Department of Histology and Embryology, Faculty of Medicine in Pilsen, Charles University, Czech Republic;

Learning goals and outcomes – Cell biology. Histological techniques (Histology chapter 1)

Be able to:

- **Define and use**: cell cycle and its phases, interphase, mitosis and its phases, meiosis and its phases, apoptosis, necrosis, cell death, stem cells, cytoplasm, cell membrane, membrane lipids, membrane proteins, glycocalyx, membrane transport, phagocytosis, endocytosis, exocytosis, pinocytosis, transcytosis, membrane receptors, microvilli, stereocilia, kinocilia, microtubules, nexin, dynein, basal body, flagellum, cellular junctions, tight junction, zonula occludens, zonula adherens, desmosome, gap junction, nexus, connexon, connexins, junctional complex, hemidesmosome, cell adhesion molecules, cadherins, selectins, integrins, cell nucleus, nuclear membrane, nucleic acids, nuclear pores, euchromatin, heterochromatin, chromosomes, centromere, telomere, chromatid, haploidy, diploidy, nucleolus, splicing, exons, introns, rough (granular) and smooth (agranular) endoplasmic reticulum, ribosomes, protein synthesis, transcription of DNA, translation of mRNA, Golgi complex (cis- and trans- faces), lysosome, autophagosome, peroxisome, phagosome, centrosome, centriole, mitochondria, mitochondrial membranes and matrix, basement membrane, basal lamina, fibroreticular lamina, laminin, type IV collagen, cell polarity, atrophy, hypertrophy, hyperplasia, metaplasia, epithelial dysplasia, cytoskeleton, microfilaments, intermediate filaments, microtubules, intracellular transport, molecular motors, cytoplasmic inclusions, pigment granules, lipid droplets, glycogen granules, histological fixation, histological sectioning and staining, basophilic, eosinophilic, histological artifacts
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Compare** the structure and compartments of prokaryotic vs. eukaryotic cells.
- **Explain** what happens during the four phases of mitosis.
- **Compare** the distribution of nuclear content in mitosis vs in meiosis.
- **Explain** possible consequences of nondisjunction of homologous chromosomes during meiosis I.
- **Compare** the resolution limits and applications of electron vs. light microscopy.
- **Name** three eosinophilic structures and three basophilic structures in histological sections.
- **Compare** the metabolic functions of smooth vs. rough endoplasmic reticulum.
- **Describe** the organization of ribosomes and their role in protein synthesis.
- **Compare** the functions of mRNA, tRNA, rRNA.
- **Describe** the organization of the Golgi complex and its role in post-translational modification.
- **Give** two examples for passive transfer of substances across cell membrane and two examples for active transport.
- **Compare** the structure and function of microfilaments vs. intermediate filaments vs. microtubules.
- **Explain** the inheritance in diseases caused by dysfunction of mitochondrial genes.
- **Describe** the organization and function of occluding junctions, adherent junctions (including hemidesmosomes), and gap junctions. **Describe** their role in cell anchorage and in regulation of intercellular and intracellular transport.
- **Compare** the organization and function of microvilli vs. stereocilia. **Describe** the role of microvilli in absorption of luminal content. **Give examples** of cells with these apical modifications.
- **Describe** the organization of kinocilia and their role in mucociliary clearance.
- **Give examples** of human cells and organs the function of which is disturbed by abnormal ciliary motion.

- **Describe** the organization of the basal lamina and basement membrane.
- **Predict** how would be cell proliferation affected by drugs disrupting the polymerization of microtubules.
- **Predict** what would happen if the intercellular occluding junctions between the cells lining large intestine would be disrupted.
- **Predict** the consequences of deficiency of lysosomal enzymes.

Learning goals and outcomes – Tissues. Epithelial tissue. (Histology chapter 2)

Be able to:

- **Define and use**: tissue, epithelial tissue, connective tissue, muscle tissue, nerve tissue, ectoderm, mesoderm, endoderm, cell polarity, apical cell domain, lateral and basal cell domains, covering epithelia, trabecular epithelium, follicular epithelium, reticular epithelium, simple and stratified epithelia, simple squamous epithelium, simple cuboidal epithelium, simple columnar epithelium, pseudostratified columnar epithelium, transitional epithelium (urothelium), stratified squamous keratinized and non-keratinized epithelium, stratified cuboidal and columnar epithelium, metaplasia, absorption, secretion, filtration, perception, contraction, podocytes, myoepithelium, exocrine glands, endocrine glands, paracrine and autocrine regulations, diffuse endocrine system, serous vs. mucous secretions, goblet cells, serous demilunes, merocrine (eccrine) vs. apocrine vs. holocrine secretion patterns, exocrine ducts and secretory portions of glands, alveolar vs. acinar vs. tubular vs. tubuloacinar secretory portions, simple vs. branched vs. compound glands, intercalated ducts, intralobular ducts, striated ducts, interlobular ducts, epidermis, keratinocytes, sweat glands, apocrine glands, sebaceous glands, renewal of epithelial cells, stem cells, neoplasia, carcinoma, parenchyma
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Describe** the embryonic origin, spatial arrangement, cellular junctions, connection to extracellular matrix, and vascular supply of epithelial tissue.
- **Name** epithelial parts of organs originating from ectoderm, from mesoderm, and from endoderm (at least three examples per each germ layer).
- **Name** the specific types of intermediate filaments in epithelial, connective, muscle, and nerve tissues.
- **Name** at least five different functions of epithelia and provide examples in human body.
- **Name** the covering epithelia according to the number of layers and shape of the cells and provide examples (at least one per each type of epithelium).
- **Compare** the stratified vs. pseudostratified epithelia.
- **Discuss** the relation between the shape of epithelial cells and shape of their nuclei.
- **Name** exocrine glands according to the shape and branching of secretory and excretory portions and provide examples (at least one per each type of glands present in the human body).
- **Compare** modifications of the lateral, the basal, and the apical surfaces of epithelia. Provide at least one example for each modification occurring in the human body.
- **Explain** how detection of intermediate filaments might be used to distinguish the origin of tumors.
- **Compare** the organization and function of serous vs. mucous vs. seromucous glands. Give at least two examples per each type.
- **Compare** the organization and secretion pattern in merocrine vs. apocrine vs. holocrine glands. Provide one example per each mode.
- **Compare** the organization of cells producing mainly protein, polysaccharides, or steroid molecules.
- **Give** examples of cells and organs the vital functions of which are disturbed by abnormal thickening of basal membrane.
- **Describe** the organization of epithelial basement membrane zone.
- **Predict** what happens in the epidermis when desmosomes or hemidesmosomes are disrupted.
- **Predict** how the probability of spreading of carcinoma cells changes after the carcinoma cells traverse the basal lamina.

Learning goals and outcomes – Connective tissue. (Histology chapter 3)

Be able to:

- **Define and use:** connective tissue, mesenchyme, connective tissue proper, cartilage, bone, fixed and wandering cells, extracellular matrix, collagen fibers, elastic fibers, reticular fibers, argyrophilic fibers, ground substance, glycosaminoglycans (mucopolysaccharides), proteoglycans, multiadhesive glycoproteins, fibroblast, myofibroblast, fibrocyte, reticular cell, unilocular and multilocular adipocyte, adipoblast, chondroblast, chondrocyte, osteoblast, osteocyte, endothelial cell, pericyte, plasma cell, immunoglobulins, resting and activated macrophages, mononuclear phagocyte system, Kupffer cell, microglia, Langerhans cell, osteoclast, dendritic cell, multinuclear giant cell, antigen-presenting cell, major histocompatibility complex (MHC, HLA, human leukocyte antigens) class I and class II molecules, cytokines, mast cell, heparinocyte, heparin, histamin, melanocyte, melanosome, procollagen, terminal peptides of procollagen, tropocollagen, collagen microfibrils, collagen fibers, bundles of collagen fibers, elastin, fibrillin, elastic network, elastic lamina, hyaluronic acid, heparan sulphate, keratan sulphate, chondroitin sulphate, dermatan sulphate, fibronectin, laminin, chondronectin, chemotaxis, vascular permeability, stroma, sarcoma, trichrome stains, orcein stain, periodic acid-Schiff stain (PAS)
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Describe** the embryonic origin of connective tissue.
- **Name** at least five different functions of connective tissues and provide examples in human body.
- **Name** the general types of the connective tissue. **Describe** their distributions in the human body.
- **Name** histological staining methods used for visualization of elastin, collagen, and polysaccharides.
- **Name** the wandering (transient) and the fixed cells occurring in connective tissues.
- **Compare** the organization and metabolic role of unilocular vs. multilocular adipocytes.
- **Name** the aminoacids occurring frequently in collagen and in elastin.
- **Explain** the importance of vitamin C for proper assembly of tropocollagen and for prevention of scurvy.
- **Compare** the organization, function, and occurrence of type I, type II, type III, type IV, and type V collagen in human body.
- **Compare** the organization, functions and occurrence of fibroblasts with myofibroblasts and fibrocytes.
- **Describe** the effect of degranulation of mast cells on permeability and diameter of small blood vessels.
- **Explain** the activation of macrophages and presentation of antigens.
- **Explain** the origin of plasma cells and their role in specific immune response.
- **Name** three examples of structural glycoproteins. **Explain** their functions.
- **Describe** the chemical composition, hydrophilia, and organization of glycosaminoglycans.
- **Give two examples** illustrating the role of glycosaminoglycans within the connective tissue matrix.
- **Predict** which organs will be dysfunctional in individuals with mutation in the gene coding fibrillin-1 (component of elastic fibres).
- **Predict** the consequences of substitution of glycine in the primary structure of type I collagen.
- **Predict** the functional outcomes of deficiency of type I and type III collagen.
- **Predict** outcomes of defective turnover of glycosaminoglycans due to deficiency of lysosomal enzymes.

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Learning goals and outcomes – Connective tissue proper. Cartilage. (Histology chapter 4)

Be able to:

- **Define and use:** mesenchyme, mucoid connective tissue, Wharton's jelly, loose connective tissue, dense connective tissue regular type and irregular type, white and brown adipose tissue, elastic connective tissue, reticular connective tissue, chondroblasts, chondrocytes, hyaline cartilage, elastic cartilage, fibrous cartilage, fibrous and chondrogenic layers of perichondrium, isogenous aggregates (groups) of cells, territorial and interterritorial cartilage matrix, cartilage lacuna
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Compare** the organization and function of mesenchyme vs. mucoid connective tissue. **Describe** their distribution according to their functions in the human body.
- **Compare** the organization and function of loose vs. dense connective tissue. **Describe** their distribution according to their functions in the human body.
- **Compare** the organization of white vs. brown adipose tissue. **Describe** their age-related distribution according to their functions in the human body.
- **Compare** the organization of dense regular vs. dense irregular connective tissue. **Describe** their distribution according to their functions in the human body.
- **Compare** the organization of elastic vs. reticular connective tissue. **Describe** their distribution according to their functions in the human body.
- **Compare** the organization of hyaline vs. elastic vs. fibrous cartilage. **Describe** their age-related distribution according to their functions in the human body.
- **Describe and explain** the histological appearance of hyaline cartilage in routine stains, namely the isogenous aggregates and the glass-like extracellular matrix.
- **Compare** the distribution of types of collagen among all three types of cartilage.
- **Compare** the appositional vs. interstitial growth of cartilage.
- **Compare** the occurrence and functions of perichondrium in articular cartilage with other examples of hyaline cartilage in human body. **Explain** the nutritional transport in synovial joint.
- **Explain** how the composition of the extracellular matrix may contribute to mechanical properties of all three types of cartilage.
- **Compare** the vascular supply of growing vs. mature cartilage. **Explain** the consequences upon metabolic rate of cartilage and upon and possible regeneration of cartilage in adults.
- **Predict** the outcome of loss of elastic fibers in the interstitial connective tissue of lungs.
- **Predict** the outcome of loss of elastic fibers in the aortic wall.
- **Predict** the consequences of a tear in the laminae of the annulus fibrosus of the intervertebral disk.
- **Predict** the consequences of chronic joint overloading on circulation of synovial fluid within articular cartilage. **Explain** how does it affect the health status and regeneration capacity of the cartilage?

Learning goals and outcomes – Bone. (Histology chapter 5)

Be able to:

- **Define and use:** mesenchyme, osteoprogenitor cells, osteoblasts, alkaline phosphatase, osteocytes, osteocyte processes, osteocyte lacuna, bone canaliculi, osteoclast, acid phosphatase, organic and inorganic component of bone matrix, type I collagen, hydroxyapatite crystal, fibrous and osteogenic layers of periosteum, endosteum, perforating Sharpey's fibers, bone lining cells, woven (primary, immature) bone, lamellar (secondary, Haversian, mature) bone, compact bone, trabecular (cancellous) bone, diploe, epiphysis, diaphysis, growth plate, circumferential lamellae, osteon (Haversian system), central canal, interstitial lamellae, Volkmann's canal, nutrient canal, bone trabecula, osteogenesis, ossification, osteoid, primary and secondary ossification centers, intramembranous (desmogenous) ossification, erosion (Howship's) lacuna, endochondral ossification, resting zone, proliferation zone, hypertrophic zone, calcification zone, erosion zone, ossification zone, mineralization, bone resorption, bone remodeling, bone healing, callus formation, medullary cavity, red (hematopoietic) bone marrow, yellow (fatty) bone marrow, calcitriol, parathormone, calcitonin, growth hormone, estrogens, menopause, pituitary dwarfism and gigantism, bone density, osteoporosis, rickets, osteomalacia, osteopetrosis, osteosarcoma
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Describe** the basic chemical composition of the bone mineral component (e.g., by writing down the chemical formula of hydroxyapatite).
- **Compare** the organization of primary vs. secondary bone tissue. **Describe** their distribution according to their functions in the human body and according to the age.
- **Describe** the organization of lamellar bone including the structure of osteons.
- **Explain** the sequence of processes occurring during chondrogenous ossification. **Name** the corresponding layers visible in histological sections of growth plate.
- **Compare** the desmogenous vs. chondrogenous ossification. **Describe** their distribution in human bones. **Name** at least three examples of bones per each type of ossification.
- **Compare** chondrogenous ossification with calcification of cartilage.
- **Compare** the organization of red vs. yellow bone marrow. **Describe** their age-related distribution in bones of the human body.
- **Discuss** the effect of physical activity and mechanical loading on bone metabolism and remodeling.
- **Give two examples** of hormones affecting the bone remodeling.
- **Explain** why immobilization of broken bone fragments promotes healing of bone fracture.
- **Explain** the sequence pf processes during healing of bone fractures.
- **Compare** the composition of bone tissue in osteomalacia vs. in osteoporosis.
- **Compare** the mechanical contributions of organic vs. inorganic components of bone tissue.
- **Predict** the outcome of calcium deficiency in children and in adults.
- **Predict** the impact of estrogen deficiency on bone structure during menopause.
- **Predict** the outcome of insufficient activity of osteoclasts.
- **Predict** the outcome of genetic mutations affecting the development of cartilage (i.e. chondrodystrophy) upon the size of skull, trunk, and extremities.

Learning goals and outcomes – Blood. (Histology chapter 6)

Be able to:

- **Define and use:** blood, blood plasma, suspended blood elements, buffy coat, serum, hematocrit, eryhtrocyte (red blood cell), normocyte, macrocyte, microcyte, reticulocyte, anisocytosis, polycythemia, polyglobulia, erythrocytosis, anaemia, cytopenia, oligocytaemia, hemoglobin (HbA, HbA_2, HbF), oxyhemoglobin, deoxyhemoglobin, carbaminohemoglobin, carboxyhemoglobin, ankyrin, spektrin, agglutinogens, hemagglutinins, AB0 blood groups, Rh system, sickle cell anemia, blood typing and cross-matching, anti-D antigen, leukocyte (white blood cell), granulocytes (polymorphonuclears), agranulocytes (mononuclears), lymphocyte, B-lymphocyte, plasma cell, immunoglobulins, natural killer cell, T-lymphocyte, T-helpers, T-cytotoxic cells, T-regulatory cells, monocyte, neutrophilic granulocyte, eosinophilic granulocyte, eosinophilic granule, basophilic granulocyte, leukocytosis, leukopenia, neutrophilia, neutropenia, agranulocytosis, rolling of leukocytes, adhering marginal pool, diapedesis, specific granules, azurophilic granules, major basic protein, eosinophil cationic protein, IgE, degranulation, eosinophilia, heparin, histamin, platelet (thrombocyte), hyalomere, granulomere, open canalicular system, fibrinogen, thrombin, fibrin, thrombus, primary and secondary hemostasis, peripheral blood smear, red blood cell count in male and female, leukocyte count, thrombocyte count, white blood cell differential count
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Calculate** the approximate volume of blood in an adult weighing 80 kg and in a child weighing 15 kg.
- **Write down** the reference values of peripheral blood smear (including units where appropriate). **Discuss** the differences between the values in male vs. in female.
- **Write down** the reference values of white blood cell differential count.
- **Discuss** the age-related changes in reference values of red blood count (newborn vs. adult) and white blood count (children vs. adults).
- **Discuss** the relations between dehydration and hematocrit.
- **Explain** how are senescent red blood cells selected and eliminated from the circulation.
- **Describe** the blood smear technique and its microscopic evaluation.
- **Explain** which agglutinogens and agglutinins are present or absent in all four blood groups of the AB0 system.
- **Identify** all the formed blood elements in a blood smear. **Describe** their microscopic structure and **discuss** their main functions.
- **Compare** the granules of neutrophilic granulocytes, eosinophilic granulocytes, and basophilic granulocytes.
- **Explain** the consequences of activation of thrombocytes.
- **Discuss** the conditions of the voluntary blood donation program in the Czech Republic. Additionally, you may **compare** these with the conditions valid in your country.
- **Discuss** the types of blood product derivatives. **Name** three examples of conditions that require blood transfusion or blood product derivatives.
- **Compare** the stability of carboxyhemoglobin vs. oxyhemoglobin. **Explain** why carbon monoxide is a poison.
- **Predict** what could happen if an Rh-incompatibility between woman and her fetus occurred repeatedly. **Suggest** how severe damage of the fetus could be prevented.
- **Predict** which changes in the peripheral blood smear or differential white blood cell count you would expect in patients with acute bacterial infection an in patients with chronic bleeding.

Learning goals and outcomes – Hematopoiesis. (Histology chapter 7)

Be able to:

- **Define and use:** hematopoiesis, pluripotent hematopoietic stem cell, self-renewal of stem cells, maturation, myeloid stem cell, progenitor cells, colony-forming units (CFUs), erythropoiesis, proerythroblast, basophilic erythroblast, polychromatophilic erythroblast, ortochromatophilic erythroblast, reticulocyte, polyribosomes, normocyte, thrombopoiesis, megakaryoblast, pro-megakaryocyte, megakaryocyte, pro-platelets, platelets, granulopoiesis, myeloblast, pro-myelocyte, myelocyte, meta-myelocyte, neutrophilic+eosinophilic+basophilic granulocytes, band neutrophils (stabs), segmented neutrophils, nucleus segmentation and nucleus lobe counting in neutrophils, left shift and right shift in neutrophils, monopoiesis, monoblast, pro-monocyte, monocyte, tissue macrophage, lymphoid stem cell, lymphopoiesis, lymphoblast, lymphocyte, plasma cell, red bone marrow, hemopoietic (erythroblastic) cords and islands, blood sinusoidal capillaries, yolk sac hemopoiesis, prenatal hematopoiesis in liver and spleen, medullary hematopoiesis, extramedullary hematopoiesis, erythropoietin, B12 vitamin, megaloblastic anemia, iron deficiency (sideropenic) anemia, cyanosis, medullary storage of blood elements, leukemia, lymphoma, bone marrow aspiration and biopsy, bone marrow transplantation, HLA typing, major histocompatibility complex (MHC), immunotolerance
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Compare** the life span of erythrocytes, thrombocytes, neutrophils, monocytes and lymphocytes.
- **Compare** the various periods of prenatal vs. postnatal hematopoiesis. **Name** the organs that are involved.
- **Explain** why the histological stainability of erythroblasts changes from basophilia to eosinophilia during eryhtropoiesis.
- **Explain** how senescent red blood cells are separated from young cells in the red pulp of the spleen.
- **Explain** why hematocrit usually differs in individuals living at sea level vs. in high altitudes.
- **Name** the levels of deoxyhemoglobin above which usually bluish or purplish discoloration of skin or mucous membranes (cyanosis) appears.
- **Explain** how hematocrit is related to blood viscosity.
- **Explain** from which compartments are immature forms of neutrophils acutely released into peripheral blood in case of need (e.g., bacterial infection).
- **Name** the stages of erythropoiesis and of thrombopoiesis in appropriate order.
- **Name** the stages of granulopoiesis in appropriate order. At what stages do the azurophilic and the specific granules appear?
- **Name** the stages of monopoiesis and lymphopoiesis in appropriate order.
- **Explain** briefly the concepts of human leukocyte antigens (HLA) or major histocompatibility complex (MHC), and immunological tolerance. **Explain** why these are important in bone marrow transplantation.
- **Predict** how can be hematopoiesis affected in patients after gastric resection.
- **Predict** how long may last the antithrombotic effect of acetylsalicylic acid (aspirin) on thrombocytes.
- **Predict** how can be hematopoiesis affected in patients with diseased or damaged kidney.
- **Predict** which changes in the peripheral blood smear you would expect in patients with following conditions: iron deficiency, vitamin B12 deficiency.

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Learning goals and outcomes – Muscle tissue. (Histology chapter 8)

Be able to:

- **Define and use:** skeletal striated muscle, skeletal muscle fiber, syncytium, muscle fascicles, sarcolemma, sarcoplasm, sarcoplasmic reticulum, terminal cistern, T-(transverse) tubule, triad, thick and thin myofilaments, myofibril, sarcomere, A-(anisotropic) band, I-(isotropic) band, Z-line, H-band, M-line, G-(globular) actin, F-(fibrillar) actin, troponin complex, tropomyosin, desmin, titin, dystrophin, epimysium, perimysium, endomysium, muscle spindle, intrafusal and extrafusal fibers, alpha-efferent and gamma-efferent motoneurons, Golgi tendon organs, proprioception, neuromuscular junction, motor end plate, acetylcholine, synaptic cleft, contraction, relaxation, action potential, postmortem rigidity (rigor mortis), slow (red) oxidative muscle fibers, fast (white) glycolytic muscle fibers, intermediate oxidative-glycolytic fibers, muscle glycogen, motor unit, myosatellite cell, myoblasts, myotubes, cardiac striated muscle, cardiac muscle cell, cardiac myofibril, desmosome, fascia adherens, gap junction, intercalated disk, diad, lipofuscin, endocrine atrial cardiomyocyte, cardiac pacemaker cell, cardiac conducting muscle cell, sinu-atrial node, atrioventricular node, atrioventricular bundle, right and left bundle branch, subendocardiac conducting Purkinje fibers, smooth muscle cell (leiomyocyte), basal (external) lamina, dense body, dense plaque, calmodulin, caveola, unitary smooth muscle tissue, multi-unit smooth muscle tissue, leiomyoma
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Compare** the internal organization of striated vs. smooth muscle.
- **Compare** the number and intracellular position or nucleus/nuclei in skeletal vs. cardiac vs. smooth muscle.
- **Explain** the events during contraction of skeletal muscle, starting with action potential on the motor end plate until the mechanical response. **Describe** the role of Ca^{2+} in initiation of contraction.
- **Describe** the structure of sarcomere.
- **Describe** the changes in geometry of sarcomere during contraction and relaxation.
- **Explain** why extreme muscular rigidity occurs after death and why it stops later.
- **Compare** the internal organization and function of extrafusal vs. intrafusal muscle fibers.
- **Compare** the internal organization and function of slow oxidative muscle fibers, fast glycolytic muscle fibers, and intermediate oxidative-glycolytic fibers.
- **Compare** the organization of contractile proteins, the triggering and the events of contraction in sarcomeric (striated) vs. non-sarcomeric (smooth) muscle.
- **Compare** the internal organization and function of working cardiac myocytes vs. conducting cardiac muscle cells.
- **Give examples** of skeletal muscles with small motor units and with large motor units (at least two examples per each size).
- **Give** examples of multiunit smooth muscle and unitary smooth muscle.
- **Give two examples** of proprioceptors.
- **Explain** how the uterine smooth muscle adapts during pregnancy.
- **Explain** why the elevated plasma concentrations of troponin indicate myocardial injury.
- **Predict** how the muscular activity may be affected by circulating antibodies against acetylcholine receptors of the neuromuscular junction.
- **Predict** how the muscular activity is affected after the toxin of *Clostridium botulinum* interferes with release of acetylcholine.

Learning goals and outcomes – Nerve tissue. (Histology chapter 9)

Be able to:

- **Define and use:** neural plate, neural tube, neuroectoderm, neural crest, central nervous system, white matter, grey matter, peripheral nervous system, nerve cells, neurons, glial cells, excitability, Na+/K+/ATPase, membrane depolarization, repolarization, hyperpolarization, resting potential, action potential, dendrites, axon (neurite), nerve cell body (perikaryon), neurolemma, axolemma, axon hillock, Nissl body (substance), neurofibrils, neurofilaments, anterograde and retrograde axonal transport, motor nerve fiber, sensory nerve fiber, axoplasm, initial segment, axon collateral, axon varicosity, terminal arborization, terminal bouton, dendritic spine, apolar neuron, unipolar neuron, bipolar neuron, pseudounipolar neuron, multipolar neuron, motor neuron, sensory neuron, afferent neuron, efferent neuron, interneuron, secretory neuron, neuromelanin, free nerve ending, gap junction, electrical synapse, vesicular (chemical) synapse, synaptic vesicle, neurotransmitter, neuromodulator, synaptic cleft, presynaptic and postsynaptic membranes, axo-axonal synapse, axodendritic synapse, axosomatic synapse, dendrodendritic synapse, somatosomatic synapse, excitatory synapse, inhibitory synapse, neuromuscular junction (motor end plate), protoplasmic and fibrous astrocyte, oligodendroglia, microglia, ependymal cell, tanycyte, satellite glial cell, Schwann cell, neuropil, myelin sheath, myelinated and unmyelinated fibers, Schwann sheath, mesaxon, myelin clefts and incisures, internodal segment, limiting membrane of superficial glia limiting membrane of perivascular glia, cerebrospinal fluid, blood-brain barrier, pia mater, arachnoid, dura mater, free nerve endings, Meissner's corpuscles, Pacinian corpuscles, muscle spindles, Golgi tendon organs, Wallerian degeneration and regeneration
- **Draw** and **label** simplified schemes of structures described in a separately provided document.
- **Describe** the neurulation and the role or the neural crest during embryogenesis of the nervous system.
- **Describe** the internal organization of nerve cell body and its afferent and efferent processes.
- **Compare** the types of neurons according to the number of processes. **Give** an example for each type.
- **Give examples** of two very small neurons and two large neurons of the human body.
- **Discuss** the need for anterograde and retrograde axonal transport.
- **Compare** the internal organization and function of electrical vs. chemical synapses.
- **Name** at least three neurotransmitters.
- **Explain** how the resting membrane potential is maintained in neurons.
- **Compare** the conduction of action potential in myelinated vs. unmyelinated nerve fibers.
- **Compare** the organization and occurrence of protoplasmic vs. fibrous astrocytes.
- **Compare** the organization, function, and occurrence of oligodendroglia vs. Schwann cells.
- **Compare** the origin, organization, function, and occurrence of microglia vs. ependymal cells.
- **Compare** the organization, function, and occurrence of grey vs. white matter in the CNS.
- **Explain** the concept of reflex arch including its afferent and efferent portions.
- Explain how the composition of cerebrospinal fluid differs from that of blood plasma.
- **Name** the layers of the blood-brain barrier.
- **Explain** how some viruses (such as varicella - zoster virus) can spread along nerves.
- **Discuss** regeneration of peripheral nervous system vs. central nervous system injuries.
- **Predict** the outcome of loss of myelin (demyelination) in the central nervous system.
- **Predict** how skeletal muscles are affected after losing their motor innervation due to injury.

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