UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physiology

2324-2-H4601D006

Aims

The course provides students with the required knowledge about the organs and systems physiology. The course analyzes the mechanisms inherent cell excitability and the interaction between excitable cells, the physiology of motor and sensory systems, the integrated functioning of different organs, apparat uses and main control systems by which the human obtains and maintains homeostasis. A special focus of the concepts in the stomatognathic system is aimed at understanding the psychophysiology and the basic clinical knowledge to practice the profession. The course, organized in one semester, is divided into lectures, tutorials and seminars

Contents

Physiology of excitable cells

• Defining the structure and function of the plasma membrane: ion channels, the resting membrane potential

• Define the genesis and propagation of action potential, EPSP and IPSP, synaptic transmission

Nervous System

• Outline the responses mediated by sensory receptors - mode, location, intensity, duration.

• Describe the perception of pain - nociceptors: anatomical distribution, mechanisms of activation and sensitization

• Describe the organization of the motor system, the anatomical and functional organization of the sympathetic and parasympathetic system.

Physiology of the Cardiovascular System

• Define the electrical activity of the heart and understand the relationships between ECG and cardiac electrical events.

• Define the organization and hemodynamic of systemic circulation, homeostasis and coagulation

• Outline and be able to perform the measurement of blood pressure in humans

Physiology of respiratory system

• Define the lung activity in term of gas exchanger: the relationship between ventilation and perfusion

• Define diffusion and transport of respiratory gases in the blood. Alveolar-capillary gas exchange.

• Describe the metabolic and respiratory acidosis and alkalosis.

Physiology of the gastrointestinal system

• Describe the general functions gastrointestinal system: secretion, motility, absorption

Renal Function

• Determine the renal function in relation to the maintenance of fluid-electrolyte balance, control of extracellular volume and osmolarity, regulation of acid-base balance.

Endocrine System

• Describe the hormonal regulation, the hypothalamus-pituitary system and endocrine glands.

Physiology of the stomatognathic system

• Describe the sensory innervation of oro-facial region, the sensory innervation of the tooth

• Outline the masticatory function

Detailed program

Physiology of muscle and nerve cell-cell excitability

Plasma membrane. Permeability, diffusion, osmosis, active and passive transport across the membrane. Ion channels. Electrochemical balance and Nernst equation. Resting membrane potential. The Na?/ K?pump. Passive electrical properties of the membrane. Action Potential: origins, bases and ionic properties. Conduction of the action potential in unmyelinated and myelinated nerve fibers. Classification of nerve fibers. Elementary interactions between excitable cells. The synapses. General concepts on the synaptic transmission. The neuromuscular junction. The central synapses. Electrical events in postsynaptic neurons (EPSP and IPSP). Neuronal integration of synaptic inputs: spatial and temporal summation. Neurotransmitters, agonists and antagonists in the CNS.

Muscle physiology

The skeletal striated muscle. Structure of the contractile apparatus. The sarcomer: contractile and regulatory proteins. Excitation-contraction coupling: role of Ca^{2} ?. Molecular basis and mechanics of contraction. Shock and tetanus. Isotonic and isometric contraction. Force-velocity and tension-length relationship.

Classification of skeletal muscle fibres. Biochemical characteristics, metabolic and histological properties of muscle fibres. Definition and classification of motor units. Modulation of force output by varying the firing rate and recruitment of motor units. The smooth muscle. Coupling between smooth muscle cells.

Level of detail:High. In this part of the program will be acquired basic knowledge for understanding topics of relevance.

The nervous system -Sensory Systems.

Organization and general mechanisms. The sensory receptors: definition and classification of receptors. Signal transduction and coding. Adequate stimulus. Adaptation. Receptive fields: mode, location, intensity, duration.

Structure of human sensory system: free nerve endings, the nociceptors and thermo receptors. Ascending pathways of somatic sensibility:the dorsal column-medial lemniscus system, the anterolateral system (spino-thalamic tract). Somatosensory cortex.

The pain. Nociceptors: anatomical distribution, mechanisms of activation and sensitization. Nociceptors somatic, deep and visceral. Central pathways of pain sensibility. Endogenous antinociceptive systems:spinal mechanisms of modulation and supraspinal descending inhibitory systems. Opioids.

Special sense organs.

Motor system control: neuronal circuits, reflex responses, voluntary movements and rhythmic activities. Organization of motor system: spinal cord, brain stem and cerebral cortex. Cerebellum and basal ganglia. The medial and lateral systems in motor control.

Motor functions of the spinal cord: spinal reflexes, muscle spindle and the stretch reflex, inverse stretch reflex, flexor reflex, the spinal preparation.

Motor functions of the brainstem and cortex; supraspinal control of the stretch reflex, posture and its maintenance. Vestibular and neck reflexes. Cortical control of movement. Motor areas of the cortex and their functional role.

Cerebellum and basal ganglia: general organization and functional role in motor control.

Autonomic nervous system

Anatomical and functional organization of the sympathetic and parasympathetic system. Chemical mediators. Organization of the autonomic reflexes. Vegetative functions of the brain stem. Central nervous control of visceral functions.

Thermo regulation: physiologic mechanisms for regulating the heat production

Level of detail: High or intermediate.

Physiology of the Cardiovascular System

With particular reference to blood coagulation and homeostasis.

The heart.

Electrical activity of the heart and ECG recordings. Cardiac action potentials. Hierarchy in rhythm generation and excitation propagation. ECG and cardiac electrical events relationship. Mechanical activity of the heart. Heart muscle. Mechanical properties. The heart pump. Cardiac cycle, cardiac output.

The control of the heart activities. Intrinsic regulation of cardiac function. Length-tension relationship and the

Starling'slaw. Adjusting extrinsic (nerve and humoral) cardiac contractility and output.

The vascular system

Hemodynamics and organization of the systemic circulation. Forces acting on the circulatory system (filling pressure, hydrostatic pressure, pulsatory pressure). Laminar flow. The Poiseuille equation. Turbulent flow. Distribution of blood volume in the vascular system. The arterial and arteriolar system. Systolic diastolic and mean arterial pressure. Blood pressure measurement. Role of the arterioles in the control of flow resistance. Role of the Veins in Venous Return, influence of gravity on the pressure of the vascular system, factors enhancing venous return. The micro circulation and lymphatics system: diffusion of solutes, filtration and re-absorption, Starling's hypothesis. Structure and flow in the lymphatic vessels. Cardiovascular regulatory mechanisms. Regulation of regional blood flow. Systemic regulation of blood pressure: cardiovascular bulbar centres, baroreceptor reflexes, long-term regulation mechanisms.

Level of study: High or intermediate depending on the relevance of the topics.

Human Physiology Respiration

Lung as gas exchanger. Spirometry: lung volumes and capacities. Ventilation. Dead space. Lung mechanics. Lung-thorax mechanical coupling; origin of negative pleural pressure; pneumothorax. Pressure-Volume Curves of the Respiratory System. Role of the surfactant. Ventilation and perfusion. Pulmonary circulation.

Diffusion and transport of respiratory gases in the blood. Alveolar-capillary gas exchange. Diffusing capacity of the lung Oxygen–haemoglobin dissociation curve: influences of PCO?, pH and temperature. Transport of CO?in the blood. Regulation of ventilation. Hering-Breuer reflex. Respiratory response to CO?, pH, O?. Peripheral and central chemoreceptors.

Respiratory regulation of acid base balance. The Davenport diagram. Metabolic and respiratory acidosis and alkalosis and their compensation.

Level of study: High or intermediate depending on the relevance of the topics.

Physiology of the gastrointestinal system

General functions of the gastrointestinal system:secretion, motility, absorption

Nervous and hormonal control of digestive function Salivarysecretion. *

Mastication and swallowing process *

Gastric digestion. Control of gastric motility and secretion. Nervous and hormonal control of gastric secretion.

Digestion and intestinal absorption. The movements of the small intestine and their nervous and hormonal control. Motility of the colon. Intestinal, pancreatic and liver secretions. Composition of the intestinal and pancreatic juice. Functions of the liver and gallbladder. Biliary lipid secretion and bile composition. General information about digestion and absorption of carbohydrates, lipids and proteins.

Calcium absorption *.

* related to Physiology of the stomatognathic system

Level of study: intermediate, high on the topics covered in the Physiology of the stomatognathic system.

Renal function- Renal blood flow and its regulation.

Glomerular filtration. The filtration barrier, filtration pressure, filtration speed.

Tubular functions. Re-absorption and secretion. Re-absorption and secretion in different sections of the tubules. Renalclearance: measurement of the renal clearance; insulin clearance and glomerularfiltration rate (GFR); clearance of PAI and plasma flow; renal clearance ofurea and creatinine.

Control of extracellular volume and osmolarity. Re-absorption of water and urine concentration. Hormonal control of hydro-saline excretion.

Renal regulation of acid-base balance. Excretion of acids. Adjustment of the excretion of H?ions.

Level of study:intermediate. Onthis topic is expected to know of the general aspects.

Endocrine System

Generality of the endocrine glands, hormones and their action.

Level of detail: basic. It'expected to know the general organization and aspects involved in the regulatory mechanisms mentioned above.

Duration: arguments may be driven by self-learning with tutorial methods.

Special Section: **Physiology of the stomatognathic system**

Salivation. Secretion of water and electrolytes. Ionic mechanisms of salivary secretion. Enzyme secretion. Cellular mechanisms of control of salivary secretion. Nervous control of salivary glands.

Sensitivity of the oro-facial region

Sensory innervation of oro-facial region: the touch-pressure receptors, thermal receptors, nociceptors, receptors of the temporo-mandibular joint. Muscle and tendon receptors.

Sensory innervation of the tooth; the innervation of the periodontal ligament

The trigeminal territory. Anatomical and functional organization of the trigeminal nuclear complex. The trigeminal pain.

Taste: taste receptors, distribution and innervation.

The biomechanics of mastication. Temporo-mandibular joint. Movements of elevation and lowering of the jaw. Lateral movements.

Bone and dental structures: dento-alveolar articulation (gomphosis) and occlusion.

The muscles of mastication: muscle fiber type and motor unit and the lowering of the elevator muscles of the jaw, tension-length relationship.

Jaw movements and muscle activity during chewing.

Central integration of the sensitivity and motility of the masticatory system.

The brain stem (cranial nerve nuclei, reticular formation and mono aminergic systems).

The reflexes of the masticatory muscles: Excitation and inhibition of mastication motor neurons: synaptic effects of proprioceptive muscle afferent of the oral cavity. Reflex actions initiated by muscle proprioceptors. Degree of jaw

reflexes: their role during locomotion and during chewing. Adjustment and sensitivity of the stretch reflex during mastication

The masticatory function

Masticatory cycle: during opening, closing, occlusal phase (phase of working power).

Control of mastication: local control: reflex compensation masticatory loading and unloading; central control: subcortical rhythm generator; trunk circuits-brain and cerebellar influences and the role of the cerebral cortex.

Deglutition

Voluntary and involuntary phases of swallowing. Influence of the pharyngeal phase on the breath. Neural control of swallowing. Motility of the esophagus and lower esophageal sphincter function.

Calcium homeostasis

Introduction of calcium in the diet and its absorption, calcium content in the blood, calcium deposits in the body, control of calcium excretion and balance.

Phonation: general

Level of study: high

Prerequisites

Fundamentals of physics, biochemistry, histology and nervous system anatomy, the cardiovascular anatomy, skeletal muscle anatomy, respiratory system anatomy, gastrointestinal system anatomy, histology and anatomy of the kidney, stomatognathic system anatomy.

Teaching form

The teaching methods will include lectures, videos, and class discussions.

Lessons in attendance, subject to any ministerial changes following the COVID pandemic situation.

In case of pandemic restrictions the courses will be delivered in mixed mode from asynchronous remote with synchronous videoconferencing events (WEBEX)

Textbook and teaching resource

Belfiore et al., FISIOLOGIA UMANA - FONDAMENTI, edi-ermes,

German & Stanfield, HUMAN PHYSIOLOGY, EdiSES

Klinke, Pape, Kurtz, Silbernagel, PHYSIOLOGY, EdiSES

Silverthorn, FISIOLOGIA, UN APPROCCIO INTEGRATO, Casa Editrice Ambrosiana

M. Berne & M. N. Levy, FISIOLOGIA**,** *Sesta edizione,* Casa Editrice Ambrosiana

Guyton & J.E. Hall, *MEDICAL PHYSIOLOGY,* Piccin

Manzoni, Scarnati, *FISIOLOGIA ORALE E DELL'APPARATO STOMATOGNATICO*, edi-ermes

D.B.Ferguson, *BIOLOGIA DEL CAVO ORALE*, Casa Editrice Ambrosiana

CONTI, *FISIOLOGIA UMANA*, edi-ermes

Semester

First semester

Assessment method

The face-to-face examination consists in a written test. Open questions will be posed to the student in order to evaluate the general knowledge of the topics. Moreover, the student will be asked to answer to questions that require the analysis of a complex phenomenon, its rationalization and the application of specific physiology principles and to solve simple exercises. Finally, a clinical case may be presented which will require the analysis of the interconnections between different physiological variables in the light of the theoretical paradigms.

Written exams , in case of pandemic restrictions, will be provided by the platform https://esamionline.elearning.unimib.it, access to which will be activated for the date and time of the exam.

Office hours

By appointment, by communication to be sent to

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING