



## **MEDTEC SHOOL**

**Course: Physiology, Anatomy, Biochemistry II**

**Year: 2<sup>nd</sup> (second)**

**Period: annual**

**Credits: 25 (Anatomy 6, Biochemistry 5, Physiology 14)**

### **Objectives**

Aim of this course is to lead the students to build a comprehensive view of how the organism works, putting together:

- anatomical information about the organization of the nervous system and the structure of the organ systems (digestive, cardiovascular, renal and genitourinary, respiratory);
- the knowledge of biochemical paths and functions, from synthesis and metabolism of hormones to the production of exocrine and endocrine secretions, the biochemical activities of the liver, the differential metabolism of distinct tissues and cancers, and from contractile proteins to the composition of plasma;
- notions about personalized medicine and the role of the microbiota;
- the physiological perspective on the functioning of sensory and motor systems, and the endocrine, digestive, cardiovascular, renal, and respiratory systems;
- an interdisciplinary view of the integrated control of glycaemia, blood pressure, body fluids, temperature, pH, feeding behaviour
- anatomical and functional hints on the organization of the brain and on how somatic and vegetative adaptations and anticipatory responses are controlled; pain is perceived and elaborated; emotions and motivation are generated and guide behaviour, procedures and facts are learned and memorised, language develops, thought and consciousness arise, and intentional motivated behaviour is controlled

In particular, the course can be considered as divided into two modules:

1. The first module will familiarise the student with
  - the sensory and motor systems, how they are organized and function
  - the neural and endocrine regulation of bodily functions and the circadian rhythms
  - the processes of nutrient absorption and metabolism by the digestive system
  - the biochemistry of energetic, muscular, adipose, digestive and hepatic metabolism
  - the distribution and exchange of substrates and gases (heart and circulatory system)
2. The second module will introduce the student to understand
  - how oxygen and energetic substrates are distributed to the tissues, and CO<sub>2</sub> and metabolites removed, through the mechanical and electrical activity of the heart and the properties of the circulatory system
  - how substances are eliminated from the body and extracellular fluid volume, and how plasma pH and composition are regulated by the kidney
  - the exchanges of gases at the lung and at peripheral tissues



- the complex interaction of neural, hormonal, visceral, cardiac, renal, hepatic and somatic factors in controlling respiration, blood pressure, cardiac output and regional perfusion, plasma pH, osmolality, volume and composition, glycemia, body temperature and weight
- the vascular supply to the brain and its main functions, from the control of feeding behaviour to the wake-sleep cycle, vegetative control and emotional responses; and from the various types of memory to pleasure and motivation, planning, strategical control of behaviour, thought, consciousness

Practicals are an integral part of the course. Through the use of the 3D anatomical table (Anatamage) students will visualize in detail the organ structure; using microscopes, they will examine and diagnose histological preparations from the most important inner organs.

The interdisciplinary training of the students will be fostered through lectures centred on topics at the border between medical and technological approaches, such as theory, measurement and instrumentation in fluid-dynamics, dialysis, extracorporeal circulation, haemogasanalysis, sensors, signals and data analysis.

## Prerequisites

The student must possess the bases of maths, physics and chemistry that are needed to grasp the conceptual aspects of the regulation of the biological processes and deal with them in quantitative terms: these are the topics faced in the first year courses.

The student must possess the basic notions of macroscopic and microscopic anatomy, embryology and development, and cell biology that are needed to face the study of the functions of cells and organisms.

In particular, in order to be admitted to the exam the students must have passed the exams of:

- Fundamentals of Experimental Physics
- Cell Biology, Embryology and Histology
- Regional anatomy and gross neuroanatomy
- Cell Physiology and Biochemistry I

## Contents

### Module 1

- Muscle Physiology
- Cell motors, extracellular matrix, connective tissues and bone
- Muscle, heart and brain metabolism, lactate metabolism and comparative metabolism in tissues
- Energy balance, lipid metabolism and the storage, thermogenic and endocrine roles of adipose tissue
- Anatomy, Physiology and Biochemistry of the digestive
  - structure, motility, nutrient absorption, secretory and endocrine activity
  - metabolic activities of the liver and GI exocrine secretions
- Synaptic biochemistry and synaptic scaffolding proteins (1 Lect. – Biochem.)
- Anatomy and Physiology of sensory receptors, sensory modalities, and sensory pathways
- Touch, nociception, proprioception
- Anatomy of the hearing system, acoustics, hearing and sound processing
- Vestibular organs and neural pathways



- Vestibular information, balance, posture and gaze control
- Anatomy of the eye and visual pathways, optics and sight
  - photoelectric transduction, image processing, object recognition and location
- Chemoceptors, smell and taste
- Movement control
  - anatomy of the descending pathways, the cerebellum, the basal ganglia
  - physiology of motor system: CPGs, locomotion, posture
  - anatomy and physiology of the cerebellum and the basal ganglia
  - conditioning and motor learning
- Anatomy of the genital organs
- The endocrine system
  - general organization, hypothalamus and hypophysis, growth hormone, sex hormones, corticosteroids, thyroid hormones, the circadian cycle, control of glycemia
  - endocrine biochemistry and the nuclear receptor family

## Module 2

- Anatomy of the heart and circulatory system
- Fluid-dynamics and the mechanical activity of the heart
- Electrical activity of the heart, ECG and regulation of heart function
- Plasma biochemistry
- The circulatory system
  - resistance and capacitance vessels, microcirculation, transcapillary exchanges, local control of vascular tone
- Anatomy of the kidney and urinary system
- The kidney and the regulation of plasma and fluid volume and composition
  - renal circulation, glomerular filtration, transport systems in the tubule
  - sodium and water balance, blood pressure control
  - the regulation of body pH
  - micturition
- Anatomy and physiology of the respiratory system
  - respiratory mechanics, gas exchanges, ventilation / perfusion
- Integrated controls – The autonomic nervous system and the hypothalamus (2 Lect. – Physiol.)
  - control of body temperature and feeding
- Cancer metabolism (2 Lect. – Biochem.)
- Notions about Personalized Medicine and the microbiota
- The Central Nervous System – Learning and Memory
- Brain vascularization and cerebrovascular problems
- Blood brain barrier and the roles of glia
- Integrated controls – The Central Nervous System
  - ascending projections from the brainstem: sleep, coma, cortical arousal, selective attention
  - limbic circuits and emotions; dopamine, pleasure and motivation; serotonin in the CNS
  - the Electro-Encephalogram
  - pain as a symptom, an emotion, and a pathology
- Language, thought, consciousness and the control of behaviour

## Teaching Methods

Lectures + Outlines and slides of the lectures aim at offering the student all needed support to help understanding the information contained in textbooks: students are encouraged to actively participate to the lectures with questions and comments, in order to assimilate the matter being discussed and make it their own.

Indication of readings aim at offering the student all the needed information and the possibility of critically and autonomously deepening their knowledge

Interactive and multidisciplinary re-elaborations aim at involving the students in an active handling of the knowledge material at hand, and showing them the profit of discussion in grasping difficult concepts

Personal and group assignments: quizzes, research assignments, open questions, self-evaluation; these aim at letting the students evaluate their own knowledge and competence and to encourage students toward group work, discussion and confrontation (to improve their capability of explaining)

Flipped classrooms – Question time – Collaborative learning and use of conceptual maps (Cmaps), all oriented to stimulate discussion

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The course is organized at three distinct levels:

1. **knowledge transfer**: Lectures, slide-sets, written lecture, suggested textbooks, scientific articles and other studying material will offer the students the *notions* needed to master the topics at hand.
2. **active knowledge mastering** will be stimulated through self-assessment tests, small-group assignments and didactic material for **flipped classrooms**
3. **knowledge activation** – will be pursued through interactive lectures, joint interdisciplinary seminars, question and answer sessions, discussions of group assignments and the actual flipped classrooms.

The objective of this organization is to lead the student to fully understand, assimilate and frame the acquired notions in an organized general perspective; the student should then be able to clearly and linearly explain the complex issues of the functions of organs and systems and their integration.

## Assessment

Learning by the students will be monitored during the course through the assignments and interactive sessions and will be eventually assessed through a written and oral examination.

The exam is comprised of four parts:

1. Module 1: written test
2. Module 2: written test
3. Practical exam at the microscope
4. Final oral interview

### **Module 1.**

- Topics: sensory and motor nervous system; muscle physiology and biochemistry; digestive system (Anatomy and Physiology); biochemistry of energetic, muscular, adipose, digestive and hepatic metabolism; anatomy of the gonads, endocrine system and the circadian clock;
- Written test: The test consists of 45 questions. Multiple Choice with single or multiple correct answers or Matching Test. Time allotted: one hour.

### **Module 2.**

- Topics: cardiovascular, renal, and respiratory systems; integrated controls: temperature, blood pressure, plasma osmolality, pH, volume and composition, glycaemia, feeding behaviour, wake-sleep cycle; brain vascularization and higher cerebral functions: emotions, memory, consciousness, language, the control of motor and cognitive behaviour
- Written test: The test consists of 45 questions. Multiple Choice with single or multiple correct answers or Matching Test. Time allotted: one hour.

### **Practical exam at the microscope:**

Description and diagnosis of histological preparations. Students' ability to describe and diagnose histological preparations at the microscope will be evaluated.

The result will be pass or fail. Passing this test is necessary to access the final interview.

### **Final oral interview**

Aimed at checking understanding and capability to explain to a patient, a nurse, a colleague, how structural aspects, biophysical and biochemical mechanisms and physiological processes contribute to the normal and altered functions in the organism.

Knowledge, but also clarity, appropriateness and conceptual organization will be evaluated.

### **Marks.**

- At least 30 correct answers out of 45 (2/3) must be given in written tests. The mark will be computed as 18 (sufficient) + the number of correct answers in excess of 30.
- The written and practical tests can be sit at different times and in any order
- In order to access the oral interview, the other three parts of the exam (Module 1, Module 2 and practical test at the microscope) must have been passed within the last 12 months.
- The final interview may modify the average (rounded up) score by no more than of +/- 3.

## **Texts**

**Anatomy, Biochemistry:** refer to 1<sup>st</sup> year textbooks

### **Physiology:**

- Guyton and Hall – Textbook of Medical Physiology, 13th ed. Elsevier, 2016.
- W.F. Boron, E.L. Boulpaep – Medical Physiology, 3rd ed. Elsevier, 2017.
- E.R. Kandel, J.H. Schwartz et al. – Principles of neural science. McGraw Hill 2013.
- Ross and Pawlina – Histology A Text And Atlas - With Correlated Cell And Molecular Biology, 8th ed. Lippincott Williams & Wilkins, 2018.