2011-12 Academic Year

General Physiology (20330)

Qualification/course: Bachelor's Degree in Human Biology
Year: 1
Term: 1
Number of ECTS credits: 8 credits
Number of study hours: 8 credits in total, which consist of 88 hours of face-to-face course and 112 hours of individual work. The face-to-face activities are divided into 40 hours of lectures, 16 hours of seminars and 32 hours of practical sessions.
Course language(s):
Teaching staff: The subject coordinator is Dr. Miguel A. Valverde (Full Professor, UPF). The lecturers are Dr. Francisco Muñoz (Tenured Assistant Professor, UPF), José Manuel Fernández (Tenured Assistant Professor, UPF), and Carole Jung (Associated Professor, UPF), who will be teaching the theoretical and the practical parts.

1. Presentation of the course

This subject concentrates on the study of cell electrophysiology, signal transduction systems, and the organization and functioning of the nervous system.

2. Competences to be achieved

The focus of this subject is on cellular processes, many of which can be used to explain the activity of nearly all types of cells. Bearing very much in mind the large amount of information that has been generated in this field in recent years, the subject syllabus will concentrate on six sections offering a dynamic and updated vision of the most important cellular processes, particularly those dealing with the functioning of the nervous system.

- I. Membrane potential. Physiology of trans-membrane transport. Taught by M. A. Valverde
- II. Excitability of the membrane and the ion channels. Taught by M. A. Valverde
- III. Intercellular and intracellular communication. Taught by M. A. Valverde
- IV. Stimulus-secretion coupling and synaptic transmission. Taught by J. M. Fernández-Fernández
- V. Muscular contraction. Taught by J. M. Fernández-Fernández
- VI. Nervous system. Taught by Francisco J. Muñoz

3. Contents

THEORY SYLLABUS

I. MEMBRANE POTENTIAL. PHYSIOLOGY OF TRANS-MEMBRANE TRANSPORT (Dr. M. A. Valverde)

Topic 1
Diffusion and diffusion coefficient. Permeability coefficient and flow. Active-passive transport. Transporters: cotransporters, antiporters, pumps.

Topic 2
Origin of membrane potential. Maintenance of ion distribution. Ion equilibrium potentials. Nernst Equation.

Topic 3
Transport of ions and non-electrolytes. The sodium pump. Calcium pumps. Sodium-calcium exchangers. Mechanism, structure and regulation.

II. EXCITABILITY OF THE MEMBRANE AND OF THE ION CHANNELS (Dr. M. A. Valverde)

Topic 4
Electrophysiological analysis of ion channels. Electrophysiological techniques. Passive electrical properties.

Topic 5
Ion channels in excitable cells. Electrogenesis of membrane excitability. Generation of action potential. Effect of the resting potential on the action potential.

Topic 6
Ion channels in non-excitable cells. Channel types. Function.

Topic 7
Relationship between the structure and function of ion channels. Biochemistry and molecular biology of ion channels. Molecular mechanisms determining the function of the channels.

Topic 8
Genetic diseases associated with the dysfunction of ion channels. Cystic fibrosis. Myotonia.

Topic 9
Osmotic properties of cells and regulation of cell volume. Movement of water through biological membranes. Regulation of cell volume in isosmotic conditions. Regulation of cell volume under anisosmotic conditions.

III. INTERCELLULAR AND INTRACELLULAR COMMUNICATION (Dr. M. A. Valverde)

Topic 10
Detection of extracellular signals. Types of receptor. Agonist binding. Adaptation of target cells. Intracellular signal amplification.

Topic 11
Proteins associated with signal transduction. G proteins. Direct actions. Indirect actions: control of adenylcyclase, control of phospholipase C. Transduction of intracellular signals. Second messengers. cAMP, cGMP, NO, inositol phosphates.

Topic 12
Calcium: intracellular and extracellular messenger. Generation of calcium signal. Activity of calcium-dependent proteins.

Topic 13
Balance between phosphorylation and dephosphorylation processes. Kinases: serine/threonine, tyrosine and histidine. Participation of phosphatases in the regulation of intracellular signals.

IV. STIMULUS-SECRETION COUPLING AND SYNAPTIC TRANSMISSION (Dr. J. M. Fernández)

Topic 14
Stimulus-secretion coupling. General concepts. Molecular components involved in the process. Fusion of vesicles with the plasma membrane. Control of exocytosis. Hormonal secretion.

Topic 15
Neurophysiology I. Introduction to the nervous system. General concepts. Chemical and electrical synapses. Cholinergic transmission.

Topic 16
Neurophysiology II. Catecholaminergic and serotoninergic transmission.

Topic 17
Neurophysiology III. Peptidergic transmission. Excitatory and inhibitory amino acids. Histamine.

V. MUSCLE CONTRACTION (Dr. J. M. Fernández)

Topic 18
Skeletal muscle. Structure of muscle fibre. The neuromuscular junction. Muscle action potential. Bases of muscular contraction. Role of calcium. The cardiac muscle and its contraction.

Topic 19
Smooth muscle. Muscle action potential. Bases of muscular contraction. Role of calcium. Maintenance of muscle tone and synergic contraction.

Topic 20

The muscle during exercise. Types of skeletal muscle fibre. Sources of energy. Muscular remodelling.

VI. NERVOUS SYSTEM (Dr. F. J. Muñoz)

Topic 21. Functional organization of the motor systems
Definition of the segmental and suprasegmental control systems. Sensorial and motor integration.

Topic 22. Segmental control of movement and posture I
Segmental reflexes. Functional characteristics of the myotatic, tendinous and withdrawal reflexes.

Topic 23. Segmental control of movement and posture II
Segmental reflex control. Activity of muscle receptors. Components and functions of the gamma motor system.

Topic 24. Suprasegmental control of movement and posture I
Functional organization of the motor cerebral cortex. Function and disorders of the motor cortex.

Topic 25. Suprasegmental control of movement and posture II
Functional organization, physiological role and changes in the basal ganglia. Functional organization, physiological role and disorders of the motor centres of the brainstem.

Topic 26. Suprasegmental control of movement and posture III
Connections and functional organization of the cerebellum. Functions and disorders of the cerebellum.

Topic 27. Introduction to sensory physiology
General functions and components of the sensory system. Sensory organs. Types of sensitivity.

Topic 28. Sensory receptors
Classification. Touch and pressure. Temperature receptors. Cutaneous receptors. Deep sensitivity and visceral sensitivity. Organic sensations. Articular receptors.

Topic 29. Transmission of the impulse from the receptor
Peripheral nerves. Sensory pathways of the spinal cord. Sensory system of the brainstem. Thalamocortical system.

Topic 30. Physiology of pain I
Mechanisms of transmission and integration of pain. Pain transmission types. Pain transmission pathways in the spinal cord. Reticular formation. Function of the thalamus. Structures involved in the interpretation of pain stimuli.

Topic 31. Physiology of pain II
Systems involved in the control of pain stimuli. Functional and neurochemical aspects involved in the descending inhibitory system.

Topic 32. Physiology of vision
Physical principles of optics. Functional anatomy of the eye. Photochemical basis of vision. Neural function of the retina. Visual acuity and colour vision. Central visual pathways. Cortical visual area.

Topic 33. Physiology of hearing
Basic physical principles of sound. Functional anatomy of hearing. Physiology of the cochlea. Transmission of auditory stimuli. Function of the outer and inner "hair cells" (auditory sensory cells). Mechanical auditory synchronization. Electrical auditory synchronization. Integration of the auditory stimuli. Theories of audition.

Topic 34. Vestibular physiology
Vestibular receptors. Control of balance and of acceleration by the vestibular system. Vestibular reflexes.

Topic 35. Chemical receptors
Sense of taste. The taste receptor. The gustatory receptor cell. Transduction of the four basic tastes. Representation of the tastes to the thalamus and to the cortex. Sense of smell. Receptors of the olfactory neuroepithelium. Transduction of smells by the receptor cells. Projection of the information to the palaeocortex and to the olfactory cerebral cortex.

Topic 36. Autonomic nervous system I
Functional organization of the sympathetic and parasympathetic systems. Physiological equilibrium between the two systems. Activity and functional variations.

Topic 37. Autonomic nervous system II
General effects of the sympathetic and parasympathetic systems. Specific effects on the glands and on the smooth, visceral and vascular muscles. Neuro-vegetative reflexes.

Topic 38. Central regulation of the visceral functions
Functional organization of the Medulla Oblongata. Role of the hypothalamus in neuroendocrine control. Role of the hypothalamus in neurovegetative control.

Topic 39. Higher functions of the nervous system I
Functional organization and connections of the limbic system. Control of emotions and behaviour. Specific functions of the amygdala, the hippocampus and the limbic cortex.

Theme 40. Higher functions of the nervous system II
Functional organization and connections of the neocortex. Learning and memory. Molecular basis of memory. Neural basis of consciousness and language.

PRACTICAL CREDITS (GROUPS OF 15 STUDENTS**)**

Practical sessions are held in groups of 15 students per session. The number of sub-groups varies according to the type of practical session.

Practical Session 1. Neuroprotection provided by antioxidants against oxidative stress.

Experiment involving cell lines. Measurement of cell toxicity through biochemical methods (mythochondrial activity with MTT assay). Analysis and interpretation of the results obtained (8 hours: 4 + 4). This practical session is held with 8 sub-groups of 2 students each. (Dr. C. Jung)

Practical Session 2. Writing a scientific article based on the data obtained in Practical Session 1

Analysis and interpretation of the results obtained (4 hours: 2 + 2). This practical session is held with 8 sub-groups of 2 students each. (Dr. C. Jung)

Practical Session 3. Action potential

Conducted by computer simulation and subsequent analysis and interpretation of the results obtained (4 hours). This practical session is held with 4 sub-groups of 3-4 students each. (Dr. M. A. Valverde)

Practical Session 4. Ion channels; voltage clamp

Conducted by computer simulation and subsequent analysis and interpretation of the results obtained (4 hours). This practical session is held with 4 sub-groups of 3-4 students each. (Dr. M. I. Bahamondes)

Practical Session 5. Synaptic inhibition and excitation. Electronic model of neural function controlled via a PC

Analysis and interpretation of the results obtained (3 hours). This practical session is held with 5 sub-groups of 3 students each. (Dr. J.M. Fernández)

Practical Session 6. Muscular contraction

Conducted by computer simulation and subsequent analysis and interpretation of the results obtained (3 hours). This practical session is held with 4 sub-groups of 3-4 students each. (Dr. J.M. Fernández)

Practical Session 7. Electromyography and reaction time

Recording of basal and maximum muscle tone during a voluntary contraction, and of the reaction time. Analysis and interpretation of the results obtained (4 hours). This practical session is held with 4 sub-groups of 3-4 students each. (Dr. J.M. Fernández)

Practical Session 8. Assessment of the practical learning content of the subject (2 hours). (Dr. M. A. Valverde)

SEMINARS (GROUPS OF 30 STUDENTS)

The seminars are held in groups of 30 students and consist of discussions of real cases in sub-groups of 6-8 students. The purpose of the seminars is to aid in the revision of the main physiological concepts and to demonstrate in a practical way that pathology is essentially the result of a physiological disorder. The ability to discuss the cases will be assessed in Seminar 8, which will consist in a practical problem and two questions which are to be answered individually. Each seminar has a duration of two hours.

Seminar 1: Poisoning with saxitoxin (Dr. M. A. Valverde)
Seminar 2: Primary hyperkalemia with paralysis (Dr. F. J. Muñoz)
Seminar 3: Cholera toxin intoxication (Dr. F. J. Muñoz)
Seminar 4: Duchenne muscular dystrophy (Dr. F. J. Muñoz)
Seminar 5: Components of the nervous system (Dr. F. J. Muñoz)
Seminar 6: Control of the motor function (Dr. F. J. Muñoz)
Seminar 7: Somato-sensory perception (Dr. F. J. Muñoz)
Seminar 8: Assessment of learning progress by problem solving with notes and books (Dr. J. M. Fernández)

4. Assessment

The assessment of academic performance is done in the following manner (out of a total of 10 points):
- Multiple-choice test based on the theoretical topics covered and will count as a maximum of 2.5 points out of the total mark.
- Theoretical written test with two short questions for each of the topics studied.
One short question is to be answered per topic, chosen from two options, and written on one side of A4 paper (maximum) This will count as a maximum of 5 points of the total mark.
- Practical test: assessment of the knowledge acquired from the content of the practical sessions. This will count as a maximum of 1,25 point of the total mark.
- Seminar Test, consisting of problem solving with notes and books. This will count as a maximum of 1,25 point of the total mark.
- Formative assessment: the Faculty of Life and Health Sciences, in keeping with its programme of continuous assessment, holds an examination to measure progress halfway through the term (topics 1 to 9). Up to 0,5 points will be added to the final mark.

REQUIREMENTS
- A good level of English is recommended to follow this subject.

- Notes dealing with each topic, and programmes for practical sessions and seminars, are available in the Aula Global from the start of the academic year.
- Attendance at practical sessions is obligatory, and official justification must be provided for any absences.
- Students for seminars and practical sessions may not change group unless the changes (which must be consistent when exchanged with another student) have been approved beforehand by the Faculty Secretary's office.
- Students must bring the session or seminar plan to all practical sessions and seminars.
- Students must wear lab-coats when participating in the practical sessions.
- The September examination will consist of one single test which will include theoretical questions, seminars and practical sessions.
- The September examination final mark will be the mark obtained during the examination, plus the marks obtained during the formative assessment session, seminars and practical lessons during the course.
- Those repeating the examination will not be required to repeat the practical sessions and seminars, but will have to carry out a new examination concerning practical work and seminars.

5. Bibliography and teaching resources

- Bases biológicas y fisiológicas del movimiento humano. M. Guillén y D. Linares. Ed. Médica Panamericana, Madrid; 2002.
- Cell Physiology Source Book. N. Sperelakis. Ed. Academic Press, New York; 1998, 2a. edició.
- Cognition, brain, and consciousness: introduction to cognitive neuroscience. B.J. Baars & N.M. Gage. Ed. Elsevier Academic Press, Boston; 2007
- El entrenamiento de la fuerza: bases teóricas y prácticas. R. Manno. Ed. INDE, Barcelona; 1999.
- Essentials of Neural Science and Behavior. E.R. Kandel, J.H. Schwartz & T.M. Jessell. Eds. Appleton & Lange, Norwalk; 1995.
- Fisiología del ejercicio físico y el entrenamiento. J.R. Barbany. Ed. Paidotribo, Barcelona; 2002.
- Fisiología del ejercicio. J. López y A. Fernández. Ed. Médica Panamericana, Madrid; 2006, 3a. edició.
- Fundamental Neuroscience. L.R. Squire. Ed. Academic Press, Burlington; 2008, 3a. edició.
- Fundamentos de Fisiología de la actividad física y el deporte. A. Merí. Ed. Médica Panamericana, Madrid; 2005.
- Hippocampal place fields: relevance to learning and memory. S. J.Y. Mizumori. Ed. Oxford University Press, Oxford; 2008.
- Memory: from mind to molecules. L.R. Squire & E.R. Kandel. Ed. W.H. Freeman & Co, Nova York; 2000.
- Neurociencia. D. Purves. Ed. Médica Panamericana, Buenos Aires; 2006, 3a. edició.
- Neuroscience: exploring the brain. M.F. Bear, B.W. Connors & M.A. Paradiso. Ed. Lippincot Williams & Wilkins, Philadelphia; 2007, 3a. edició.
- Prescripción de ejercicio físico para la salud. R.S. Grima y C.B.Calafat. Ed. Paidotribo, Barcelona; 2004.

- Principios de Anatomía y Fisiología. G.J. Tortora & B. Derrickson. Ed. Médica Panamericana, Buenos Aires; 2006, 11a. edició.
- Principios de Fisiología Animal. Moyes CD y Schulte PM. Pearson (Addison-Wesley), 2007.
- Principios de Neurociencia. D.E. Haines. Ed. Elsevier Science, Barcelona; 2003, 2a. edició.
- Principios de Neurociencia. E.R. Kandel, J.H. Schwartz & T.M. Jessell. Ed. McGraw-Hill- Interamericana, Madrid; 2001, 4a. edició.
- Principles of Neural Science. E.R. Kandel, J.H. Schwartz & T.M. Jessell. Ed. McGraw-Hill, New York; 2000, 4a. edició.
- Principles of Physiology. M.N. Levy, B.A. Stanton & B.M. Koeppen. Eds. R.M. Berne & M.N. Levy, St. Louis; 2006, 4a. edició.
- Synapses. W.M. Cowan, T.C. Südhof & C.F. Stevens. Ed. Johns Hopkins University Press, Baltimore; 2001.