COURSE DATA

DATA SUBJECT

Code: 40143
Name: Systems neurobiology
Cycle: Master's Degree
ECTS Credits: 12
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
2074 - Master's Degree in Basic and Applied Neurosciences	Facultat de Ciències Biològiques	1	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
2074 - Master's Degree in Basic and Applied Neurosciences	Neurobiology of systems	COMPULSORY

COORDINATION

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SUMMARY

The Systems Neurobiology course is located in the first semester of the Master's Degree in Basic and Applied Neurosciences at the University of Valencia. It shares the course period with Cellular and Molecular Neurobiology and Behavioral Neurobiology. It is an integrative course, moving between the cellular/molecular and behavioral levels.

The general objectives of the Systems Neurobiology course are to provide students with basic knowledge regarding the organization of the nervous system into functional systems, to recognize the anatomical location of its centers in the brain and their structural organization, and to understand how the activity of the centers of each of the functional systems contributes to processing information to achieve sensory perception, decision-making, the execution of motor patterns, and more complex mental processes such as cognition, emotion, and memory.

The practical content of the course aims to ensure that students understand the fundamentals of the experimental methods used in the study of the anatomical and functional relationships of the nervous system, and to acquire skills in experimental design and the use of the most common techniques in this

field. They are also capable of interpreting the results of experiments and understanding their implications in the context of the current state of knowledge.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

COMPETENCES / LEARNING OUTCOMES

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Adquirir destrezas en el manejo de las metodologías empleadas en las neurociencias y en el registro anotado de actividades, así como en el manejo de programas informáticos para la obtención y análisis de los datos y la exposición de los resultados

Comprender las aproximaciones experimentales y sus limitaciones, así como interpretar resultados científicos en neurociencias y saber elaborar y redactar informes que los describan

Comprender y conocer las bases neuroanatómicas, neurohistológicas, neuroquímicas y electrofisiológicas del sistema nervioso central y periférico

Conocer la neurobiología de la percepción sensorial, la función motora y neuroendocrina, el aprendizaje, la memoria y la conducta así como las bases neurales de los trastornos psicológicos asociados y las estrategias terapéuticas

Conocer los principios éticos y legales de la investigación científica en neurociencias

Saber aplicar el método científico a los estudios en neurociencias y poseer el espíritu crítico requerido para distinguir la información científica rigurosa de la pseudociencia

Saber comunicar el conocimiento sobre neurociencia y sus implicaciones a públicos especializados y no especializados de un modo claro y sin ambigüedades, usando la lengua propia y el inglés.

Saber trabajar de manera responsable y rigurosa en el laboratorio, considerando los aspectos de seguridad, manipulación y eliminación de residuos así como del correcto uso de los animales de experimentación y los principios éticos para la investigación en humanos.

Saber trabajar en equipos multidisciplinares y diseñar estrategias experimentales multidisciplinares en el ámbito de las neurociencias para la resolución de problemas biológicos complejos

Ser capaz de aplicar las técnicas de búsqueda, identificación, selección y recogida de información científica especializada, así como de los métodos que se han de tener en cuenta a la hora de examinar críticamente cualquier clase de fuentes y documentos científicos.

Ser capaz de elaborar y estructurar una presentación en los distintos formatos de comunicación científica.

Ser capaz de realizar una correlación ajustada de estructura-función asignando los elementos estructurales asociados a las principales vías nerviosas, entender sus relaciones, la biofísica y la neuroquímica de la interacción entre centros y el papel en la función global del sistema

Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.

Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.

Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.

Students should demonstrate self-directed learning skills for continued academic growth.

Students should possess and understand foundational knowledge that enables original thinking and research in the field.

DESCRIPTION OF CONTENTS

THEORETICAL CLASSES

Topic 1. Development of the nervous system. Differentiation of the neuroectoderm during embryonic development. Neurulation of the neural plate into the neural tube (spinal cord and head vesicle) and neural crests. Evolution of the head vesicle into three vesicles: the forebrain, midbrain, and hindbrain. Formation of the olfactory placodes, olfactory nerves, optic placodes, retina, optic nerves, and structure of the eye. Formation of the auditory placodes, the ear, and auditory nerves and ganglia. Subdivision of the three initial vesicles into the five definitive vesicles (telencephalon (cerebral hemispheres), diencephalon, midbrain, metencephalon, and myelencephalon) and the cerebellum. Development of the PNS from the neural crests.

Topic 2. Anatomical organization of the nervous system. Central Nervous System. Telencephalon or brain: organization into gray matter and white matter (commissures), hemispheres, ventricular system. Layered structure and functions of the neocortex, paleocortex, and hippocampus. Anatomy and basic functions of the striatum, amygdala, and septum. Diencephalon: ventricular system, thalamus, hypothalamus, and epithalamus. Midbrain: ventricular system. Anatomy and function of the tectum (visual and auditory colliculi), tegmentum (motor nuclei). Hindbrain: ventricular system. Columnar organization, fiber bundles and nuclei, reticular formation. Anatomy and function of the cerebellum, pons, medulla oblongata. Spinal cord. Metamerism in the CNS and peripheral nervous system. Basis of neuroimaging techniques in the study of the human brain.

Topic 3. Bodily senses and pain. Primary somatosensory cells. Modalities of somatosensitivity: touch (pressure), temperature, and nociception. Anatomical (metameric) organization of somatosensitivity:

dermatomes. Somatosensory nerve pathways: the dorsal column and the spinothalamic pathway. Organization of the somatosensory cortex. Pain as adaptive sensitivity. Induced (gate theory) and endogenous analgesia. Role of opioids. Hyperalgesia and neuropathic pain. Pharmacology of pain and analgesia. Research into pain and analgesia. Animal models for studying pain and analgesia.

Topic 4. Auditory system. Sounds, stimulus characteristics, and environmental scanning. The cochlea, hair cells, and auditory transduction. Auditory pathways: binaural convergence and sound source localization. Tonotopia. Subcortical and cortical processing.

Topic 5. Chemical senses: Olfaction and gustation. Olfactory and vomeronasal systems. Odors and pheromones, the dual olfactory hypothesis. Olfactory epithelium and sensory transduction. The olfactory receptor family and odor coding. Processing in the olfactory bulb. Organization of the olfactory cortex. Hypotheses on the neurobiology of odor detection. Odors, memories, and emotions. The taste system. Taste buds, basic tastes, and sensory transduction. Gustatory pathways. Taste, smell, and flavor: integration in the insular cortex. Conditioned aversion to flavors.

Topic 6. Visual system. The retina, photoreceptors, and visual transduction. Cellular elements and retinal processing. Receptive fields. Structure of the visual field, the fovea, and the M and P systems. Visual pathways. The visual cortex. Visual disorders.

Topic 7. Vestibular system and proprioception. Role of the cerebellum.

Topic 8. Motor systems. Spinal motor control mechanisms: the neuromuscular spindle and the Golgi tendon organ, spinal reflexes, and spinal integration of motor commands. Descending motor systems: pyramidal and extrapyramidal pathways. Motor control: the basal ganglia and the cerebellum. Neurodegenerative pathologies of the motor systems.

Topic 9. The neuroendocrine system. Functional anatomy of the hypothalamus. Homeostasis and its disruption: stress. Neural pathways of intake control. Neural pathways of biological rhythms. Sleep. Contribution of the hypothalamus to social behavior.

Topic 10. Neurobiology of learning and memory. Types of memory. Animal models for the study of the neurobiology of learning and memory. Habituation and sensitization in Aplysia. Synaptic plasticity. Short-term and long-term memory. The role of the cyclic AMP-PKA-MAPK-CREB pathway. Associative learning. The role of the amygdala in classical conditioning. The role of the hippocampus in spatial learning (and explicit memory). Long-term potentiation (and depression). Structural plasticity and memory. Consolidation and reconsolidation.

Topic 11. Fundamentals of Computational Neuroscience.

PRACTICES

1. Human Neuroanatomy. Dissection of the human brain, gross anatomy. Sagittal, transverse, and coronal sections. Segments. Brainstem, cerebellum, pyramids, epicritic sensory nuclei, pons, superior and inferior colliculi. Diencephalon, epithalamus, thalamus, subthalamus, and hypothalamus. Basal nuclei, septum,

amygdala, hippocampus, cortex, cerebral peduncles. Irrigation diagram.

2. Stereotaxy. Cranial landmarks, Bregma, Lambda, and the zero point. Stereotaxic atlases. AP, ML, and DV scales. Turrets, micropipettes, electrodes, and cannulas. Injection of tracers, drugs, or neurotoxic agents (lesion).

3. Applications of stereotaxic surgery: tracing connections using tracers and viral vectors. Practical example.

4. Functional neuroanatomy techniques: c-fos expression.

5. Guided tour of the Pain Unit at the General Hospital of Valencia.

SEMINARS

1. The Sleep Laboratory. Analysis and interpretation of polysomnograms and video sleep recordings. Examples of sleep disorders.

2. Fundamentals of Computational Neuroscience

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	16,00
Theory	36,00
Seminar	4,00
Other activities	3,00
Laboratory	18,00
Total hours	**77,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	210,00
Preparation of lessons	13,00
Preparation for assessment activities	0,00
Resolution of case studies	0,00
Total hours	**223,00**

TEACHING METHODOLOGY

Lectures with active participation through discussion of the most complex aspects and the resolution of doubts and questions.

Laboratory practices with sample handling, problem-solving, practical scenarios, preparation of practice reports, etc.

Discussion, reflection, and preparation of reports on practical tasks.

EVALUATION

Evaluation of group tutorials at the beginning of the course (15%): The final theoretical and practical tests of the subject can only be taken once the evaluation of the tutorials at the beginning of the course has been passed.

Evaluation of theoretical knowledge (50%): The concepts worked on in the theoretical sessions will be evaluated by carrying out tests with questions and/or multiple-choice questions. It will be essential to obtain at least 4 points out of 10 in the theory exam to make the total calculation.

Evaluation of practical knowledge and skills (10%): Attendance at 80% of the practical classes (laboratory and classroom) is required. An evaluation will be made by carrying out tests with questions and/or multiple-choice questions on the experimental approach to neurobiological problems or the interpretation of the results of experiments such as those raised in the practical classes.

Practical report (25%): Students will prepare a practical report in groups of 2-3 people that will be evaluated taking into account the concreteness, clarity and bibliographical material used.

Second call: if the student has not passed the subject in the first call, the grades of the approved parts (tutorials, practicals, activities carried out during the course and practical report) are kept.

REFERENCES

Kandel ER, Koester JD, Mack SH, Siegelbaum SA. eds. 2021 Principles of Neural Science, 6e. McGraw Hill

Squire LR et al. 2013 (4ª edición). Fundamental Neuroscience. Chapter 33 and 38, The Hypothalamus: an overview of regulatory systems & Neuroendocrine Systems

Kandel E, et al. (2013) Principles of Neural Science, 5th Edition McGrawHill

Purves D, Augustine, Fitzpatrick, Hall, LaMantia, McNamara, White. 2007. Neurociencia. 3a Edicion. Editorial Médica Panamericana. Cuarta Edición inglesa en 2008, de Sinauer.

Squire LR, Berg D, Bloom FE, du Lac S, Ghosh A, Spitzer NC. 2008. Fundamental Neuroscience, 3rd Edition. Academic Press.

Cardinali DP. 2007. Neurociencia Aplicada: Sus fundamentos. Ed. Panamericana, Buenos Aires y Madrid

Martin JH. 1998. Neuroanatomia (segunda edición). Prentice-Hall. Madrid

Paxinos G (Ed). The Rat Nervous System (Third Edition). Academic Press. ISBN: 978-0-12- 547638-6

Paxinos G, Franklin KBJ. 2001. The Mouse Brain in Stereotaxic Coordinates. Academic Press, San Diego.

Paxinos G, Watson C. 2007. The Rat Brain in Stereotaxic Coordinates, 6th Edition. Academic Press, San Diego.

Puelles L, Martinez-Pérez S, Martinez de la Torre M. 2008. Neuroanatomia. Ed. Panamericana, Buenos Aires y Madrid

Breedlove SM, Watson NV, Rosenzweig MR. 2010. Biological Psychology: An Introduction to Behavioral, Cognitive, and Clinical Neuroscience, Sixth Edition. Edicion española de Ariel, de 2005

Carlson NR. 2009. Fisiología de la conducta. 8a edición. Madrid: Pearson Educación. Edición inglesa, Physiology of Behavior, por la misma editorial (de Allyn and Bacon)

Kalat JD. 2009. Biological Psychology. Wadsworth Cengage Learning.