Komisija za študijske zadeve
UL Medicinske fakultete

Univerza *v Ljubljani*
Medicinska fakulteta

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Course Regime

Course: Human physiology

Study Programme: Medicine

Year of the Course: **2nd**

Semester: Winter and Summer

Course type: Compulsory

Number of ECTS credits: 12

Lecturer(s): prof. Žarko Finderle PhD, prof. Ksenija Cankar PhD, Assoc. prof. Helena Lenasi PhD

Participating Organisational Units (Departments and Institutes): Institute of Physiology

Date of Issue: September 15th 2023

A. General part *(applies to compulsory and elective courses)*

1. Course objectives

The course in physiology is based on the lessons learned from biophysics, biochemistry, biology and normal morphology. The student learns about the normal functioning of the organism. She or he acquires the basic concepts in physiology and learns the principles of measurements in physiology. She or he is encouraged in accordance with the concepts, to interpret the results of the measurements. The aims of physiology course are that a student develops the critical thinking and ability of solving problems independently and it encourages the habit of self-education.

2. Comprehensive outline of the course organisation

All notifications about physiology class for students of the Medicine and Dental Medicine program will be published on the Physiology sub-site on the website of the Faculty of Medicine and in online classroom.

2.1 LECTURES:
The terms and titles of lectures will be published on the Physiology sub-site on the website of the Faculty of Medicine and in the online classroom.

2.2 TUTORIALS AND INSTRUCTIONS FOR TUTORIALS:
Tutorials and instructions for tutorials are mandatory. The terms of tutorials and instructions for tutorials are published together with the schedule of lectures. Student performs tutorials in groups, which are determined in advance. The list of groups will be to announced on the website of the Faculty of Medicine on the site of Physiology and will be valid for all subjects of the second year. When a student is unable to perform a tutorial in his own group because of illness or other justifiable reason, he can do it with another group, but only after prior arrangement with the teaching assistant. In each semester, a student can perform one exercise, at which he was not present for justifiable reasons, during the repetitive exercises. A student who is unreasonably absent from the tutorial cannot replace the tutorial. The tutorial is done when the following conditions are accomplished: standby, active participation, skills acquired, and passed protocol.

2.3 SEMINARS:
Each student must complete seminars.

Instructions for preparing a seminar:
A student or group of students prepares the content of the assigned seminar on 1 slide in a .ppt format. The slide must present a shortened title and a maximum of 1 diagrams and 5 paragraphs for the subject of the seminar, font size at least 24. The footnotes should include the names of the students. Oral presentation of the seminar lasts for 15 minutes and includes a short presentation (up to 5 minutes) and a discussion where the seminar leader interrogates the students. Students submit a .ppt file (in Office 2003 version and not newer !!) to the seminar leader by email no later than 3 working days before the seminar. The file should have title with the name of one of the seminarists name and a seminar physio (example: JKovac_seminar_fizio.ppt). Exchange of individual students among groups is possible, but only after prior arrangement with the leader of the seminar. A student who wants to replace a group must find the appropriate replacement for himself. Topics of seminars will be published on the Physiology sub-site on the website of the Faculty of Medicine and on online classroom.

3. Description of on-going assessment of knowledge and skills

3.1 PARTIAL EXAMS:

Student must have completed all three mandatory partial exams.
The first partial exam covers the content of the following tutorials: Measurements, Blood, and ECG,
The second partial exam covers the content of the tutorials: Blood Pressure, Cardiovascular system, Respiration, and the Respiratory Function of the Blood,
The third partial exam covers the tutorials: Acid-base physiology, Kidney, Metabolism and Exercise physiology
An absence in the mandatory partial exams must be apologized in the secretariat of the Institute of Physiology. Before each (except for the first) exam, there is a repetitive partial exam, which can be attended by students, who did not reach an average of 60,00 % of the three partial exams during the year or who did not take part in the partial exam from justified reasons during the year.

Student who wants to do a repetitive partial exam must apply by an e-mail addressed to the secretary of the Institute of Physiology no later than three working days before the deadline. Repetitive partial exam covers the contents of all tutorials.

3.2 SEMINARS:
All students in the group who are attending a seminar must be prepared for the seminar. They must answer to the questions that are similar to the exam questions. Student's appropriate knowledge is a prerequisite for the seminar approval. The seminar is evaluated with done/not done.

4. Required conditions for the final examination (Course Exam)
In accordance with the Paragraph 23 of the Rules, prerequisites for attending the exam are:
- all tutorials must have been attended and approved,
- an average of three partial exams must be at least 60,00 %,
- approved seminars.

5. Final assessment and examination of knowledge and skills (Course Exam)
Student knowledge is evaluated by a written test exam (multiple choice questions). Students which passed the written exam must then pass the oral part of the exam.

Evaluation of the written examination:
• For a positive result of a written examination, at least 60,00 % of points are required.
• A positive evaluation of the written examination is a prerequisite to attend an oral examination, except for the third to the fifth/sixth attempt of written examination, where every student has the right to attend the oral examination. In the fourth, fifth and sixth performance of the exam, the oral part of the examination is conducted in front of a commission. The Commission exam is conducted in accordance with the Rules on the assessment and Assessment of knowledge and skills of a uniform master's program in medicine and dental medicine.
• A bonus is given to the result of the written examination. Bonus is a positive part of the average grade of three regular partial exams, weighted by one third. The bonus is only given in the current academic year. Example: if the student receives an average grade of 90 % in partial exams, the positive part of the assessment is 30 % (90 % – 60 % = 30 %). Dividing the positive part of the assessment by 3, we get a value of a bonus which in this case comprises 10%. The received bonus (10 %) is added to the result that the student obtained in the written examination. For example: when the result of a written exam is 60 %, this bonus improves the student's mark by 10 %; the final result of the written exam (after taking into account also the student's bonus) is 70 %. The bonus is added to the result of the written exam only when the result of the written exam is equal to or higher than 60,00 %.

Applications and check-outs for written exams must be managed over the VIS Information System.

Students must apply for inspections of written exams to the secretary of the Institute of Physiology by an e-mail no later than seven days after the exam. Registered students will be notified via email of the exact date of inspections.

Written exams are available for inspections only after oral examinations have been completed. Inspections of the written exams are not intended to reveal the correct answers. For such or similar questions that relate to the professional content of the course, pedagogical workers are available throughout the year during their office hours (after prior announcement).

During inspection of written exams, in addition to his exam, the student gets a table, which shows whether he answered the question correctly or incorrectly. Student must check the consistency of his answers from the exam and table. If he wants to have a personal interview with the teacher, student must fill in a form in which he writes a consecutive number of exam question, as well as comments / objection / explanation why he thinks that the question was misjudged. The teacher then contacts the student via email, where he provides an explanation. They can also arrange an individual interview.

6. Other provisions

Article 34 of the Rules on the Verification and Assessment of Knowledge and Skills for the Uniform Master's Study Program Medicine and Dental Medicine shall apply.

Students with special needs must provide a certificate and confirmed status to the secretariat of the Institute of Physiology at the beginning of the school year (not later than 14th October or at the latest 14 days after they have acquired their status).

7. Fundamental study material and Supplement reading

Boron WF, Boulpaep EL. Concise Medical Physiology

Bruce M. Koeppen & Bruce A. Stanton: Berne & Levy Physiology

Boron WF, Boulpaep EL. Medical Physiology

John E. Hall PhD: Guyton and Hall Textbook of Medical Physiology

8. Exam topics, clinical presentations and skills

SUBJECT	SUBJECT DETAILS
Homeostasis	Maintaining constant internal environment. Regulated quantities, overview. *Modern description with mathematical laws, systems theory, cybernetics.
Transport mechanisms – overview	Intensive and extensive quantities in physiology, description of energy law. Capacity, relations between intensive and extensive quantities (volume – pressure, heat – temperature, charge – voltage, amount of substance – concentration). Flow, changes of extensive quantities in time (diffusion, convection). Currents, flows and driving forces (thermal flux – diffusion, convection, radiation, evaporation, volume flow – convection, substance flow – convection, diffusion, electric current, solutions – separately). Flow through elements, arranged in parallel vs. in series, effect of resistance. Similarities between different types of flow: thermal flux, electric current (Kirchoff's laws), flow of substance, volume – profiles of temperature, voltage, concentration (partial pressures), pressure.
Thermodynamics of biological solutions	Thermodynamic equilibrium for two or more compartments. Chemical potential and description of multiple forces on a particle. Equilibrium systems: electrochemical equilibrium, osmotic equilibrium, Henry's law.

	*Non-equilibrium systems and shift of substances between compartments (different ions, solute and solvent). *Dissipation function.
Systemic analysis in physiology	Description of a system, state of a system. Static response of a system, transition between states (water container as an analogue of arterial system). Types of disturbances (short-term, long-term), types of responses (PID…). Static stability of a system.
Regulation in biological systems	Control system and its parts (receptor, afferent branch, control centre, efferent branch, effector). Characteristics of a control system. Amplification of a system. *Dynamic stability of a system. *The problem with a reference value. Types of regulation (closed-loop, open-loop, program control, adaptable systems).
Transport of substances across cell membrane	Facilitated diffusion, competitive inhibition, allosteric inhibition, cooperativity: demonstration with diagrams. Secondary and primary active transport. Ion channels and transporters.
Transport of water, osmosis	Colligative properties of substances and physiological influences. Osmosis: general features – tonicity, osmolarity. Ideal systems, non-ideal systems, reflection coefficient. *Regulation of cell volume.
Membrane potential	Example of a membrane that is permeable only for one type of cations. Example of a membrane that is permeable only for one type of cations and anions, but non-permeable for other anions. Donnan's equilibrium (where in the body), impact on a membrane potential, osmotic forces. General example: membrane is permeable for two types of cations – electrochemical non-equilibrium. Goldman's equation (of a constant field). *Electrical model of a cell membrane.
Smooth muscle	Structural differences compared to skeletal muscle (size, contractile apparatus, cell-to-cell contact, sarcoplasmic reticulum), transfer of force. Smooth muscle contraction, mechanical characteristics and mechanism of activation. Ways of transducing an activation-triggering signal on the sarcolemma. Integration of contractile activity of smooth muscles (organization on a basis of innervation, neurotransmitters) Electomechanical relationships in smooth muscle.
Fuctioning of muscles in the body	Activation of body muscles, mechanisms for modulation of the force of contraction. Transfer of force at joints, relationship of torque to muscle insertions, joint angle and characteristics of muscle. *Functioning of muscles at more than one joint and in different directions at one joint, effect of penante muscles.
Overview, divisions	Elements of circulation and their function. Distribution of cross-sectional area, velocity, volume of blood and blood pressure along the cardiovascular circuit. Flow through vessels arranged in series versus in parallel. *Preservation of blood volume and consequences for functioning of a closed cardiovascular circuit.
The cardiac pump: the cardiac cycle	Cardiac chambers and their function (structure of ventricle wall, structure of cardiac valves, pericardium). The cardiac cycle, description with a synoptic picture. Mechanism of function of cardiac valves and heart sounds. Measuring (ultrasound, mechanophonogram).

Electrical activity of the heart – types of potentials, conduction velocity, excitability	Importance of conduction system for the cardiac function. Description of monophasic action potential for fast-response and slow-response fibers. Ionic basis for fast-response and slow-response fibers (functioning of sodium channel and calcium channels). Conduction of cardiac action potential and factors that affect conduction velocity. Excitability, its role, mechanisms. Automaticity and mechanisms.
Normal excitation of the heart, ECG	Electrocardiogram, what information do we get. Description of ECG waves and what they represent. *Distribution of potentials in a volume conductor and principles of spreading of electrical currents. Scalar and vector ECG recording. ECG recording, leads, determining the electrical axis (preclinical practical courses).
Cardiac muscle cell, energetics of heart	Structure of cells (myocytes), tissue (myocardium) and function. Maximal (isometric) force – length relationship, Starling's law. Homeometric and heterometric regulation. Contraction velocity – load relationship. Excitation-contraction coupling, calcium cycling. Contraction mechanics, preload, afterload. Analogy between muscle fibre and ventricle. Contractility. Energy consumption in the heart, factors that influence it.
Control of cardiac function, effect of heart rate	Definition of cardiac output, heart index, units. Control of heart rate, normo-, tachy- and bradycardia, heart rate variability. Characteristics of pacemakers. Effects of autonomic nervous system: effect of sympathetic input and parasympathetic imput, neurotransmitters and speed of action, course of fibres and lateralization. Afferent influences on cardioregulatory centre; brain cortex, brainstem and autonomic reflexes. Baroreceptive reflex, Bainbridge reflex and atrial volume receptors, ventricular receptors, chemoreceptor reflex, stimulation of visceral organs. Respiratory sinus arrhythmia.
Control of cardiac function, effects of preload, afterload and contractility	Regulation of diastolic ventricular filling and effect of filling pressure, ventricular compliance, filling time, mitral valve resistance, presence of atrial contraction and previous filling. Regulation of end-systolic volume, effect of geometrical factors and intrinsic features. Denervated heart, features and when they occur. Starling's law, experiments on an isolated heart (changing of ventricular filling and load). Homeometric regulation, induced by heart rate or load. Extrinsic control of carciac function (nervous and humoral factors) and changing of contractility. Cardiac function curves.
p-V diagram	Regulation of cardiac function, effects of filling, load and contractility.
Hemodynamics	Use of conservation laws to describe blood flow (Bernoulli equation). Flow through rigid tubes, laminar flow and Poiseuille's law. Deviations from Poiseuille's law in different vessels, demonstration with flow – perfusion pressure relationship. Turbulent flow, description and criteria (Reynold's number). Flow through elastic tubes, definition of compliance. Effect of compliance of arterial and venous system on shift of blood between them. "Windkessel" concept, pulsatile flow.
Arteries (pulsations, compliance)	Arterial compliance and effect on arterial blood pressure, changes associated with ageing. Importance of compliance for energetic effectiveness of a system. Factors that determine mean arterial pressure and pulse pressure. Factors that determine rise and falling of arterial pressure. *Characteristics of pulse and appropriate physical quantities that determine them.

	Changing of pulse wave amplitude on periphery and causes. Pulse wave velocity, measuring, importance. Measuring arterial blood pressure.
Veins (and collapsible vessels)	Description of flow through collapsible vessels. Effect of gravitational forces on blood flow (redistribution of blood, vascular resistance). Venous valves, anatomical and functional. Accessory pumps in circulation. Flow of lymph and problems with driving forces.
Microcirculation (exchange, regulation)	Functions of endothelial and smooth muscle cells and their coupling (mediators). Elements of microcirculatory network (resistance vessels, vessels for exchange of substances, capacitance vessels, bypass vessels). Microvascular dynamics and influences (hemorheologic properties of blood, flow-induced vasodilation, autoregulation). Microcirculatory transport, diffusion, substance clearance. Filtration – reabsorption and factors that influence them (Starling's law of capillary exchange). Local regulation of microcirculatory transport (myogenic and metabolic). Active and reactive hyperaemia. Extrinsic regulation of microcirculatory transport, vascular reflexes.
Regulation of cardiac output (venous return = cardiac output)	Characteristics of venous system that influence blood flow. Concept of mean circulatory pressure and venous return, advantages and disadvantages. Vascular function curves and factors that influence them. Coupling between the cardiac and vascular function curves and regulation of cardiac output (Guyton's analysis).
Regulation of arterial pressure	Arterial pressure values and changes associated with ageing. What determines arterial pressure? Definition of arterial pressure with filling of arterial system. *Impact of cardiac output and peripheral resistance, analysis with flow-pressure diagram. Regulation of arterial blood pressure and circulatory reflexes. Circulatory response to erect posture and to exercise.
Measuring the cardiac output	Methods for measuring based on a single beat: Fick's principle with measurement of oxygen consumption, indicator dilution method. *Methods for measuring time course (thermodilution method, electromagnetic flowmeter, volume conductometry). Measuring volumes of heart chambers with diagnostic imaging.
Blood flow through particular vascular networks and characteristics	Coronary circulation. Cutaneous circulation. Cerebral circulation. Fetal circulation.
Link between structure and function	Functions of respiratory system, basic definition (hyper- and hypoventilation, eupnea, tachypnea, hyper- and hypocapnia, hypoxemia, hypoxia). General characteristics of airways according to their function (conducting and respiratory zones), cross-section, resistance. Fate of microscopic particles that come into the airways – bronchial exhalator. Physical laws to describe transport of gasses (gas law, mixtures of gasses, dissolution of gasses, dilution of gasses at inspiration).
Ventilation	Respiratory volumes and capacities, measuring with spirometry, gas dilution and body plethysmography. Lung ventilation and alveolar ventilation, relationship to frequency and depth of breathing. Dead space (anatomical, physiological) and measuring alveolar ventilation. Effect of alveolar ventilation on partial pressures of carbon dioxide and oxygen in alveoli.
Mechanics of breathing	Respiratory muscle and their function. Pressures in lungs and thorax, differences between them and their role for lung function.

	Elastic features of lungs and thorax. Surface tension of alveoli and its consequences for lung function. Compliances of lungs and thorax and factors that affect them. Airway resistance in different lung compartments. Dynamic airway compression during exhalation. Respiratory cycle in p-V diagram of lungs and work of breathing.
Diffusion in lungs	Laws of diffusion, its components (diffusion coefficient, diffusion area, alveolar wall thickness and pressure difference across alveolocapillary membrane) and effects of different physiological situations. Diffusion capacity for gasses, definition and measurement. Coupling of diffusion and convection (blood flow) and distribution of partial pressures along pulmonary capillary. *Diffusion-limited and perfusion-limited transport of gasses, examples.
Pulmonary circulation	Characteristics of pressures in pulmonary circulatory network. *Effect of lung volume on calibre of pulmonary vessels. Factors that regulate pulmonary vascular resistance. Pressures in pulmonary circulation, their relationship with hydrostatic pressure and consequences. Hypoxic vasoconstriction and hypocapnic bronchoconstriction.
Transport of gasses in blood	Oxyhaemoglobin dissociation curve, dependency of its shape on type of haemoglobin. Capacity of blood for transport of oxygen. Physiological shifts of HbO_2 dissociation curve and their role. Ways of CO_2 transport in blood and CO_2 binding curve.
Coupling of ventilation, diffusion, perfusion	Effects of ventilation and perfusion on oxygen concentration in arterial blood. Mixing of oxygenated and non-oxygenated blood in lungs, physiologic shunt and impact on pO_2. Factors that affect oxygen deliver to tissues. Distribution of pO_2 from alveoli to tissues.
Control of respiration	Definition of system for exchange of oxygen and CO_2 and regulatory centre. Elements of regulatory loop and characteristics, afferent and efferent pathway, receptors, effectors. Respiratory centre and generators of breathing pattern. Characteristics of central and peripheral chemoreceptors and factors that affect them. Mechanoreceptors, other receptors and influence of higher centres on breathing. Ventilation response to pCO_2 and metabolic hyperbola and regulation of breathing. Factors that affect ventilation response to pCO_2 and metabolic hyperbola.
Link between structure and function	Balance of substances in the body (zero, positive, negative). Structure of a nephron in the view of basic mechanisms – filtration and reabsorption. *Transport of solutes (secretion and reabsorption) along a nephron and relationship with inulin clearance. Microscopic structure of vessels, capillary network and juxtaglomerular apparatus. Characteristics of cortical and juxtaglomerular nephrons. Effects of hormones and nervous system. Distal parts of urinary system (ureter, urinary bladder, urethra), characteristics of urine flow (men, women).
Renal circulation	Capillary dynamics, factors that affect pressure in glomerular capillary (influence of a. afferens and a. efferens). Autoregulation of blood flow through capillaries (definition with a diagram, role, mechanisms). Blood flow and urine output, anuria. *Distribution of blood flow in different kidney layers. Oxygen consumption in kidneys and its relationship to load on kidneys.
Glomerular filtration	Glomerular filtration (GF), definition and values, characteristics of ultrafiltrate. Renal plasma flow (PPL), estimation with clearance. Capillary filtration (in comparison with systemic capillaries) and filtration fraction.

	Factors that affect GF (filtration pressure, characteristics of glomerular membrane, PPL, oncotic pressure). Renin-angiotensin-aldosterone system, effects, control of secretion. Regulation of GF and PPL.
Kidney function tests, clearance	Basic mechanisms for tubular reabsorption and secretion. Excretion of substances in kidneys and its relationship to filtered load, transport maximum and threshold for excretion, factors that affect it. Definition of clearance, units, measurement. Clearance for substances which are only filtered, totally or partially reabsorbed or secreted. Relationship of clearance to filtered load.
Transepithelial transport (solutes, water): proximal tubule	Types of transmembrane transport and their features (active, passive, electrical, solvent drag). Model of cellular epithelium for tubular reabsorption (TR) in proximal tubule and membrane transporters. Reabsorption of sodium and solutes in proximal tubule. Forces that determine TR in proximal tubule. Relationship between proximal TR of water and sodium and other solutes – glomerulotubular balance. Tubuloglomerular feedback and its role. *Relationship of TR to filtered load (intrinsic and extrinsic = neural and hormonal influences – diagram). *Osmotic diuresis (example for demonstration of functioning of mechanisms).
Transepithelial transport (solutes, water): distal tubule	Definition of proximal and distal nephron. Reabsorption capabilities of proximal and distal nephron. *Features of luminal sodium transporters in different parts of distal nephron. *Cellular model for transepithelial transport in collecting ducts.
Countercurrent	Features of transtubular transport in Henle's loop. Role of distal nephron in urine dilution. Production of concentrated urine. Role of ADH. Description of countercurrent mechanism. Renal medulla and role of urea (abilities of mechanism according to time scale). Diuresis, antidiuresis, water diuresis. Examples of other countercurrents in the body.
Water balance in the body, control of osmolarity	Water balance in the body, sources and excretion of water. Hydration (dehydration, hyperhidration) according to the osmolarity of body fluids. Cell's size and osmolarity, role of sodium pump. Shifts of fluid between ECT and ICT and influences, demonstration and analysis with diagrams. Control mechanisms for regulation of osmolarity of body fluids. Osmotic and other stimuli for ADH secretion. Measuring of renal diluting ability, osmolar clearance and free water clearance. Solute excretion and free water clearance. Link between regulation of osmolarity and volume of body fluids.
Transport of sodium and water in the body	General principles that enable transport of salt and water in the body. Body's response to higher salt excretion (time graphs of changes of body weight and water intake and excretion). Receptors for homeostasis of body fluids (volume receptors in circulation). Systemic effectors (sympathetic nervous system and AII). *Regulators of sodium reabsorption in kidneys according to changes in osmolarity. *Effectors of regulation in kidneys – principles of function (changes of glomerular hemodynamics, renal nerves, transtubular ionic gradient, composition of medullary interstitium and blood flow through kidneys, stimulation of sodium reabsorption in collecting ducts with aldosterone). *Effectors in kidneys (collecting duct, proximal tubule, Henle's loop, ANH and pressure in medullary interstitium). Effect on regulation of arterial pressure.

Renal excretion of potassium	Functions of potassium and potassium turnover in the body (balance, intake – excretion). Distribution of potassium between ECT and ICT and factors that influence sudden shifts. Potassium shifts according to acid-base status in ECT. *Renal excretion and factors that affect distal tubule and collecting duct (aldosterone concentration, dietary potassium, delivery of sodium to distal tubule, tubulary fluid flow in distal tubule, delivery of sodium with impermeant anion to distal nephron, ADH concentration – explanation with cellular model).
Acid-base physiology – buffers and Davenport diagram	Role of regulation of hydrogen ion concentration, expression with pH and physiological threshold values. Sources of H^+ in the body. Definitions of acidemia, acidosis, alkalemia and alkalosis. Buffers (in blood and urine), volatile vs. nonvolatile buffers and their features in the body, buffer capacity and buffering power, titration curve and demonstration with diagrams, isohydric principle. *Titration of non-volatile buffers in the body with H^+. *Volatile buffers – bicarbonate buffer system (titration with acid or base, titration with CO_2, titration with CO_2 in presence of nonvolatile buffers). *Titration with H^+ in presence of volatile and nonvolatile buffers. Davenport diagram and its use. *Use of Davenport diagram for plasma, erythrocyte, renal tubular cell.
Acid-base physiology – kidneys and regulation of pH in the body	Determining amount of H^+ excreted in urine, titratable acid. Characteristics of a nephron that enable excreting large amounts of H^+. Transport systems for excreting H^+ in the body (bicarbonate, phosphate and ammonia) and buffers in urine. Role of ammonia, ammonia turnover in kidneys and induction of the system. *Stimuli for ammoniagenesis in kidneys, timescale. *Stimuli for renal excretion of hydrogen ions, impact on bicarbonate buffer function. H^+ balance in the body, excretion of H^+ in the lungs and kidneys and impact on pH in the body. *Filtration of bicarbonate in kidneys and impact on pH in the body.
Functions of blood	Role of blood in homeostasis. Role of haemoglobin. Blood plasma – its relationship to other body fluids. Protective function of blood.
Composition of blood	Cellular elements in blood. Composition of blood plasma. Plasma proteins and their roles.
Erythrocytes	Definition and measurement of haematocrit. Regulation of erythropoiesis. Life span and degradation of erythrocytes. Measuring of haemoglobin concentration. Measuring of erythrocyte concentration. Erythrocyte parameters and their calculation.
Blood groups	Blood group types and role of determination. Comparison of erythrocyte blood group systems AB0 and Rh.
Haemostasis	Definition of haemostasis. Stages and components of haemostasis. Role of vasculature in haemostasis. Role of platelets. Coagulation of blood plasma, mechanisms of activation. Fibrinolysis, mechanisms of activation. Tests of haemostasis, bleeding time, clotting time.
Metabolism of substances and	Role of metabolism and energy for homeostasis of cellular function. Transformations of energy substrates, intake and storage.

transformation of energy in the body	Features of metabolic processes digestive and fasting stages.
Regulation of metabolism in different physiological conditions	Regulation of metabolism when the intake of nutrients is normal vs. prolonged / without intake of nutrients. Regulation of metabolism during exercise. Regulation of metabolism while growing up. Regulation of metabolism during prolonged exposure to cold.
Organism's basal metabolic rate	Principle of determining basal metabolic rate. Basal conditions and standardization of measured values. Evaluation of measured values.
Energy balance in organism	Transformation of energy and energy storage in the body. Energy balance and physiological conditions. Diet-induced thermogenesis. Regulation of body mass. Diet and physical exercise.
Regulation of body temperature	Body's mechanisms for thermogenesis and thermolysis. Impact of environment and physiological conditions on regulation of body temperature. Regulation of body temperature. Acclimatisation to heat and cold.
Overview of digestive processes	Structural and functional features of digestive tract. Role of enteric and autonomic nervous system in regulation of processes of motility and secretion. Gastrointestinal reflexes. Structural and functional features of processes of digestion and absorption.
Gastrointestinal motility	Chewing and swallowing, neural control. Gastric motility, neural control. Endocrine, paracrine and neuropeptide regulation of motility. Gastrointestinal reflexes. Haustrations and mass movements.
Salivary secretion	Overview of salivary glands, structural and functional features of salivon. Composition and functions of saliva. Electrolyte transport in salivon. Neural control of salivation.
Secretion, digestion and absorption in stomach	Composition and functions of gastric juice. Mechanism for secretion of acid and enzymes in stomach. Regulation of gastric secretion in different stages. Absorption of nutrients in stomach.
Pancreatic secretion	Composition and functions of pancreatic juice. Stages of pancreatic secretion. Neural and hormonal regulation of secretion. Secretion of bile, composition, regulation of secretion.
Secretion, digestion and absorption in small and large intestine	Secretion in small intestine, regulation of secretion. Digestion in duodenum and small intestine. Absorption of nutrients in small intestine. Digestion and absorption of lipids. Absorption of water and electrolytes in small intestine. Absorption of water and electrolytes in large intestine.
Endocrine system – principles of function	Types of cell-to-cell communications. Specificities of hormone activity. Neuroendocrine system. Ways of acting of amine, peptide and steroid hormones.

	Regulation of hormone secretion. Physiological and pharmacological effects of hormones.
Neuroendocrinology	Hypothalamo-hypophyseal system. Hormonal feedback loops. Examples of regulatory loops. Neurohypophyseal hormones.
Thyroid hormones	Hypothalamic control of thyrotropin (TRH) synthesis. Regulation of thyroid growth and synthesis of hormones (TSH, TSI). Thyroid gland's responsiveness to TSH. Effects of thyroid hormones on basal metabolism and tissue growth.
Calcium homeostasis and physiology of bones	Daily Ca^{2+} balance, intake, storage, excretion. Vitamin D metabolism and absorption of Ca^{2+} in GIT. Regulation of plasma concentrations of calcium and phosphate (parathormone, calcitonin). Effects of parathormone and calcitonin on bones, kidneys and digestive system. Role of calcium homeostasis for growth of bones and teeth.
Hormones of adrenal cortex	Mineralocorticoids (regulation of tubular Na^{+} reabsorption). Glucocorticoids (effect on metabolism of carbohydrates, proteins and lipids). Cortical androgens. Hypothalamo-hypophyseal regulation of cortisol secretion. Hyper- and hypofunction of adrenal cortex and role of adrenocortical hormones in medicine.
Hormones of adrenal medulla	Adrenomedullary hormones (synthesis, regulation of synthesis and release). Physiological and psychological factors that affect catecholamine release. Physiological effects of catecholamines.
Gonadal steroids	Testicular hormones. Hormonal regulation of testicular function. Physiological effects of androgens. Ovarian hormones. Hormonal regulation of ovarian cycle, role of hypothalamo-hypophyseal axis in regulation. Placental hormones.
Pregnancy	Physiology of conception. Hormonal control of pregnancy (oestrogens, progesterone, hCG, hCS). Physiological role of placenta, amniocentesis. Foetal development during pregnancy.
Parturition and lactation	Control of beginning of parturition. Factors that regulate uterine contractions. Hypothalamo-hypophyseal control of mammary glands during pregnancy and after parturition. Suckling, milk let-down and control of oxytocin release.

9. Other information

The Pedagogical College of the Institute of Physiology is responsible for questions regarding physiology education.

The official hours of the secretariat of the Institute of Physiology are from Monday to Friday from 9.30 to 10.30.

B. Elective Courses *(considered as Elective Course Announcement)*

1. **Participating main and guest lecturers**

2. **Estimated time period in the semester**

3. **Maximum number of students for the elective course (if the number of students able to attend the course is limited)**

4. Please specify if the elective course is available in English for incoming international students (Erasmus + and others). Please specify any additional conditions in the case that the elective course is available for visiting students.

Additional explications and notes:

1. The Course Regime enters in force on the date of issue and remains valid until its revocation or alteration. The Course Regime may not be altered during the academic year. Any changes to the Course Regime may only enter into force starting with the next academic year (changes must be submitted no later than 14 days prior to the start of the academic year as the **new Course Regime**).

2. The Course Regime for *compulsory courses* must be published no later than 14 days prior to the start of the academic year.

3. The Course Regime for *elective courses* is also considered the Elective Course Announcement and must be published no later than the 30th of July prior to the start of the academic year in which it enters in force.

4. The Course Regime must be published in Slovenian and English.

5. In the Course Regime, the »Regulations for the Assessment of Knowledge and Skills for the Single-Cycle Master Study Programmes Medicine and Dental Medicine« will be referred to as *"Regulations"*.

In case of any further questions, please contact the Study Affairs Commission of the UL MF, via e-mail: ksz@mf.uni-lj.si.

Ta navodila pred shranjevanjem pobrišite:

- **Za izpolnjevanje tega obrazca uporabite pisavo Garamond, 12pt.**
- **Dokument shranite v .pdf.**