Introduction to Molecular Neurobiology

Mission of the Course:

The course mission is give all-encompassing and comprehensive overview of how the neural system is functionally organized and how it operates from the cellular and molecular to the systemic levels. Due to time limitation, the course will provide exploratory knowledge. However, the all-encompassing nature of the course will the students to manage easily deeper study of specific regions and functions of the neural system in the future.

Prerequisites:

Although this is a basic course, it requires from the students already acquired knowledge in cellular physiology, general physiology of the excitable tissues, gross and histological anatomy of the neural system. These courses are necessary prerequisites, since despite some topic are similar to the prerequisite course requirement, the program of the course does not repeat the knowledge acquired previously, but uses it for deeper understanding.

Class duration: 3 academic hours.

Evaluation: Exam at the end of the course.

Lectures:

Section 1: Cellular and Molecular Neurobiology

Lecture 1: Membrane potential and passive membrane properties.

- Ion distributions and electrochemical potential
- Passive membrane properties: Ion current, conductance, resistance and capacitance of the membrane. Grade potential. Distance and time constants, spatial and temporal summation
- Ion channels – types and molecular composition

Lecture 2: Electrical signal propagation. Action Potential.

- Signal propagation issues
- All-or-none response. Action potential, its types and phases.
- Ion current compositional analysis of the action potential temporal evolution
- Action potential propagation. Types of neural fibers. Propagation velocity. Salutatory conductance.
- Compound action potential.

Lecture 3 & 4: Synaptic transmission

- Types and classifications of synapses.
- Morphological and molecular composition of synapses
- Neuromuscular junction. End-plate potential.
- Post-synaptic potential. Ionotropic receptors vs. metabotropic receptors. Fast vs slow postsynaptic potentials. Excitatory and inhibitor synapses. Current components of post-synaptic current.
- Neurotransmitter release. Molecular organization of presynapses. Electrical coupling of presynaptic potential and transmitter release. Spontaneous and evoked release.
- Synaptic plasticity: short- and long-term types of plasticity. Post-synaptic impact on presynaptic release, signal backpropagation.

Section 2: Functional Neurobiology of the Neural System

Lecture 5 - 8: Neurobiology of sensory system

- Organization of sensory section of the neural system. Modality of the sensory system. Types of senses. Sensation vs. perception.
- Receptors – types and modality, receptive potential, receptive fields. Topographic projections of sensory system. Sensory coding.
- Pathways of the sensory system – functional neuroanatomy.
- Somatosensory system: receptors and central pathways.
- Pain and analgetic system
- Special senses – overview.
- Vision: organization of visual receptors, pathways of the visual system. Low and high level visual processing. Visual perception. Regulation of eye movement.
- Auditory system: organization of the human organ of Corti. Sound sensing. Central pathways of the auditory system.
- Chemical senses: smell and taste. Olfactory receptors. Central analysis of the olfactory signal. Odors and behavior. Organization of the gustatory system.

Lectures 9 - 11: Neurobiology of motor system

- Motor unit
- Spinal reflexes and locomotion
- Control of posture and reflex behavior
- Voluntary movements organization: The primary motor cortex, the parietal and premotor cortex
- Extrapyramidal system: basal ganglia and cerebellum

Lecture 12: Cognitive neurobiology overview

- Types of memory and the brain systems involved
- Perception and attention
- Language
- Prefrontal cortex and executive brain functions
- Consciousness