HUMANITAS MEDICAL SCHOOL

Course: **BODY AT WORK 1**

Year **2nd (second)**

Period **1st semester**

Credits: **12 (Anatomy 3, Physics 2, Biochemistry 2, Physiology 5)**

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 acquire 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 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 sensory and motor functions.

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 exam "Building bodies, from gametes to organs".
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 and supervised small group activity

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

Learning goals:

Physics: understand charges, electric dipole, electric force, electric potential and field, current, resistors and capacitors, magnetic force, magnetic field, magnetic dipole moment

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, nociception and pain, hyperalgesia, allodynia, descending control of pain, proprioception and how muscle spindles work - understand how the various touch receptors let us perceive the nature and texture of object – explain the functional roles of muscle spindles and 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 its 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 visual cortex, 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 differential 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 neurones 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:

- *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; analyse lipogenesis, lipolysis, and adipose tissue metabolism and endocrine properties; 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 Ca2+ 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 in isometric and dynamic conditions; define the Motor Unit; discern the three types of motor units and understand the properties of motor neurones 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.
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 – aimed 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 – aimed 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
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 part: 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 { $18 + 0.75 \cdot (\text{correct answers} - 40)$ }. Students who passed the written test do not need to repeat it if they take the oral during 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. The mark will be modified (generally by no more than 3 points), based on the performance in the oral interview, also taking into consideration the attendance and active participation to the classes as well as the results of formative tests possibly held during the course.

Since failing this exam implies repeating the second year, an extra-session will be set up in the last days before the beginning of next academic year to give a final opportunity to students who failed all previous sessions. On this exam session only, the students will be given the opportunity of an oral interview even if they failed the written test, to confirm the judgement and discuss their learning performance and possible problems for tutoring. Only students who did attend (and failed) the last session in September will be admitted to this extra session.

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.