FISIOLOGIA I - channel 1

13 CFU - 1° and 2° Semester

Teaching Staff

VENERA CARDILE - Module Physiology I and Biophysics - BIO/09 - 4 CFU
Email: cardile@unict.it
Office: Dipartimento di Scienze Biomediche e Biotecnologiche, Torre Biologica, Via Santa Sofia 97-95123 Catania
Phone: 0954781318
Office Hours: martedì e mercoledì 10-12

AGOSTINO PALMERI - Module Physiology I - BIO/09 - 9 CFU
Email: apalmeri@unict.it
Office: Ed. 1 - I piano - Policlinico - Via s. Sofia
Phone: 095-3781333
Office Hours: venerdì ore 11-13

LEARNING OBJECTIVES

- **Physiology I and Biophysics**
  To provide knowledge about the physico-chemical mechanisms and molecular bases of fundamental cellular physiological processes, such as the electrical polarization of the resting membrane, the genesis of the action potential (excitability), the communication between cells by means of synapses, the muscular contraction, the transduction of physiological stimuli in electrical signals by the receptor cells of sensory systems, useful for the medical profession.

- **Physiology I**
  Knowledge of thè nutritional value of food, nutritional status, energy expenditure and energy requirements, physiological use of diet nutrients.

  Knowledge of adaptive mechanisms during exercise and in extreme environments. Knowledge of thè experimental approach and thè chance to translate results from bench to bedside. Knowledge of thè mechanisms involved in thè maintenance of homeostasis in relation to internai and environmental modifications.

  Knowledge of thè electrophysiological and functional mechanisms in single cells, tissues, organs and their interactions.

  Knowledge of thè cardiovascular, respiratory, renai, gastroenteric systems and their interactions.

COURSE STRUCTURE

- **Physiology I and Biophysics**
  Frontal lessons (28 hours).

  Should teaching be carried out in mixed mode or remotely, it may be necessary to introduce changes with respect to previous statements, in line with the programme planned and outlined in the syllabus.

- **Physiology I**
  Frontal lessons.

DETAILED COURSE CONTENT

- **Physiology I and Biophysics**
  The cell as an integrated system

  Dynamic equilibrium, the cell as a thermodynamic system, the cell as a chemical system, exchanges through the membranes of gas and solutes (Fick's law, passive diffusion, facilitated diffusion, regulated diffusion, primary and secondary active transport), homeostasis, regulation of cellular functions.

  Water compartments and homeostasis

  Large water compartments

  The extracellular compartment and the intracellular compartment. Their volumetric size and methods used for the determination. Exchanges of water and electrolytes through biological membranes. Concentration gradient and electrochemical gradient.

  Osmotic pressure

  Definition, unit of measurement, plasma value. The physiological, isotonic and isoosmotic solutions, and their use. The colloidosmotic and oncotic pressure: plasma value and its oscillations. Consequences of changes in plasma oncotic pressure. The balance of water and salts.

  Ionic channels and membrane potential

  Ionic channels: voltage-gated ion channels (sodium, potassium, calcium, chlorine), chemiodependent channels, mechanosensitive channels, patch clamps, ion channels activated by phosphorylation, ion channels activated by electromagnetic waves. The canalopathies.

  Cell excitability: polarization of the cell membrane (ion distribution on the two sides of the membrane and its genesis). Characteristics and genesis of potentials (membrane potential, graduated potentials, miniature potentials, action potentials). Technique for the derivation of bioelectric events. Repolarization of the membrane, excitability cycle and measurement of membrane excitability. Methods for electrical stimulation of excitable tissues. Current type and stimulus parameters. Law of "all or nothing". Conduction of excitation along excitable membranes. Point-to-point propagation and skipping conduction.

The nervous system: general

The transformation of the stimulus into a bioelectric event. Receptors: classification, mode of operation and adaptation. The information encoded as a discharge sequence. The nerve fibers. The neuron as a morphological, functional, biochemical and trophic unit of the nervous system. The axoplasmic flows. The glia.

The glia. Macrology and micrology. Myelin synthesis is both central and peripheral.

Synaptic transmission

Interaction between excitable elements. Transmission of excitation at the synaptic level. Chemical and electrical phenomena in the synaptic region. Excitement and inhibition. Synaptic integration. Neuromuscular junction, synaptic transmission in the CNS.

Neurotransmitters: Chemical mediators (transmitters) and their recognition. Liberation and secretion of neurotransmitters, neurotransmitter cycle, synaptic vesicle cycle, ionotropic and metabotropic receptors.

Synaptic plasticity

Synaptogenesis, Hebb's law, short and long-term plasticity (long-term potentiation and long-term depression).

Skeletal and visceral muscles

Skeletal muscles. The sarcomere and the contractile mechanism. Muscle energetics. Muscular fatigue. Isometric and isotonic contraction. Length-voltage diagram. Simple shock, muscular tetanus. Calorie production. Muscle work, muscle performance. Metabolism during and after muscle contraction. Innervation of skeletal muscles. Electromyelogram.

Smooth muscles. Generality, structure, contraction mechanisms, contraction regulation, biomechanics.

Principles of Hemodynamics and Hematology

General considerations on circulation

Entity and velocity of flow in the various districts of the vascular system.

Blood flow

Physical factors that influence blood flow. Bernoulli principle and piezometry. Pressure, resistance and flow: Hagen-Poiseuille's law. Viscosity: relationship between viscosity and hematocrit. Turbulence. Laplace law applied to arterial vessels. Critical closure of arterial vessels. Laplace law applied to capillaries.

Characteristics of the vessels

General characteristics of arterial, capillary and venous vessels.

Laws of gases and their applications

Equation of perfect gases: Boyle's Law, Charles's Law or Gay-Lussac's Law, second Gay-Lussac Law

and Avogadro's Law; Dalton's Law; Graham's Law; Henry's Law; Laplace law applied to pulmonary alveoli.

- **Physiology I**

  BLOOD AND LYMPH

  Blood composition. Corpuscular and liquid component. Hematocrit. Plasmatic proteins. Electrophoretic proteinogram. Common blood tests. Complete blood count.

  Red blood cells. Erythropoiesis and iron metabolism. Life span and destruction of red blood cells. Globular resistance and hemolysis. Respiratory function of red blood cells..Hemoglobin affinity for gases. Hemoglobin's acquisition and delivery of 02.

  Leukocytes function. Distribution, count, pathophysiology.

  Platelets function. Hemostasis and coagulation.

  Blood in temperature control.

  Lymphatic system. Lymph node stations, lymph composition and function. The blood-tissue barrier.

  CARDIOVASCULAR SYSTEM

  Arteries structure and function. Arterial bed characteristics. Nervous, endocrine and paracrine regulation of arterioles.

  Capillary bed. Generalities. Types of capillary endothelium. Transcapillary exchange: diffusion, filtration, absorption and macropynocitosis. Microcirculation. Pathophysiology of edema.

  Venous bed. Venous compliance. Veins and posture. Venous return to the heart.

  Phlebogram and its features. Venous pressure and its variations, jugular pulse.

  Heart functions. Electrophysiology of heart muscle. Myocardium excitability. Heart automaticity. Stannius ligature. Cardiac pacemakers. All-or-none law. Refractory periods. Effects of extrinsic innervation on heart properties. Chemical mediators of the heart. Mechanical events of the cardiac cycle. Movements of the valves and pressure variations during the cardiac cycle phases in atria and ventricles. Duration of cardiac cycle phases and limits in its variation. Cardiac output. Frank-Starling law in the heart. Cardiac work. Cardiac metabolism and oxygen consumption. Laplace law in the heart. Heart rate and its regulation. Flutter, fibrillation and extrasystoles. Cardiovascular nervous control. Cardiac control center in medulla oblongata. Hypothalamic centers. Cardiovascular reflex regulation. Vascular and extravascular cardiac mechanoreceptors.

  Systemic blood pressure. Systolic, diastolic, differential, mean. Mechanisms of short- and long-term regulation of systemic blood pressure. Arterial pulse.

  Systemic arterial chemoreceptors. Cortico-hypothalamic influences on the cardiovascular system.

  Humorai control of cardiovascular system. Renin-angiotensin-aldosterone system. Bradykinin. Catecholamines and dopamine. Serotonin.

  Vascular districts. Cardiac redistribution. Circulation time. Coronary, brain, cutaneous, muscle,

hepatosplanchnic, lung, kidney, spleen, fetal circulations. Lymphatic flow.

Cardiopulmonary function evaluation. Systemic blood pressure measurement. Heart sounds: auscultatory Sites and characteristics. Cardiac catheterization: applications. Cardiac output measurement methods. Cardiac work measurement. Electrocardiography: Einthoven triangle, mono- and bipolar leads, precordial leads. Standard ECG conventions, analysis of common ECG patterns, hearth axis calculation and its functional significance. Vectorcardiogram. Echocardiogram.

RESPIRATORY SYSTEM

Generalities and comparative physiology. Upper airways. Nasal and tracheobronchial filter.

Respiratory mechanics. General considerations. Functions of the upper airways. Respiratory mechanical processes in eupnea: costai and diaphragmatic components. Accessory muscles of respiration. Intrapleural depression. Pneumothorax. Physiological importance of tensioactive substances acting on surface tension (surfactants) and elastic recoil of lung and chest wall. Lung and chest wall compliance. Airways work of breathing. Lung hysteresis.

Respiratory activity and nervous regulation. Respiratory centers and their functional significance. Vagus respiratory function. Respiratory reflexes. Fast and slow adapting tensoreceptors. Lung volumes and capacities. Alveolar ventilation. Pulmonary gas exchange.

Oxygen and carbon dioxide transport in the blood. Hemoglobin and its combination with oxygen or with carbon dioxide. 02 and C02 transport in the body. Transport kinetics. Myoglobin. Physiological blood reaction: buffer system, relationship between C02 and pH, functional significance of Henderson-Hasselbach equation, blood Hb02 and HbC02 dissociation curves.

Chemical regulation of respiration. Hydrogen ion concentration and breathing.

Lack of oxygen. Aortic and carotid chemoreceptors. Types of anoxia. Cyanosis. Voluntary hyperventilation effects. Effects of Hyperoxemia. Voluntary apnea. Hemo- respiratory modifications during exercise.

Lung metabolism. Biotransformation inhaled or circulating substances. Biotransformation of hormones and mediators. Pulmonary metabolism of proteins, lipids and carbohydrates.

Pulmonary function tests. Spirometry. Determination of dead space. Alveolar air samples withdrawing methods. Techniques of artificial respiration. Determination of the respiratory quotient. Pathophysiology. Dyspnea and its characteristics.

URINARY SYSTEM

Kidney functions. Generalities. Elements of functional anatomy. Nephron as the functional unit of the kidney. Differences between cortical and juxtamedullary nephrons. Renai vascular bed.

Glomerular functions. Mechanisms involved in glomerular filtration. Effective glomerular filtration pressure, ultrafiltrate characteristics, resistances against ultrafiltrate or tubular fluid. Glomerular filtration rate. Quantitative evaluation filtration volume: dearance of inulin and clearance of urea. Mechanisms modifying the ultrafiltrate volume. Filtered load concept and functional significance.

Tubules functions. Obligatory reabsorption in the proximal tubule. Active and passive transport. Concept of renai threshold and transport maximum. Glucose reabsorption and glycosuria. Facultative reabsorption in the distai tubule. Aldosterone action.

Urine concentration. Loop of Henle and countercurrent multiplier system. Vasa recta countercurrent current. Vasopressine action.

Tubular secretion. Secretion of hydrogen, potassium and ammonium ions. Urine acidification.

Renai circulation. Extrinsic control of renai circulation. Autoregulation of renai blood flow related to systemic blood pressure.

Systemic functions of the kidney. Control of systemic blood pressure. Osmolarity control. Adjustment of body fluids composition and volume. Erythropoietin production. Endocrine functions.

Applied physiology. Renai function tests: the concept of clearance and its application to control glomerular and tubular functions, and vascular bed. Significance of glucose and water loads. Osmotic and water diuresis. Fluid deficit: dehydration and its systemic consequences. Fluid excess: water intoxication, edema. Kidney contributions to the regulation acid-base balance; alkalosis and acidosis.

Physiology of the urinary bladder. Bladder filling and emptying. Action of the nervous system. Neurogenic bladder. Cystography.

GASTROINTESTIN AL SYSTEM, METABOLISM AND NUTRITION Digestive system. Chewing. Salivary secretion. Saliva composition and function. Conditioned reflexes. Swallowing. Gastric emptying. Movements of the stomach. Gastric secretion. Nervous and humoral regulation of gastric secretion. Pancreatic secretion. Secretin and pancreozymin. Pancreatic juice. Small intestine and colon secretion. Small bowel movements. Bowel intrinsic innervation. Intraluminal

pressure regimes. Movements of the villi. Myogenic and neurogenic mechanisms of bowel movements. Enteric extrinsic innervation. Visceral reflexes. Colonie motility. Defecation. Digestive tract functional tests: collection of pure gastric juice; endoscopy; registration of motor activity. Gastrointestinal hormones.

Liver. Functional units of the liver. Hepatic artery and hepatic portai vein. Oxygen consumption. An overview of the main liver functions. Liver role in hematopoiesis and blood* coagulation. Bile production and exeretion. Hepatic bile versus gallbladder bile. Enterohepatic circulation. Hemoglobin degradation processi jaundice and its various forms. Complete or partial removai of the liver. Liver regeneration. Liver detoxifying and protective effects. Liver failure and its consequences.

Metabolism. Chemical transformation: release and transport of energy.

Mechanisms of biological oxidation. Carbohydrate metabolism: food carbohydrates, intermediate metabolism of carbohydrates and blood sugar regulation. Lipid metabolism: lipid chemistry, digestion of neutral fats, fat absorption, lipemia, events following fats absorption, liver and lipid metabolism, fatty liver and lipotropic factors, relationship between liver and ketogenesis, integration between lipid and carbohydrate metabolism. Protein metabolism: proteins digestion, amino acid pool, examples of amino acids utilization, nitrogen balance, specific metabolic roles of

amino acids, exogenous and endogenous metabolism. Nucleic acid metabolism. Hormones metabolic actions. Basai metabolism.

Nutrition. Principles of dietetics. Energy requirements. Composition of a normal diet. Food requirements in particular conditions (pregnancy, lactation, infancy, aging, etc.). Mechanisms of hunger and satiety.

PH REGULATION

PH control in intracellular and extracellular fluids, buffer systems, acid-base balance disorders and the compensatory mechanisms.

TEMPERATURE CONTROL

Regulation of body temperature in humans, physiological and pathological changes in body temperature, heat balance, thermogenesis, heat dissipation, temperature regulation, physiological responses to heat and cold.

ADAPTATION

Adaptations to exercise. Body responses to exercise (cardiovascular, respiratory, plasmatic, and muscular responses), physical inactivity-induced diseases. High-altitude adaptations. Body responses to altitude, altitude sickness.

Diving adaptations. Pathophysiology of hyperbaric gas, Hyperbaric syndrome. Absence of gravity effects.

TEXTBOOK INFORMATION

- **Physiology I and Biophysics**
  Fisiologia Umana – A cura di F. Grassi, D. Negrini e C. A. Porro, Poletti Editore

  Fisiologia – Silverthorn – Casa Editrice Ambrosiana

- **Physiology I**
  Fisiologia medica, by F. Conti - EdiErmes

  Fisiologia Medica by Guyton e Hall - Elsevier
