes such as cell motility, phagocytosis, endocytosis, exocytosis and vesicle movement. Proteins associated with microtubules (kinesins and dyneins) and microfilaments (actin-binding proteins).

The centrosome. The membrane cytoskeleton. Cilia: structure and function. The primary cilium.

THE NUCLEUS

Structure of the interphase nucleus. Exchange between nucleus and cytoplasm. Composition of interphase chromatin and the nuclear matrix. Euchromatin and heterochromatin. Nucleosomes. Histones and non-histone regulatory proteins.

The nucleolus: structure and molecular organisation; rRNA synthesis and assembly of ribosomal subunits.

Overview of cell division and the phases of the cell cycle. Overview of chromosome formation and structure and of the mitotic apparatus. Overview of the stages of mitosis.

The nuclear envelope: differences between its cytoplasmic and nuclear surfaces; structure and function of nuclear pores; importins and exportins; associated regulatory molecules; the nuclear lamina.

CELL INTERACTIONS

General principles of paracrine, autocrine, endocrine and juxtacrine cell interactions.

Cell-cell and cell-matrix adhesion systems. Intercellular junctions: structural and molecular organisation of tight junctions, anchoring junctions (adherens junctions and desmosomes) and communicating junctions (gap junctions). Integrins. Podosomes and focal adhesions. Hemidesmosomes.

HISTOLOGY

METHODS FOR THE MORPHOLOGICAL STUDY OF TISSUES

Overview of the use of light microscopes (bright-field, phase-contrast, interference, fluorescence and confocal) and electron microscopes (TEM and SEM); units of measurement and resolving power (Abbe's formula). Procedures for preparing specimens for light microscopy (paraffin embedding and frozen sections) and electron microscopy. Cell cultures. Electrophoresis. Main histomorphological and histochemical staining techniques. Principles of immunolocalisation of molecules and cell organelles. Differential centrifugation.

STEM CELLS

Overview of cell differentiation. Stem cells (general characteristics of embryonic stem cells, adult tissue stem cells and induced pluripotent stem cells). Stem-cell niches. Cloning. Tissue regeneration.

EPITHELIAL TISSUES

General features (organisation, vascularisation and innervation) and embryonic origin. Characteristics of epithelial cells [shape, polarity, specialisations of the apical surface (motile cilia and the primary cilium, microvilli, stereocilia), specialisations of the lateral surface [adhesion molecules and junctional complexes (ultrastructural and molecular organisation of tight junctions, adherens junctions and desmosomes), gap

junctions], specialisations of the basal surface (structural and molecular organisation and function of the basal lamina), and the cytoskeleton. Epithelial stem cells (general characteristics of adult tissue stem cells).

Classification of epithelial tissues (lining and glandular epithelia; overview of sensory and special epithelia).

Lining epithelia. General characteristics, classification, distribution and overview of functions. Mucous membranes (epithelium of the digestive tract, respiratory tract and urinary bladder), serous membranes, skin and endothelium [overview of the structure of capillaries (continuous, fenestrated and sinusoidal capillaries; passage of molecules and cells through the endothelium) and blood vessels]. Epidermis (keratinocytes and cornification, melanocytes and melanogenesis, Langerhans cells and Merkel cells).

Clinical correlations: overview of coeliac disease, primary ciliary dyskinesia (PCD) or immotile cilia syndrome, ciliopathies, Bardet-Biedl syndrome (BBS), pemphigus, harlequin ichthyosis and melanoma.

Glandular epithelia. Embryonic origin and histological organisation of exocrine and endocrine glands (parenchyma and stroma). *Exocrine glands.* Location, organisation, types of secretory units and excretory ducts, classification and secretions (serous, mucous and mixed). Myoepithelial cells. Examples of exocrine glands: skin glands (sebaceous, sweat and mammary), major salivary glands (parotid, submandibular and sublingual), pancreas, digestive-system glands and goblet cells. *Endocrine glands.* General characteristics (concepts of autocrine, paracrine and endocrine cell signalling, and exosomes) and histological organisation (cordonal, follicular and interstitial). Hormones (polypeptide, amino-acid-derived and steroid). Examples of the histological organisation and functions of endocrine glands: pituitary, thyroid, adrenal glands and pancreas.

CONNECTIVE TISSUES

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

Connective tissue proper (classification, distribution and functions): loose (areolar) and dense (regular and irregular). Mesenchymal stem cells. Resident cells [fibroblasts, reticular cells, macrophages (phagocytosis: opsonins, Toll-like receptors and complement; their role as antigen-presenting cells; the macrophage system), mast cells and adipocytes]. Integrins and their interactions with molecules of the intercellular substance. Intercellular substance (amorphous matrix and protein fibres). Amorphous matrix (GAGs, proteoglycans and glycoproteins) and interstitial fluid. Fibres. Collagens [classification: fibrillar, network-forming/reticular and FACIT; molecular organisation, particularly of type I collagen; synthesis and fibrillogenesis]. Elastin and elastic fibres (molecular characteristics of elastin, fibrillins and their synthesis). Connective tissues proper with special properties [adipose (white and brown), reticular, elastic, pigmented and mucous].

Clinical correlations: overview of selected proteoglycan disorders, collagenopathies and elastinopathies, degenerative arthritis, myxoedema, Graves' disease, scurvy, Ehlers-Danlos syndrome (EDS) and Marfan syndrome.

Supporting connective tissues.

Cartilage tissues. Hyaline cartilage (embryonic origin, histological organisation, distribution and growth: staining characteristics, perichondrium, chondroblasts/chondrocytes, intercellular substance and aggrecans, collagen fibres). Special types of hyaline cartilage (epiphyseal/growth-plate cartilage and articular cartilage). Elastic cartilage (embryonic origin, histological organisation, distribution and growth: staining characteristics, perichondrium, chondroblasts/chondrocytes and intercellular substance). Fibrocartilage

(embryonic origin, histological organisation, distribution and growth: staining characteristics, perichondrium, chondroblasts/chondrocytes and intercellular substance).

Bone tissues. General features of their composition and histological organisation (types of bone, vascularisation and innervation). Cells (osteoprogenitor cells, osteoblasts, osteocytes and osteoclasts). Intercellular substance (mineralised matrix, collagen fibres and glycoproteins). Lamellar bone (compact or spongy) and woven bone. Preparation of a bone-tissue histological specimen (demineralisation or ground section). Periosteum and endosteum. Osteoblasts [synthesis of molecules of the intercellular substance; their role in osteoclast formation through RANK/RANKL, in maintaining the haematopoietic stem-cell niche and in mineralisation]. Osteocytes. Osteoclasts [origin, cytological features (podosomes) and functional features (proton pump and lysosomes)]. Role of osteoblasts and osteoclasts in calcium metabolism (parathyroid hormone and calcitonin). Overview of osteoporosis (oestrogens, RANKL and OPG).

2. Ossification. Intramembranous ossification. Endochondral ossification. Example of ossification of the bones of the face and skull (chondrocranium and neurocranium). Example of endochondral ossification of a long bone of the appendicular skeleton (primary and secondary ossification centres). Growth in length (epiphyseal cartilage) and width and ossification of a bone. Formation of an osteon. Mechanisms of mineralisation (role of osteoblasts, matrix vesicles, collagen fibres and proteoglycans).

Clinical correlations: overview of osteoarthritis, rheumatoid arthritis, dwarfism, osteogenesis imperfecta, osteopetrosis and osteoporosis.

Blood and lymph.

Blood (composition and functions). Plasma (serum) and formed elements (haematocrit, buffy coat and blood smear). Red blood cells [structural features (size, shape and cytoskeleton) and functional features (counts, haemoglobin, transport of oxygen and carbon dioxide, haemolysis processes and overview of blood groups)]. Platelets [structural features (size, granulomere, hyalomere, shape, cytoskeleton and granules) and functional features (counts, platelet plug and thrombus)]. Platelet activation (adhesion to collagen, granule exocytosis, exposure of phospholipids and thrombin and fibrinogen receptors, and aggregation). Overview of the intrinsic and extrinsic pathways of blood coagulation. White blood cells (types and counts, differential white cell count and diapedesis). Neutrophils (recognition in a blood smear, features under light microscopy and TEM; functions, the 'kamikaze' and 'Spider-Man' effects, and the respiratory burst). Eosinophils (recognition in a blood smear, features under light microscopy and TEM; functions and major basic protein). Basophils (recognition in a blood smear, features under light microscopy and TEM; functions). Monocytes (recognition in a blood smear and features under light microscopy and TEM). Lymphocytes (recognition in a blood smear, features under light microscopy and TEM; functions).

Lymph (composition and function).

Lymphohaematopoietic tissues. Lymphoid tissues (overview of the structure and functions of the thymus, lymph nodes, spleen and bone marrow).

Haematopoiesis [the haematopoietic stem cell, haematopoietic cytokines, progenitors and precursors of differentiating cell lineages, erythropoiesis, granulopoiesis, monocytopenia, thrombopoiesis (mechanisms of platelet release) and lymphopoiesis].

The immune system. Innate and adaptive immunity. Overview of the functions of B, T and NK lymphocytes (the concepts of antigen, antibodies, complement, clonal selection, gene rearrangement, immunological memory, antigen-presenting cells, the HLA system and the different classes of T lymphocytes).

Clinical correlations: overview of haemolytic disorders (cytoskeletal abnormalities, favism and sickle-cell anaemia), microcytosis, macrocytosis, red blood cell membrane defects, anaemias, red blood cell enzymopathies, red blood cell haemoglobinopathies, allergies and inflammation.

Dental tissues

Mineralised tissues: enamel, dentine and cementum. Soft tissues: periodontium and pulp.

Adipose tissue

General characteristics. White adipose tissue, its regulation and adipokines. Brown adipose tissue. Transdifferentiation. Obesity and BMI.

MUSCLE TISSUES

General characteristics, embryonic origin, classification and distribution.

Skeletal muscle tissue. General organisation of a muscle. Cytological (shape, dimensions, staining, bands and striations) and ultrastructural features of muscle fibres. Myofibrils and contractile myofilaments; the sarcomere. Actin filaments (molecular organisation); myosin filaments (molecular organisation); accessory filaments and proteins of the sarcomere (titin, nebulin, obscurin, protein C and myomesin); dystrophins and the costamere. Triads and the sarcoplasmic reticulum. Neuromuscular junction, motor endplate and function of a cholinergic synapse. Molecular mechanism of muscle contraction (action potential, T-tubules, DHPRs and ryanodine receptors, calcium ions and troponins/tropomyosin, the interaction cycle involving myosin heads, ATP and binding sites on actin filaments). Satellite cells. Structural, metabolic and functional heterogeneity of muscle fibres (type I, IIa, IIb and IIx fibres). Overview of the muscle-fibre growth factors IGF-1 and myostatin, testosterone and anabolic steroids.

Smooth muscle tissue. General tissue organisation (layers, small muscles and myoepithelial cells). Cytological (shape and dimensions) and ultrastructural features of the smooth muscle cell (caveolae, gap junctions, dense bodies and contractile filaments). Organisation of contractile filaments (caldesmon, calponin, dense bodies and intermediate cytoskeletal filaments). Characteristics and stimuli of contraction (neural, hormonal, mechanical and NO). Single-unit and multi-unit smooth muscle. En passant synapses. Molecular mechanism of contraction (calmodulin, MLCK, phosphorylation of myosin light chains and caldesmon/calponin).

Cardiac muscle tissue. General organisation of the tissue, cardiomyocyte network and intercalated discs. Cytological (shape and dimensions) and ultrastructural features of the cardiomyocyte (intercalated discs, contractile filaments, sarcomere, dyads and mitochondria). Features of cardiomyocyte contraction (sodium channels and spontaneous onset of the action potential, DHPRs and ryanodine receptors, calcium ions and the sarcomere). Specialised cardiomyocytes of the sinoatrial node and Purkinje cells.

Clinical correlations: overview of muscular dystrophies.

NERVOUS TISSUE

General characteristics, embryonic origin, classification and distribution. Central and peripheral nervous systems. The autonomic nervous system.

General tissue organisation (neural networks, synapses, glia, grey matter and white matter). Connective-tissue coverings (meninges) and vascularisation (blood-brain barrier). Special histological methods for studying nervous tissue, from Golgi's 'black reaction' to CLARITY.

Cytological (shape and dimensions, Nissl bodies, cytoskeleton and Golgi apparatus) and ultrastructural features (neurotubules and neurofilaments, actin filaments and rough endoplasmic reticulum) of the neuron. Morphological and functional classification of neurons. Dendrites. The axon and its coverings (the myelin sheath and the concept of the nerve fibre). Structure, ultrastructure and molecular organisation of the myelin sheath. Axoplasmic transport. Regenerative capacity of the axon. General principles of neuronal function (resting potential, action potential and propagation of the nerve impulse). Electrical and chemical synapses. Interneuronal chemical synapses (synaptogenesis, types and structure, pre- and postsynaptic densities, neurotransmitters and neuropeptides).

Histological structure of nerves and ganglia.

Glia (astrocytes, oligodendrocytes, ependymal cells, microglia, Schwann cells and satellite cells). Overview of neural stem cells.

Clinical correlations: overview of Charcot-Marie-Tooth disease and multiple sclerosis.

EMBRYOLOGY

SPERMATOGENESIS, OOGENESIS AND FERTILISATION

Meiotic division. Timing and mechanisms of meiosis in spermatogenesis and oogenesis. Aneuploidy. Structure of the testis: tunica albuginea, lobules, seminiferous tubules, straight tubules and rete testis. Location and function of Sertoli cells, Leydig cells and myoid cells. Male genital ducts and accessory glands. The seminiferous epithelium. Spermatogenesis: the mitotic phase, meiotic phase and spermiogenesis. Structure of spermatozoa. Cycle and wave of the seminiferous epithelium. Immune privilege of the testis. Hormonal control of spermatogenesis.

Structure of the ovary: cortex and medulla. Folliculogenesis: primordial, primary, secondary, antral, dominant and ovulatory follicles. The zona pellucida. Theca cells. Ovulation. The corpus luteum. Ovarian and uterine cycles. Hormonal control of the ovarian cycle and follicular selection. Reciprocal influence between somatic cells and the oocyte: oocyte growth and maturation and follicular-cell proliferation and maturation. Semen. Sperm capacitation and the acrosome reaction. Fertilisation. Oocyte activation: calcium, the cortical reaction, and completion of meiosis (MPF and cytostatic factor). Parthenogenesis and imprinting. Contraceptive methods. Assisted reproductive techniques. General overview of prenatal development: the embryonic and fetal periods and sensitivity to teratogenic agents. Prenatal diagnosis and therapy.

FIRST WEEK OF DEVELOPMENT

Cleavage. Cloning. Embryonic stem cells (ES cells), adult stem cells and induced pluripotent stem cells (iPSCs). Preimplantation genetic testing. IVF and ICSI. Embryonic genome activation. X-chromosome inactivation. Imprinting and hydatidiform mole.

SECOND WEEK OF DEVELOPMENT

Embryo implantation. Trophoblast differentiation: cytotrophoblast, syncytiotrophoblast and the lacunar system. hCG and pregnancy testing. Amniotic cavity and yolk sac. Formation of extraembryonic mesoderm. Chorionic cavity, or extraembryonic coelom. Decidual reaction. Ectopic implantation.

THIRD WEEK OF DEVELOPMENT

Gastrulation and formation of the three germ layers. Primary epithelial-mesenchymal transition. Oropharyngeal and cloacal membranes. Allantoic diverticulum. Development of the notochord, induction of

the neural plate (BMP inhibitors: chordin, noggin and follistatin) and neurulation. Neural tube and neural crest. Paraxial, intermediate and lateral mesoderm. The intraembryonic coelom. Formation of extraembryonic and intraembryonic angioblastic islands. Cardiogenic area and transverse septum. Regression of the primitive streak and sacroccygeal teratoma. Establishment of the body axes: AVE, Hensen's node, notochord, primitive streak and posterior-to-anterior, dorsal-to-ventral and left-to-right gradients of TGF-beta family factors (Nodal and BMP). Neural crest differentiation and the importance of BMP, WNT and FGF.

FOURTH WEEK OF DEVELOPMENT

Lateral and craniocaudal folding and establishment of the cylindrical body form. Development of the ectoderm, mesoderm and endoderm. Homeotic genes and the body plan along the anteroposterior axis. Molecular mechanisms of somitogenesis (clock and wavefront model).

ORGANOGENESIS

The ectoderm: epidermis and associated glands. Origin of melanoblasts, Merkel cells and Langerhans cells. Development of placodes and hair neogenesis. Malformations: epidermolysis bullosa, harlequin fetus, ectodermal dysplasia and albinism.

The neuroectoderm: development of the neural tube. Caudal eminence or tail bud. From three to five brain vesicles. Derivatives of the walls and cavities of the five vesicles. Development of the pituitary gland. The spinal cord and formation of the cauda equina. Derivatives of the neuroepithelium: neurons and glia of the central nervous system. Radial glial cells. Differentiation of microglial cells. The peripheral nervous system and other derivatives of neural crest cells. Importance of BMP and SHH in the differential development of spinal-cord neurons. NGF and neurotrophic factors. Malformations: rachischisis, spina bifida occulta, meningocele and myelomeningocele.

Development of the face and neck. Development and derivatives of the frontonasal process, pharyngeal arches, clefts and pouches. Stomodeum and oropharyngeal membrane. Embryonic origin of the cartilage, bones, muscles and nerves of the face. Development of the primary and secondary palate, tongue and thyroid gland. Tooth development: four stages. Malformations: cervical sinus, cleft lip, cleft palate and cleft lip and palate.

The endoderm and formation of the primitive gut. Mesenteries and intraperitoneal, retroperitoneal and secondarily retroperitoneal organs.

Foregut: vascularisation and development. Pharyngeal gut, oesophagus, stomach, omentum, superior duodenum, liver, gallbladder and pancreas. Spleen. Development of the respiratory system. Formation of the pericardial, pleural and peritoneal cavities. The diaphragm. Malformations: tracheoesophageal fistula, oesophageal atresia, diaphragmatic hernia, duodenal stenosis and atresia, and annular pancreas.

Midgut: small intestine, caecum, ascending colon and proximal two-thirds of the transverse colon. Rotation and vascularisation. Malformations: Meckel's diverticulum, omphalocele, rotational defects and volvulus.

Primitive hindgut: the cloaca and its partitioning. Formation of the distal third of the transverse colon, descending colon, sigmoid colon, rectum and upper part of the anal canal. Proctodeum. Bladder and urethra.

Development of the urogenital system. Formation and hormonal and genetic regulation (SRY, SOX9 and FGF9) of the gonads, genital ducts and male and female external genitalia. Differentiation of primordial

germ cells (PGCs). Ovarian reserve. Malformations: pseudohermaphroditism, hypospadias, cryptorchidism and bicornuate uterus; germ-cell tumours.

Formation of the urinary system. Development of the ureters and kidneys: pronephros, mesonephros and metanephros. The mesonephric duct and ureteric bud. Metanephric blastema. Functional maturation and ascent of the kidneys. Endodermal origin of the bladder and urethra. The bladder trigone. Molecular processes in the development of the collecting system and nephrons (WT1, GDNF and WNT4). Malformations: renal agenesis, supernumerary ureters and supernumerary kidneys.

Overview of development of the circulatory system. Angioblastic islands. Haematopoietic stem cells of the yolk sac and the aorta-gonad-mesonephros region. Sites of haematopoiesis before and after birth. Development of the heart. Folding and expansion during the fourth week. Partitioning of the primitive atrium. Formation of endocardial cushions and the signalling pathways involved. The heart at the end of the eighth week. FGF, VEGF and ANG1 in vasculogenesis. Overview of the development of the arterial and venous systems. Fetal circulation and changes at birth.

Development of the locomotor system. Development of the somites: sclerotome, dermatome and myotome. Origin of the axial, appendicular and cranial skeletons and associated muscles. Limb formation. The apical ectodermal ridge, progress zone and zone of polarising activity, and limb development along the three Cartesian axes. Malformations: polydactyly and phocomelia.

Extraembryonic structures: placenta, allantois, yolk sac and umbilical cord. Development, structure and function of the placenta. Placental hormones. Placental circulation. Decidual reaction: decidua basalis, capsularis and parietalis. Angiogenesis and changes in the vascular wall. Immunological tolerance. Amnion and amniotic fluid. Dizygotic and monozygotic twins. Malformations and disorders: polyhydramnios and oligohydramnios. Erythroblastosis fetalis and the Rh factor.

PRACTICAL HISTOLOGY

Using images obtained by light microscopy, students will be required to identify histological specimens, describe their organisation and relate structure to function at the cellular and tissue levels. The histological specimens to be studied are:

- Simple lining epithelium: squamous (mesothelium and endothelium), cuboidal (glandular ducts) and columnar (intestine) epithelia
- Stratified lining epithelium: non-keratinised squamous (oesophagus) and keratinised squamous (epidermis) epithelia
- Pseudostratified epithelium (trachea)
- Transitional epithelium (ureter)
- Glandular epithelium: unicellular intraepithelial glands (goblet cells); examples of exocrine glands (major salivary glands) and endocrine glands (thyroid and parathyroid glands); mixed exocrine/endocrine gland: pancreas
- Connective tissue: loose connective tissue (trachea, intestine and oesophagus); dense irregular connective tissue (skin); dense regular connective tissue (tendons); adipose tissue
- Supporting connective tissues: tracheal cartilage; compact bone (ground section and H&E-stained section) and spongy bone
- Blood smear
- Lymphoepithelial tissue of the thymus
- Skeletal, cardiac and smooth muscle tissues

- Nervous tissue: spinal cord section

COURSE STRUCTURE

The course unit comprises 100 hours: 80 hours of lectures, delivered in two- or four-hour sessions in accordance with the academic timetable, and 20 hours of seminars and practical sessions. Lectures integrate the content of cytology, histology and embryology, also through images, diagrams and morphofunctional and clinical correlations. Practical sessions focus on the observation and interpretation of specimens of the main tissues using light microscopes and digital virtual microscopy platforms. Supplementary teaching materials are made available through the University's WebApp platform. Attendance is compulsory to the extent specified in the Degree Programme Teaching Regulations.

The course consists of 2.5 hours of practical exercises for each CFU (ECTS credits).

Lecture presentations, microscopic images, digitised histological specimens, guidance for practical sessions and any supplementary materials are made available through the University's WebApp platform. These materials support study and do not replace the recommended textbooks.

COURSE GRADE DETERMINATION

Achievement of the expected learning outcomes is assessed through a single integrated examination consisting of two consecutive stages: a written test and an oral examination that includes a practical component. Passing the written test is a prerequisite for admission to the oral examination.

Written test

The written test consists of 60 multiple-choice questions. One point is awarded for each correct answer; 0.2 points are deducted for each incorrect or unanswered question. Students who obtain an overall score of at least 24/60 are admitted to the oral examination. The time allowed is 60 minutes. The written test primarily assesses knowledge and understanding of cytology, histology and embryology and of the main relationships among the concepts covered.

Oral examination and practical component

The oral examination includes at least three questions on the syllabus (at least one on cytology, one on histology and one on embryology) and a practical component involving the recognition and description of one or two histological specimens observed using a light microscope and/or digital virtual microscopy platforms. During the practical component, students must recognise the main cell types and tissues present, describe their organisation and relate morphological features to function. Identification of the organ of origin is not required; however, students must provide a correct and complete description using appropriate technical and scientific terminology, leading to a reasoned identification of the tissue type.

The oral examination and practical component assess:

- knowledge and understanding of the content;
- the ability to relate structure, function and development;
- the ability to apply knowledge to the interpretation of images, histological specimens and straightforward applied questions;

- independent judgement, assessed through interpretation of the specimen and justification of the morphological criteria used;
- the ability to organise and present concepts clearly, logically and coherently, using technical and scientific language correctly.

To pass the examination, students must achieve at least a satisfactory result in all components. The written-test result constitutes the starting point for the assessment; the oral examination, including the practical component, is decisive in determining the final grade. The grade is expressed on a 30-point scale, with honours where appropriate.

During examinations, students are not permitted to use or keep at their workstation any textbooks, notes, charts, electronic devices (e.g. tablets, earphones, mobile phones or smartwatches), or other reference materials. Possession or use of such devices or materials, as well as failure to comply with the rules governing the examination, will result in the immediate annulment of the examination.

Students with disabilities or certified specific learning disorders are entitled to the compensatory measures and examination arrangements specified by the relevant University offices. Any necessary adjustments shall be agreed upon while ensuring that the learning outcomes being assessed remain equivalent.

Overall, examination performance will be assessed according to the following criteria:

Fail	Poor or inadequate knowledge and understanding of the topics; limited analytical and synthesis skills, with frequent overgeneralisation of the required content; inability to use technical language.
18-20	Barely sufficient knowledge and understanding of the topics, with evident inaccuracies; barely sufficient analytical, synthesis and independent judgement skills; poor ability to use technical language.
21-23	Satisfactory knowledge and understanding of the topics; satisfactory analytical and synthesis skills, with the ability to discuss the required content logically and coherently; satisfactory ability to use technical language.
24-26	Good knowledge and understanding of the topics; good analytical and synthesis skills, with the ability to discuss the required content rigorously; good ability to use technical language.
27-29	Very good knowledge and understanding of the required content; very good analytical and synthesis skills, with the ability to discuss the required content rigorously; very good ability to use technical language.
30-30 with honours	Excellent knowledge and understanding of the required content, together with excellent analytical and synthesis skills and the ability to discuss the required content rigorously, innovatively and originally; excellent ability to use technical language.

OPTIONAL ACTIVITIES

Office hours and individual tutoring are available upon request and by appointment arranged via institutional email. Any thematic seminars and supplementary learning activities will be announced through the University's official channels and WebApp platform.

READING MATERIALS

- Pawlina W.: Histology a text and atlas, latest 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, 6th edition.
- Moore, Persaud, Torchia. The Developing Human: Clinically Oriented Embryology. Elsevier.
- Monesi. Histology, in publication, Piccin.