Komisija za študijske zadeve
UL Medicinske fakultete

Univerza *v Ljubljani*
Medicinska fakulteta

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Course Regime

Course: Physiology

Study Programme: Dental medicine

Year of the Course: 2nd

Semester: Whole year

Course type: Compulsory

Number of ECTS credits: 15

Lecturer(s): prof. dr. Žarko Finderle, izr. prof. dr. Ksenija Cankar, doc. dr. Helena Lenasi

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

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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 function of the organism. She or he acquires the basic concepts in physiology and learns the principles of measurement of physiological events. She or he is encouraged in accordance with the concepts, to interpret the results of the measurements. The student develops the ability to independently solve problems and critical thinking and 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 addresses of lectures will be published on the Physiology sub-site on the website of the Faculty of Medicine and in 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 published on the website of the Faculty of Medicine on a 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 one seminar per semester.

Instructions for preparing the seminar:
A student or group of students prepares the content of the assigned seminar on 1 slide in .ppt format. The slide must present a shortened title and a maximum of 1 diagrams and 5 indents for the subject of the seminar, font size at least 24. The footnotes should include the names of the students. The presentation of the seminar lasts 15 minutes and includes a short presentation (up to 5 minutes) and a discussion where the seminar leader asks the students. Students submit a .ppt file (in Office 2003 version and not newer !!) to the seminar leader by email no later than 3 business days before the seminar. The file should have an address 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:

The student must have completed all three mandatory partial exams. The first partial exam covers the substance of the tutorial: Measurements, Blood, Nerve and muscle, and ECG, the second partial exam covers the substance of the tutorial: Blood Pressure, Heart and Vessel, Breathing and Respiratory Function of Blood, and the third partial exam covers the tutorial: Sensory, Neurophysiological Measurements, Metabolism and Kidney.

Absence in mandatory partial exams must be apologized in the secretariat of the Institute of Physiology. The student receives a negative point for the wrongly answered question at the partial exam. Before each (except for the first) exam, there is a repetitive partial exam, which can be attended by student, who did not reach an average of three partial exams 50.01 % during the year or who did not perform the partial exam from justified reasons during the year. The student must report participation on a repetitive partial exam to the secretary of the Institute of Physiology to an e-mail no later than three working days before the deadline. Repetitive partial exam covers the substance of all tutorials.

3.2 SEMINARS:

All students in the group who have a seminar must be prepared for the seminar. They must answer to a questions that are similar to questions for the exam. Student's willingness is a condition for the seminar to be completed. The seminar is evaluated with done/not done.

4. Required conditions for the final examination (Course Exam)

In accordance with Article 23 of the Rules, the conditions for entering the exam are:

- all tutorials must be completed,
- an average of three partial exams must be 50.01 % or more,
- completed seminars.

5. Final assessment and examination of knowledge and skills (Course Exam)

Assessment is being implemented with written test exam with questions of an optional type. Students which passed exam must then complete the oral part of the exam.

Evaluation of the written examination:

• For each incorrect answer marked the student receives a 0.2 negative point.

• For a positive assessment of a written examination, is required at least 50.01 % of points.

• A positive assessment of a written examination is a condition to approach the oral examination, except for the third to the fifth/sixth written examination, where every student has the right to approach the oral examination. In the fourth, fifth and sixth performance of the exams, the oral part of the examination is conducted before the commission. The Commission exam is conducted in accordance with the Rules on the assessment and assessment of knowledge and skills for a uniform master's program in medicine and dental medicine.

• To the result of the written examination is added a bonus. This is a positive part of the average grade of three regular partial exams, weighted by one third. The bonus is only counted in the current academic year. Example: if the student receives an average grade of 80 % in partial exams, the positive part of the assessment is 30 % (80 % – 50 % = 30 %). If we share the positive part of the assessment with 3, we get a value of a bonus which in this case is 10%. Received bonus (10 %) is added to the grade that student obtained at the written examination. If a written assessment of the exam is for example, 50 %, bonus improves grade for 10 %; The total score of the exam is then 60 %. The bonus is added only if the assessment of the written part of the exam is greater than or equal to 50.01 %.

Written exams are available for a view but only after oral examinations have been completed. Insights are not intended to determine which of the possible answers is correct. For such or similar questions that relate to the subject matter of the course, pedagogical workers are available throughout the year during office hours (after prior announcement).

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

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 brought 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

• Textbooks:

- John E. Hall PhD: Guyton and Hall Textbook of Medical Physiology, 13e: chapters in nervous physiology
- Bruce M. Koeppen & Bruce A. Stanton: Berne & Levy Physiology, 6e: all chapters except nervous system physiology
- Štrucl M. Fiziologija živčevja. Ljubljana: Medicinski razgledi, 1999

•Extracts from lectures: e-classroom

•Tutorial instructions

8. Exam topics, clinical presentations and skills

EXPLANATION OF ACRONYMS:
L (Lectures); **S** (Seminars); **T** (Textbook, chapter from a book, instructions for preclinical practical courses, article); **PPC** (Preclinical Practical Courses); **OFS** (Other Forms of Study)

SUBJECT	SUBJECT DETAILS	LITERATURE
Principles of physiology		
Homeostasis	Maintaining constant internal environment. Regulated quantities, overview. *Modern description with mathematical laws, systems theory, cybernetics.	L: Homeostasis. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Homeostasis: Volume and Composition of Body Fluid Compartments.
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,	L: Transport mechanisms – overview.

	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.	L: Thermodynamics of biological solutions.
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.	L: Systemic analysis in physiology (M).
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).	L: Regulation in biological 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.	L: Transport of substances across cell membrane. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Principles of Cell and Membrane Function.
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.	L: Transport of water, osmosis. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Principles of Cell and Membrane Function. - Homeostasis: Volume and Composition of Body Fluid Compartments.
Electrophysiology		
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.	L: Membrane potential. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Principles of Cell and Membrane Function. - Homeostasis: Volume and Composition of Body Fluid Compartments.

	Goldman's equation (of a constant field). *Electrical model of a cell membrane.	
Electrical communication (localized and travelling potentials)	Measuring of electrical phenomena. Excitability and types of stimuli and responses (local response, action potential). Types of channels according to excitability (depolarizing and repolarizing currents). *Classic description (according to Hodgkin and Huxley), static description (patch clamp). Passive response of cell membrane to stimulation, transient phenomena. Local response, conduction with decrement (for example electrotonic potential). *Spreading of excitation, travelling of an interference along a cable (hose). *Electrical stimulation: effects of an electrical current depending on direction of the current, amplitude and duration of a stimulus, shape of current pulses and frequency.	L: Electrical communication (localized and travelling potentials). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Generation and Conduction of Action Potentials.
Muscle		
Skeletal muscle: macroscopic description	Observing and defining contractions (concentric, eccentric, isometric, isotonic contraction). Physical quantities describing mechanical functioning of a muscle (length, velocity, tension) and muscle's characteristics (muscle force and power). Types of muscle activation (twitch, tetanus, contracture). Mechanical characteristics of skeletal muscle. Force – velocity relationship. Length – tension relationship (isometric contraction).	L: Skeletal muscle: macroscopic description. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Skeletal Muscle Physiology.
Microscopic description, excitation-contraction coupling	Sarcomere as a basic unit of contractile apparatus, its elements and function. Role of cross-bridges in contraction. Activation of contractile apparatus with calcium and sensitivity to calcium. Excitation-contraction coupling.	L: Microscopic description, excitation-contraction coupling. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Skeletal Muscle Physiology.
Energetics of muscle contraction	Energy sources and metabolism. *Heat discharge during contraction. *Energy consumption depending on work done, load, contraction velocity and type of activation.	L: Energetics of muscle contraction. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Skeletal Muscle Physiology.
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.	L: Smooth muscle. T: Berne RM, Levy MN. Physiology or Principles of physiology: - 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.	L: Fuctioning of muscles in the body. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Skeletal Muscle Physiology.

	*Functioning of muscles at more than one joint and in different directions at one joint, effect of penante muscles.	
Circulation – heart		
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.	L: Overview, divisions. T: Berne RM, Levy MN: Physiology or Principles of Physiology: - Overview of Circulation.
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).	L: The cardiac pump: the cardiac cycle. T: Berne RM, Levy MN: Physiology or Principles of Physiology: - Elements of Cardiac Function.
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.	L: Electrical activity of the heart – types of potentials, conduction velocity, excitability. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Cardiac Function.
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).	L: Normal excitation of the heart, ECG. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Cardiac Function.
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.	L: Cardiac muscle cell, energetics of heart. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Cardiac Muscle. - Elements of Cardiac Function.
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.	L: Control of cardiac function, effect of heart rate. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Cardiac Function. - Regulation of the Heart and Vasculature.

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.	L: Control of cardiac function, effects of preload, afterload and contractility. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Regulation of the Heart and Vasculature.
p-V diagram	Regulation of cardiac function, effects of filling, load and contractility.	L: p-V diagram of the heart. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Cardiac Function.
Circulation – vasculature		
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.	L: Hemodynamics. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Properties of the Vasculature.
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.	L: Arteries (pulsations, compliance). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Properties of the Vasculature.
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.	L: Veins (and collapsible vessels). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Properties of the Vasculature.
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).	L: Microcirculation (exchange, regulation). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Properties of the Vasculature.

	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).	L: Regulation of cardiac output (venous return = cardiac output). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Integrated Control of the Cardiovascular System.
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.	L: Regulation of arterial pressure. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Properties of the Vasculature. - Regulation of the Heart and Vasculature. - Integrated Control of the Cardiovascular System.
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.	L: Measuring the cardiac output. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Cardiac Function.
Blood flow through particular vascular networks and characteristics	Coronary circulation. Cutaneous circulation. Cerebral circulation. Fetal circulation.	L: Blood flow through particular vascular networks and characteristics. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Properties of the Vasculature.
Respiration		
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).	L: Link between structure and function of the lungs. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Introduction to the Respiratory System. - Oxygen and Carbon Dioxide Transport. - Nonphysiological Functions of the Lung: Host Defense and Metabolism.
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.	L: Ventilation. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Static Lung and Chest Wall Mechanics. - Dynamic Lung and Chest Wall Mechanics. - Ventilation, Perfusion, and Ventilation/Perfusion Relationships.
Mechanics of breathing	Respiratory muscle and their function.	L: Mechanics of breathing.

	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.	T: Berne RM, Levy MN. Physiology or Principles of physiology: - Static Lung and Chest Wall Mechanics. - Dynamic Lung and Chest Wall Mechanics.
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.	L: Diffusion in lungs. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Ventilation, Perfusion, and Ventilation/Perfusion Relationships. - Oxygen and Carbon Dioxide Transport.
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.	L: Pulmonary circulation. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Ventilation, Perfusion, and Ventilation/Perfusion Relationships.
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.	L: Transport of gasses in blood. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Oxygen and Carbon Dioxide Transport
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.	L: Coupling of ventilation, diffusion, perfusion. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Ventilation, Perfusion, and Ventilation/Perfusion Relationships. - Oxygen and Carbon Dioxide Transport.
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.	L: Control of respiration. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Control of Respiration.
Kidneys and transport of electrolytes in the body		
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	L: Link between structure and function.

	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).	T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Renal Function.
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.	L: Renal circulation. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Renal Function.
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.	L: Glomerular filtration. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Renal Function.
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.	L: Kidney function tests, clearance. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Elements of Renal Function.
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).	L: Transepithelial transport (solutes, water): proximal tubule. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Solute and Water Transport along the Nephron: Tubular Function.
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.	L: Transepithelial transport (solutes, water): distal tubule. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Solute and Water Transport along

		the Nephron: Tubular Function.
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.	L: Countercurrent. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Control of Body Fluid Osmolality and Volume.
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.	L: Water balance in the body, control of osmolarity. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Control of Body Fluid Osmolality and Volume.
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.	L: Transport of sodium and water in the body. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Control of Body Fluid Osmolality and Volume.
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).	L: Renal excretion of potassium. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Potassium, Calcium, and Phosphate Homeostasis.
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.	L: Acid-base physiology – buffers and Davenport diagram. T: Berne RM, Levy MN. Physiology or

	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.	Principles of physiology: - Role of the Kidneys in the Regulation of Acid-Base Balance.
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.	L: Acid-base physiology – kidneys and regulation of pH in the body. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Role of the Kidneys in the Regulation of Acid-Base Balance.
Blood		
Functions of blood	Role of blood in homeostasis. Role of haemoglobin. Blood plasma – its relationship to other body fluids. Protective function of blood.	L: Functions of blood. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Homeostasis: Volume and Composition of Body Fluid Compartments.
Composition of blood	Cellular elements in blood. Composition of blood plasma. Plasma proteins and their roles.	PPC: Blood, respiratory function of blood. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Homeostasis: Volume and Composition of Body Fluid Compartments. T: Guyton and Hall Textbook of Medical Physiology: - Red Blood Cells, Anemia, and Polycythemia. - Resistance of the Body to Infection: I. Leukocytes, Granulocytes, the Monocyte-Macrophage System, and Inflammation. - Resistance of the Body to Infection: II. Immunity and Allergy Innate Immunity. - Hemostasis and Blood Coagulation.

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.	PPC: Blood, respiratory function of blood. T: Guyton and Hall Textbook of Medical Physiology: - Red Blood Cells, Anemia, and Polycythemia.
Blood groups	Blood group types and role of determination. Comparison of erythrocyte blood group systems AB0 and Rh.	PPC: Blood, respiratory function of blood. T: Guyton and Hall Textbook of Medical Physiology: - Blood Types; Transfusion; Tissue and Organ Transplantation.
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.	L: Haemostasis. PPC: Blood, respiratory function of blood. T: Guyton and Hall Textbook of Medical Physiology: - Hemostasis and Blood Coagulation.
Metabolism		
Metabolism of substances and transformation of energy in the body	Role of metabolism and energy for homeostasis of cellular function. Transformations of energy substrates, intake and storage. Features of metabolic processes digestive and fasting stages.	L: Metabolism of substances and transformation of energy. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Hormonal Regulation of Energy Metabolism.
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.	L: Metabolism of substances and transformation of energy. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Hormonal Regulation of Energy Metabolism.
Organism's basal metabolic rate	Principle of determining basal metabolic rate. Basal conditions and standardization of measured values. Evaluation of measured values.	L: Metabolism of substances and transformation of energy. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology ali Principles of physiology: - Hormonal Regulation of Energy Metabolism.
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.	L: Metabolism of substances and transformation of energy. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion).

		T: Berne RM, Levy MN. Physiology or Principles of physiology: - Hormonal Regulation of Energy Metabolism.
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.	L: Metabolism of substances and transformation of energy. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Hormonal Regulation of Energy Metabolism. - The Autonomic Nervous System and Its Central Control.
Digestion		
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.	T: Johnson LR. Gastrointestinal physiology. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Functional Anatomy and General Principles of Regulation in the Gastrointestinal Tract.
Gastrointestinal motility	Chewing and swallowing, neural control. Gastric motility, neural control. Endocrine, paracrine and neuropeptide regulation of motility. Gastrointestinal reflexes. Haustrations and mass movements.	T: Johnson LR. Gastrointestinal physiology. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - Functional Anatomy and General Principles of Regulation in the Gastrointestinal Tract. - The Cephalic, Oral, and Esophageal Phases of the Integrated Response to a Meal. - The Gastric Phase of the Integrated Response to a Meal. - The Small Intestinal Phase of the Integrated Response to a Meal. - The Colonic Phase of the Integrated Response to a Meal.
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.	T: Johnson LR. Gastrointestinal physiology. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology:

		- The Cephalic, Oral, and Esophageal Phases of the Integrated Response to a Meal.
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.	T: Johnson LR. Gastrointestinal physiology. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Gastric Phase of the Integrated Response to a Meal.
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.	T: Johnson LR. Gastrointestinal physiology. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Small Intestinal Phase of the Integrated Response to a Meal.
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.	T: Johnson LR. Gastrointestinal physiology. T: Koren A. Presnova, termoregulacija in prebava (Metabolism, Thermoregulation and Digestion). T: Berne RM, Levy MN. Physiology ali Principles of physiology: - The Small Intestinal Phase of the Integrated Response to a Meal. - The Colonic Phase of the Integrated Response to a Meal.
Endocrinology		
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.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Introduction to the Endocrine System.
Neuroendocrinology	Hypothalamo-hypophyseal system. Hormonal feedback loops. Examples of regulatory loops. Neurohypophyseal hormones.	T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Introduction to the Endocrine System. - The Hypothalamus and Pituitary Gland.

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.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Thyroid Gland.
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.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - Hormonal Regulation of Calcium and Phosphate Metabolism. - Potassium, Calcium, and Phosphate Homeostasis.
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.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Adrenal Gland.
Hormones of adrenal medulla	Adrenomedullary hormones (synthesis, regulation of synthesis and release). Physiological and psychological factors that affect catecholamine release. Physiological effects of catecholamines.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Adrenal Gland.
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.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Male and Female Reproductive Systems.
Physiology of pregnancy/parturition		
Pregnancy	Physiology of conception. Hormonal control of pregnancy (oestrogens, progesterone, hCG, hCS). Physiological role of placenta, amniocentesis. Foetal development during pregnancy.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Male and Female Reproductive Systems.
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.	Lecture T: Greenspan FS, Strewler GJ. Basic and clinical endocrinology. T: Berne RM, Levy MN. Physiology or Principles of physiology: - The Male and Female Reproductive Systems.

SUBJECT	SUBJECT DETAILS	LITERATURE
Neuron and synapse		
General features and functions of nervous system	Functions of nervous system. Structure of nervous system. Maturation of nervous system.	Online classroom of the MF. T: Guyton and Hall Textbook of Medical Physiology: - Organization of the Nervous System, Basic Functions of Synapses, and Neurotransmitters.
Membrane potentials	Resting membrane potential. Action potential. Graduated, localized potential.	L: Membrane potentials. L: Electrical communication (localized and travelling potentials). T: Berne RM, Levy MN: - Homeostasis - Generation and conduction of action potencials. T: Guyton and Hall Textbook of Medical Physiology: - Membrane Potentials and Action Potentials.
Synaptic transmission	Types of synapses. Chemical synapse – mechanism of function. Neurotransmitters. Neuromuscular junction. Synaptic plasticity.	L: Electrical communication (localized and travelling potentials). T: Berne RM, Levy MN: - Synaptic transmission. T: Guyton and Hall Textbook of Medical Physiology: - Organization of the Nervous System, Basic Functions of Synapses, and Neurotransmitters.
Homeostasis of neural function	Role of blood–brain barrier. Types and roles of glial cells. Cerebrospinal fluid dynamics. Regulation of cerebral circulation. Relationship between neural activity, local metabolism and blood flow.	L: Electrical communication (localized and travelling potentials). T: Guyton and Hall Textbook of Medical Physiology: - Cerebral Blood Flow, Cerebrospinal Fluid, and Brain Metabolism.
Sensory sistem		
General features of sensory systems	Principles of information processing in sensory pathways, modality, specificity. Ways of information transmission along a sensory pathway; somatotopicity, retinotopicity, tonotopicity. Types of sensory processes: receptor activation, transmission and processing of information, perception. Receptor events: transduction, transformation, adaptation. Receptive field concept; role of peripheral inhibition. Relationship between stimulus intensity and size of response (physiological and psychophysical). Sensory threshold, differentiation threshold, spatial resolution.	L: General features of sensory systems. T: Guyton and Hall Textbook of Medical Physiology: - Sensory Receptors, Neuronal Circuits for Processing Information.
Somatosensory system	Types of mechanoreception on skin and mucosa. Special features of thermoreception on the body surface. Proprioceptors and their role.	T: Guyton and Hall Textbook of Medical Physiology: - Somatic Sensations: I. General

	Mechanisms of nociception. Role of cerebral cortex in analysis of somatosensory information.	Organization, the Tactile and Position Senses.
Physiology of pain	Reception of pain. Special features of transmission and processing of nociceptive signals. Systems for pain modulation.	L: Physiology of pain. T: Guyton and Hall Textbook of Medical Physiology: - Somatic Sensation: II. Pain, Headache and Thermal Sensations.
Optics of vision	Eye's optic apparatus. Accomodation of vision. Pupillary reflex. Principles of depth perception (monocular, binocular).	PPC: Vision. T: Guyton and Hall Textbook of Medical Physiology: - The Eye: I. Optics of vision.
Neurophysiology of vision	Photoreception in rods. Photoreception in cones. Typical retinal structure, role of horizontal and vertical connections. Retinal processing of achromatic signals. Retinal processing of chromatic signals; threechromacy theory, antagonism of pathways for color vision. Retinal functional specialization: magno- and parvocellular system.	L: Neurophysiology of vision. U Guyton and Hall Textbook of Medical Physiology: - The Eye: II. Receptor and Neural Function of the Retina. T: Štrucl M. Fiziologija živčevja (Physiology of the Nervous System): - Vidni sistem (Visual System).
Cortical processing of visual information	Functional specialization of visual pathway. Principle of modullary architecture of visual cortex (types of modules). Selective processing of visual stimuli: shape, colour, movement, depth perception. Problem of combining visual information into unified perception.	L: Cortical processing of visual information. T: Guyton and Hall Textbook of Medical Physiology: - The Eye: III. Central Neurophysiology of Vision. T: Štrucl M. Fiziologija živčevja (Physiology of the Nervous System): - Vidni sistem (Visual System).
Psychophysics of vision	Measuring fields of vision. Measuring visual acuity. Intensity-frequency field of photopic vision. Intensity-frequency field of scotopic vision. Psyshophysical photometric units.	L: Psychophysics of vision. PPC: Vision. T: Guyton and Hall Textbook of Medical Physiology: - The Eye: III. Central Neurophysiology of Vision.
Transmission of sound to inner ear	Physical features of sound. Problems of sound transmission and systems that enable transmission to inner eat. Air vs. bone conduction of sound.	T: Guyton and Hall Textbook of Medical Physiology: - The Sense of Hearing.
Neurophysiology of hearing	Mechanisms for excitation of hair cells in inner ear. Principles of analysis of sound in auditory system. Principles of tone analysis. Principles of loudness analysis. Principles of sound direction analysis. Principles of analysis of speech. Role of auditory cortex in sound analysis. Physiological principles of hearing aids.	L: Neurophysiology of hearing. T: Guyton and Hall Textbook of Medical Physiology: - The Sense of Hearing.
Psychophysics of hearing	Intensity-frequency field of hearing. Physiological basics of subjective audiometry. Objective audiometry.	L: Psychophysics of hearing. PPC: Hearing. T: Guyton and Hall Textbook of Medical Physiology: - The Sense of Hearing.

Vestibular apparatus	Sensory reception in sacculus, utricculus and cristae ampullares. Roles of vestibular apparatus. Control of head position in space, with vision, without vision. Vestibular tests.	T: Guyton and Hall Textbook of Medical Physiology: - Cortical and Brain Stem Control of Motor Function.
Olfaction	Principles of substance differentiation with olfaction. Sensory processes in olfaction, mechanism for coding. Olfactory pathways.	T: Guyton and Hall Textbook of Medical Physiology: - The Chemical Senses-Taste and Smell.
Taste	Principles of substance differentiation with tasting. Sensory processes in tasting, mechanism for coding. Gustatory pathways.	T: Guyton and Hall Textbook of Medical Physiology: - The Chemical Senses-Taste and Smell.
Motor system		
Motor system – overview	Types of movements and their features (reflex, rhythmic, voluntary). Principle of hierarchic structure of motor system. Role of sensory-motor integration in control of movement.	L: Motor system – overview. T: Guyton and Hall Textbook of Medical Physiology: - Organization of the Nervous System, Basic Functions of Synapses, and Neurotransmitters.
Motor role of spinal cord (reflex excitability)	Motor unit. Types of motor units. Basic mechanisms for modulation of force of muscular contraction. General scheme of a reflex, types of reflexes. Myotatic reflex. Inverse myotatic reflex. Role of muscle spindle and gamma motor neurons. Flexion reflexes. Comparison of myotatic reflex and polysynaptic reflexes. Habituation and sensitisation. Physiological basics of EMG. Muscle tone: anti-gravitational, in clinical practice.	L: Motor role of spinal cord (reflex excitability). T: Guyton and Hall Textbook of Medical Physiology: - Motor Functions of the Spinal Cord; the Cord Reflexes.
Descending motor pathways	Types and physiological characteristics of descending motor pathways. Origin and role of lateral motor pathways. Origin and role of medial motor pathways.	L: Descending motor pathways. T: Guyton and Hall Textbook of Medical Physiology: - Cortical and Brain Stem Control of Motor Function.
Motor role of brainstem (control of posture)	Postural reflexes. Motor abilities of decerebrated vs. decorticated animal. Vestibulocollic and vestibulospinal reflexes. Vestibuloocular reflex. Control of rhythmic movements.	L: Motor role of brainstem (control of posture). T: Guyton and Hall Textbook of Medical Physiology: - Cortical and Brain Stem Control of Motor Function.
Cortical control of motor function	Stages of initiation and execution of voluntary movement. Typical cortical areas involved in initiation of voluntary movements. Function of primary motor cortex. Role of premotor and supplementary motor area. Role of parietal association cortex in voluntary movement. Definition of primary cortical efferent areas.	L: Cortical control of motor function. T: Guyton and Hall Textbook of Medical Physiology: - Cortical and Brain Stem Control of Motor Function.
Role of cerebellum	Role of cerebellum.	L: Role of cerebellum. T: Guyton and Hall Textbook of Medical Physiology:

		- Contribution of the Cerebelum and Basal Ganglia to Overall Motor Control.
Motor functions of basal ganglia	Typical connections of basal ganglia, direct vs indirect pathway. Typical neurotransmitters in basal ganglia. Comparison of motor and sensory connections of basal ganglia and cerebellum. Experimental and clinical proofs of motor functions of basal ganglia.	L: Motor functions of basal ganglia. T: Guyton and Hall Textbook of Medical Physiology: - Contribution of the Cerebelum and Basal Ganglia to Overall Motor Control.
Higher neural functions		
Integrative functions of brainstem	Functions of cranial nerves. Functional aspects of reticular formation, modulation of motor and sensory functions and level of consciousness. Typical modulatory neurotransmitter systems that originate from brainstem. Control of qualitative aspect of consciousness; wakefulness, sleep. Stages of sleep. Physiological basis of EEG.	L: Integrative functions of brainstem. T: Guyton and Hall Textbook of Medical Physiology: - Cortical and Brain Stem Control of Motor Function. - State of the Brain Activity-Sleep, Brain Waves, Epilepsy, Psychoses and Dementia.
Neural control of instinctive behaviour	Patterns of homeostatic behaviour and their physiological features (fight-flight-fear, feeding, reproduction). Role of integration of vegetative hormonal and motor functions in behavioural patterns. Functions of hypothalamus in the aspects of major physiological needs, environmental motivational charts and behavioural patterns. Explanation of "reward centre" and addiction. Typical groups of neurons (nuclei) that provide hypothalamic functions. Circadian rhythms and control.	T: Guyton and Hall Textbook of Medical Physiology: - Behavioral and Motivational Mechanisms of the Brain- The Limbic System and the Hypothalamus. T: Štrucl M. Fiziologija živčevja (Physiology of the Nervous System): - Vloga hipotalamusa (Role of the Hypothalamus).
Role of autonomic nervous system	Comparison of organization of somatic and autonomic nervous system. Typical examples of vegetative reflex arches. Sympathetic vs. parasympathetic nervous system. Enteric nervous system. Diagram of control of bladder emptying as a model of coordinated reflex patterns. Typical neurotransmitters in autonomic nervous system. Examples of autonomic control of function in different organs.	T: Guyton and Hall Textbook of Medical Physiology: - The Autonomic Nervous System and Adrenal Medulla.
Principles of structure and function of cerebral cortex	Principle of vertical cytoarchitecture of cerebral cortex (major cell types, connections). Principle of horizontal cortical architecture; cytoarchitectural maps, functional maps. Cortical hierarchy: primary areas and higher order areas.	T: Guyton and Hall Textbook of Medical Physiology: - Cerebral Cortex, Intellectual Functions of the Brain, Learning and Memory.
Control of speech	Simplified scheme of control of speech (comparison with general motor scheme).	L: Control of speech. T: Štrucl M. Fiziologija živčevja (Physiology of the Nervous System): - Višje dejavnosti živčevja (Higher Neural Functions).
Physiological basics of memory and learning	Classification of memory and learning on the basis of type of learning, time and content of memory. Physiological basis of memory	L: Physiological basics of memory and learning.

Legend
* = more difficult subject

Literature:

John E. Hall PhD: Guyton and Hall Textbook of Medical Physiology, 13e.
Berne RM, Levy MN (ur). Physiology. St. Louis: Mosby, the newest edition.
Berne RM, Levy MN (ur). Principles of physiology. St. Louis: Mosby, the newest edition.
Greenspan FS, Strewler GJ (ur). Basic & clinical endocrinology. London: Prentice-Hall International, the newest edition.
Johnson LR. Gastrointestinal physiology. St. Louis: Mosby, the newest edition.
Koren A. Presnova, termoregulacija in prebava: temelji fiziologije prehrane. Ljubljana: Biotehniška fakulteta, Oddelek za živilstvo, the newest edition.
Štrucl M. Fiziologija živčevja. Ljubljana: Medicinski razgledi, 1999.

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.