HUMANITAS MEDICAL SCHOOL

Course: **BODY AT WORK 1**

Year **2nd (second)**

Period **1st semester**

Credits: **13 (Anatomy 3, Physics 2, Biochemistry 2, Physiology 6)**

Objectives

This is the first part of a complete journey through the mechanisms that sustain life and the functioning of the human organism. It builds on the knowledge acquired in first year course "The Cell, Functions and Control", about the basic mechanisms of life, homoeostasis, and control of cellular functions, and about receptors, signal transduction pathways, cell excitability, neuronal and synaptic function and activity.

The student will acquire a solid knowledge of the organization and functioning of the sensory and motor systems and the competence to understand and recognize the main neurological problems related to their dysfunction. The students will be introduced to the principles of the neurological examination.

Key physical, biochemical and anatomical aspects will be addressed, either in specific lectures or in joint lectures, in a functional and Pathophysiological perspective, to help the student to acquire a comprehensive, interdisciplinary perspective.

The course is organized at two 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. *knowledge activation* – will be pursued through interactive lectures, joint interdisciplinary seminars, question and answer sessions, discussions of group assignments and C-map elaboration.
   In particular, at the end of most Physiology classes 5-10 students will be picked at random and requested to draw a conceptual map (C-map) about a topic treated in this or some previous classes. The maps will be interactively discussed by reserving a ½ hour slot in one of the subsequent classes. The skill and proficiency in producing the maps will not be considered for the final evaluation, but the attitude and commitment will.

The objective of this organization is to lead the student to fully understand, assimilate and frame the acquired notions in an organized general perspective. A medical doctor is supposed to be able to understand and explain clinical issues with appropriate terminology and clear sentences organized in a logical flow. Thus, producing and discussing elaborates on the course topics constitutes an aspect of professional training: the student should learn to clearly and linearly explain the complex issues of sensory and motor functions. An important part of the final evaluation will consist in an oral interview to evaluate these skills.

The course also includes PhysioLab experiences to practice with physiological measurements (electro-myogram and electro-oculogram).

Professionalizing activity: the course includes two practical activities on the neurological examination of the patient. These activities build on the knowledge acquired during the first year courses and the anatomical and functional content of this course, and help the students to further proceed in acquiring the basic skills of the general physical examination.

Prerequisites

In order to be able to take the exam the students must have passed the 1st year exams: "Building bodies, from gametes to organs", "Principles of the Living Matter", "Cells, Molecules and Processes", "Body Architecture" and "The Cell: Function and Control".
However, in order to profitably attend the course, the students must absolutely have acquired the main concepts of cellular function and regulation and the basis of neurobiology, as covered by 1st year course "The cell, function and control": cell excitability, receptors, transduction mechanisms, synaptic functions, neuronal processing and plasticity. They should know the gross anatomy of the body and the structure of the tissues; they should master the principles of embryology and cellular biochemistry.

Contents

SPECIFIC LEARNING GOALS

For each module, learning goals will be achieved through activities in class and personal study at home (lectures, readings, off-campus personal and group assignments), while **knowledge activation goals** will be achieved through interactive and collaborative work: problem based learning, joint seminars, question time, revision of assignments, flipped classrooms, supervised small group activity, and in particular through the elaboration and public discussion of conceptual maps, and activity that should train the student to organize their knowledge and clearly explain, with appropriate terminology and a linear logic flow, the issues under consideration.

1 – Sensory systems – Generalities, touch, pain, proprioception

Learning goals:

Anatomy: describe sensory modalities, fibres, receptors; primary sensory neurons and sensory ganglia; the medial division and the lateral division of the dorsal root, the anterolateral system and the dorsal column pathway; the trigeminal pathway and the pathways to the cerebellum; the routes of visceral information, the thalamic nuclei and their target, primary and secondary somatosensory areas, the structure of the somatosensory cortex

Physiology: know how mechanoceptors work; understand receptive field and adaptation properties, understand how the various touch receptors let us perceive the nature and texture of object – understand nociception and pain, hyperalgesia, allodynia, descending control of pain – understand proprioception and how muscle spindles work and their functional role – explain the purpose of alpha+gamma coactivation

2 - Optics, sight and visual elaboration

Learning goals:

Physics: examine the light, the basic aspects of electromagnetic waves, geometric optics, refraction, reflection, and transmission; discuss the physics of lenses, image formation and magnification; physically model the eye and discuss the principles of vision; understand the physical basis of sight defects

Biochemistry: describe the structure and turnover of vitamin A and retinal; understand their role in visual transduction, adaptation and recovery

Anatomy: describe the anatomy of the eyeball and the organization of the extra-ocular muscles; describe the retina, the course of the optic nerve, the medial and lateral component of the optic tract, the path to the lateral geniculate body, optic radiation and visual cortex

Physiology: examine the properties of visible light and photoelectric transduction; describe cones and rods; understand dark and light adaptation; analyse image processing in the retina and the paths of different kinds of information to the CNS; describe the cortical ventral and dorsal pathways and movement detection circuits; discuss colour vision, object recognition, analysis of space; understand the role of ocular movements and the differential competences of the two hemispheres to image analysis; understand how the superior colliculus works and controls eye/head movements; appreciate the visuomotor role of the parietal cortex

3 – Acoustics – Hearing and sound processing – Vestibular function

Learning goals:

Physics: study the basics of waves and harmonic motion, examine the rules of sound wave propagation; understand the concepts of standing waves, acoustic impedance, Fourier analysis, interference and resonance; biophysically model the ear and the hearing mechanisms; discuss ultrasounds and Doppler effect in medicine

Anatomy: study the structure of the external, middle and inner ear; describe the labyrinth and the cochlea, the acoustic and vestibular pathways and the medial longitudinal fasciculus.

Physiology: study the frequency band of audible sounds and amplification by the middle ear, describe the mechanoelectrical transduction mechanism in hair cells; understand the principles and mechanisms of frequency decomposition, scale compression and processing of auditory input: pitch, timber, intensity, localization; understand the memory for sounds and the central processing of sound; explore the mechanical responses of the semicircular canals and the otolithic organs to perturbations; explain the differences between cochlear and vestibular transduction; study the contribution of the labyrinth to gaze control and posture

4 - Chemoceptors, smell and taste

Learning goals:

Anatomy: describe olfactory and taste receptors and the functional interaction between taste and olfactory pathways in perception.

Physiology: study the mechanism of sensory transduction in smell and the various mechanisms of sensory transduction in taste; understand the vital importance of olfaction and explain why it requires a cortex

5 - Movement control

Learning goals:

Anatomy: overview the descending pathways: the medial and lateral systems; reticulo-spinal, vestibulo-spinal and rubro-spinal tracts; describe the origin and course of the pyramidal tract, the structural features of the motor cortex and the location of the primary and secondary motor areas; build a comprehensive view of motor control by the descending systems; describe the organization of the cerebellum, its microcircuitry, inputs and outputs; describe the structures that constitute the basal ganglia circuitry, the intrinsic connections, their inputs and outputs and the four parallel paths that run across them

Physiology: illustrate the hierarchical organization of the motor system; analyse somatic and visceral reflexes in the spinal cord/brain stem and the general neural network underlying spinal automatism; recognize Central Pattern Generators in complex reflexes and innate behaviours; describe axial control of locomotion and posture; understand and explain how the cerebellum controls movements and the distinct roles of the inferior olive and the cerebellum in motor learning; describe neural plasticity in the cerebellum and its role in classical conditioning; examine the role of the cerebellum in cognition, mood and non motor behaviour; understand and explain how the basal ganglia help to initiate, conciliate, select movements and "switch"; discern the neurochemical, regulatory and plastic roles of dopamine; examine cognitive roles of the basal ganglia

6 – Brain perfusion and metabolism – Cortical circuitry

Learning goals:

Biochemistry: describe intercellular junctions and how they determine cell polarity and regulate paracellular transport; understand how tight junctions and transcytosis regulate the blood brain barrier; describe brain metabolism at different ages; understand neurovascular coupling and neuron-astrocyte metabolic cooperation

Anatomy: discuss cerebral vascularization: the circle of Willis, the three main cerebral arteries, the most important penetrating vessels and their territories of supply, the vascular supply to the brainstem, the superficial and deep venous drainage of the cerebral hemispheres; imagine the consequences of localized cerebrovascular problems

Physiology: examine the functional properties of the blood brain barrier (BBB), discuss the functional consequences of lack of oxygen and energetic substrates, or of passive and active penetration of substances, in the brain

Anatomy+Physiology: discuss the development, structure and microcircuits of the cortex; examine the main types of neurons in the cortex; understand and explain the function of typical cortical micro-circuits in maintaining the excitation/inhibition balance and in processing information; discuss excitation/inhibition balance, paroxysmal depolarizing shifts and the genesis of seizures

7 – Energy balance

Learning goals:

Biochemistry: describe Discuss the principles of energy balance in the body, in resting and stressed conditions
Describe components of energy expenditure and explain key mechanisms of energy balance regulation
Examine the biochemistry of oxidative stress
Discuss lipid metabolism, the endocrine functions of adipocytes, their storage role, lipogenesis and lipolysis
Describe the hormonal control of adipocytes and the function of adipose tissue in body homoeostasis.
Describe the endocrine properties of adipose tissue, and the differences between white and brown adipocytes
Build a comprehensive picture of oxidative and energetic balance in cells and in the whole body

8 – ECM, connective tissues. bone, muscle - motor units

Learning goals:

Biochemistry: describe the composition of cytoskeleton and extracellular matrix, and their interactions; describe connective tissue biochemistry and bone structure, metabolism and remodelling; examine the major types of cytoskeletal filaments; describe the mechanochemical properties of motor proteins; discuss the sliding filament model of muscle contraction; examine muscle energetics and aerobic/anaerobic metabolism, and explain the changes in skeletal muscle mass and metabolism in response to acute and prolonged exercise (power vs endurance);

Physiology: Study the structural and functional organization, the different patterns of contraction and excitation-contraction coupling in skeletal, cardiac and smooth muscle; understand and explain the different dynamics of intracellular Ca^{2+} in skeletal and cardiac muscle; explain how the force of contraction is differently regulated in skeletal and cardiac muscle; understand and explain why smooth muscles are so differently organized; study how tension builds up in skeletal muscles during tetanus; study the functional behaviour of the muscle during isometric and isotonic contractioin; define the Motor Unit; discern the three types of motor units and understand the properties of motor neurons and synaptic currents to frequency coding; understand the neural mechanisms controlling muscle force and the role of agonist and antagonist muscles in producing joint stiffness

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.

Personal and group study **are absolutely needed: studying the textbook** and not only one's own or other students' notes is essential; also essential is to discuss with schoolmates and friends the acquired information to learn to express clearly and precisely – with appropriate terms and an ordered line of thought – the acquired information and explain the mechanisms involved

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 aim at having the students evaluate their own knowledge and competence and at encouraging group work, discussion and confrontation (to improve the capability of explaining)

C-maps – Question time – Collaborative learning aim at stimulating discussion

Practicals (Neurological examination) – *PhysioLab* (Electrooculogram, Electromyogram)

Assessment

The exam is comprised of three parts:

1. Evaluation of the skills on the neurological examination of the patient
2. Written examination: Multiple Choice Questions or similar tests
3. Oral examination

1. **Physical examination**: this part of the exam consists in a pass-or- fail evaluation. Students will be asked to perform part of the checklist they have learned during the Practicals. This part or the exam ***must be passed*** to proceed to the written part.

2. **Written test**: Multiple Choice Question or similar test. The test consists of 60 items (18 Anatomy, 12 Physics, 12 Biochemistry, 18 Physiology). Time allotted: 90 minutes.

In order to pass the written test, 2/3 of the questions must be answered correctly (40/60); 60% of the correct answers must also be given for each discipline (11/18 Anatomy, 7/12 Physics, 7/12 Biochemistry, 11/18 Physiology). Occasionally, thresholds might be lowered, in case of anomalous average, best and worst performances. Only students who pass the written test will access the oral examination.

The mark obtained in the written test will be given by the formula $\{ 18 + 0.75 \cdot (\text{correct answers} - 40) \}$. A passed written test remains ***valid until the end of the same exam session***.

3. **The oral interview** will assess the competence of the student in ***explaining*** how the structural aspects, the biophysical and biochemical mechanisms and the physiological processes contribute to the functions of sensory systems, to sensory elaboration, motor programming and control, muscle function.

Obtaining a successful mark in the written test does not grant success.

Students who have attended **at least 85%** of the classes can be admitted to the first exam call.
After the end of the course and before the first exam call a one-day activity will be organized (8 hours) as a remediation session. It will be an interactive discussion of the main topics of the course.
Students who have attended **less than 85%** of the classes **must attend the remediation activity**, otherwise they will not be admitted to the exam.
Students who have attended **less than the prescribed minimum (75%)** will not be admitted to the first exam call. They must attend a second one-day remediation activity, that will be organized before the second exam call, otherwise **they will not be admitted to the exam**.

The mark obtained in the written test will be reduced by 0.4 points for every 1% below 80% attendance to the classes (e.g., 2 points for 75% attendance), and **can be largely modified** following the oral interview, based on the following criteria: the student must be able to say something relevant about each of the questions asked; the student must use the appropriate scientific and medical terminology and talk clearly and logically; after thinking and possibly taking some notes, the student must be able to produce a sensible speech, made of ordered sentences (subject, verb, etc.) that follow a logical thread, and to be able to illustrate the cause, the mechanism, the result and the purpose of the structure, phenomenon, process, regulation, or metabolic process they have been asked about; the student must be able to clarify specific details that the teacher may ask about, as if they were talking to a patient, the parent of a child, or a health operator; the student must be able to clearly explain the matter at hand.

Since failing this exam implies repeating the second year, in the last call before the beginning of next academic year the students who failed all previous sessions will be given the opportunity – **on this exam session only** – of an oral interview even if they failed the written test. The oral interview will aim at possibly revising the judgement and discussing their learning performance and possible problems for tutoring.
Only students who did attend (and failed) the last previous call will be offered this opportunity.

Texts

Anatomy, Physics, Biochemistry: refer to 1st 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.