UNIVERSIDAD COMPLUTENSE DE MADRID

UNIVERSIDADES NORTEAMERICANAS REUNIDAS

SUBJECT
SUBJECT TITLE: NEUROSCIENCE
QUARTER AND ACADEMIC YEAR: 4TH QUARTER (SEPT-DEC). 2024-25.
SCHEDULE:
PREREQUISITES:NONE
COMPETENCES- OBJECTIVES (BRIEF DESCRIPTION): **Course Description:** This course provides an overview of the fundamental principles and concepts in neuroscience and neurology. It covers the structure and function of the nervous system, neurophysiology with cellular and molecular mechanisms including neuronal communication and brain development, basic concepts of neuropharmacology, neural plasticity and nervous system regeneration, higher cognitive functions, as well as the main neurological disorders and ethical issues in Neuroscience Research. Through lectures, discussions, and laboratory exercises, students will gain a foundational understanding of the field of neuroscience and its relevance to various disciplines such as biology, psychiatry, and medicine. **Main objectives:** **1. Introduction to Neuroscience:** • Understand the scope and interdisciplinary nature of neuroscience. • Define key terms and concepts in neuroscience. • Explore the historical development and major milestones in neuroscience research. • Identify the relevance and applications of neuroscience in various fields. **2. Neuroanatomy:** • Learn the anatomical organization of the nervous system, including the brain, spinal cord, and peripheral nerves. • Identify and describe the major brain regions and their functions. • Understand the structural and functional organization of neural circuits. • Gain proficiency in neuroanatomical terminology and imaging techniques. **3. Neurophysiology, Cellular, and Molecular Neurobiology:** • Explore the electrical properties of neurons and neuronal communication. • Understand the cellular and molecular mechanisms underlying synaptic transmission. • Learn about neurotransmitters, receptors, and signaling pathways in the nervous system. • Investigate the role of ion channels, membrane potentials, and action potentials in neuronal function. **4. Neuropharmacology:** • Study the principles of drug action and pharmacokinetics in the nervous system.

- Learn about major classes of psychoactive drugs and their effects on neurotransmitter systems.
- Understand the mechanisms of drug addiction, tolerance, and withdrawal.
- Explore the therapeutic applications of pharmacological agents in treating neurological and psychiatric disorders.

5. Neural Plasticity and Nervous System Regeneration:

- Explore the concepts of neural plasticity and synaptic plasticity.
- Understand the cellular and molecular mechanisms underlying neuroplasticity.
- Investigate the role of neurogenesis, synaptogenesis, and dendritic remodeling in nervous system development and repair.
- Learn about experimental approaches and therapeutic strategies for promoting neural regeneration and recovery after injury or disease.

6. Higher Cognitive Functions:

- Explore the neural basis of higher cognitive functions, including memory, attention, language, and executive functions.
- Understand the role of specific brain regions and neural circuits in cognitive processes.
- Investigate cognitive neuroscience methods and experimental approaches for studying brain-behavior relationships.

7. Neurological Disorders:

- Learn about common neurological disorders and diseases, including neurodegenerative diseases, stroke, epilepsy, and psychiatric disorders.
- Understand the underlying pathophysiology, clinical manifestations, and diagnostic criteria for neurological disorders.
- Explore current treatments and therapeutic interventions for managing neurological conditions.

8. Ethical Issues in Neuroscience Research:

- Discuss ethical considerations and principles in neuroscience research, including informed consent, privacy, and confidentiality.
- Explore ethical challenges related to animal research, human subjects research, and emerging technologies in neuroscience.
- Examine case studies and ethical dilemmas in neuroscience research and clinical practice.
- Develop critical thinking skills and ethical decision-making abilities in the context of neuroscience.

By addressing these objectives, students will gain a comprehensive understanding of key concepts and principles in neuroscience/neurology, as well as develop critical thinking skills and ethical awareness relevant to the field.

TEACHER
NAME: IGNACIO LIZASOAIN
DEPARTMENT: PHARMACOLOGY AND TOXICOLOGY. COMPLUTENSE MEDICAL SCHOOL.
OFFICE TELEPHONE: +34-1-3941452 (+34-629054711)
CORREO ELECTRÓNICO: ignacio.lizasoain@med.ucm.es
OFFICE:
TUTORING HOURS: Tuesday 11:00-13:00

COURSE SCHEDULE, TOPICS, LECTURES AND TASKS ASSIGNED

COURSE TITLE: NEUROSCIENCE

Week 1: Introduction of Neuroscience

- Lecture 1: Overview of Neuroscience: Definition of neuroscience, Historical milestones, Interdisciplinary nature of neuroscience
- Lecture 2: Neurons and Glial Cells: Structure and function of neurons, Types of neurons: sensory, motor, interneurons, Role of glial cells: astrocytes, oligodendrocytes, microglia

Week 2: Neuroanatomy

- Lecture 3: Overview of Brain Anatomy: Gross anatomy: lobes, cortex, subcortical structures, Brain regions and their functions
- Lecture 4: Central Nervous System (CNS) vs. Peripheral Nervous System (PNS): Structure and function of the CNS and PNS, Role of spinal cord and brainstem

Week 3: Neurophysiology, cellular and molecular neurobiology I

- Lecture 5: Basics of Neural Communication: Resting membrane potential, Action potential generation and propagation.
- Lecture 6: Neuronal excitability. Ion channels I. Synapses. General characteristics. Chemical and electrical synapses.

Week 4: Neurophysiology, cellular and molecular neurobiology II

- Lecture 7: Synaptic transmission: neurotransmitters and receptors. overview of metabotropic and ionotropic receptors.
- Lecture 8: Neurotransmitter Systems: Major neurotransmitter systems: glutamate, GABA, dopamine, serotonin, acetylcholine, Functions and dysfunctions of neurotransmitter systems

Week 5: Neurophysiology, cellular and molecular neurobiology III

- Lecture 9: Transcription factors in the nervous system. Role of growth factors in the nervous system. Cerebral blood flow and oxygen consumption.
- Lecture 10: Neuronal death: mitochondria, excitotoxicity and calcium, DNA repair, apoptosis and caspases. Oxidative stress: generation of ROS and RNS. Antioxidant defenses.

Week 6: Neuropharmacology I.

- Lecture 11: Pharmacokinetics and routes of administration. Pharmacodinamics. Pharmacological targets of action: molecular aspects.
- Lecture 12: Pharmacology of the sympathetic and parasympathetic nervous systems

Week 7: Neuropharmacology II.

- Lecture 13: Opioid analgesic drugs. Anesthetic drugs.
- Lecture 14: Anxiolytic and hypnotic drugs. Antidepressant and antimanic drugs. Antipsychotic drugs.

Week 8: Neuropharmacology III.

- Lecture 15: Drugs for neurological disorders: Epilepsia, Parkinson's disease, Huntington's disease, Alzheimer's disease and ischemic brain injury.
- Lecture 16: Drugdependence: nicotine -tobacco-, ethanol, cannabis, cocaine, amphetamines, opiates, other

Week 9: Neural Plasticity and Nervous System Regeneration.

- Lecture 17: Neuronal and synaptic plasticity. Mechanisms, structural changes and types. Plasticity during learning and memory. Plasticity in the adult brain and brain aging. Brain injury and plasticity.

- Lecture 18: Neurogenesis. Stem cells and neurogenic niches. Extrinsic and intrinsic signals in the regulation of adult neural stem cells. Angiogenesis. Brain injury and neurogenesis and angiogenesis.

Week 10: Higher Cognitive Functions

- Lecture 19: Learning and Memory. Types of memory: short-term, long-term, working memory. Brain regions involved in memory formation.
- Lecture 20: Emotion and Motivation. Limbic system and emotional processing. Neural basis of motivation and reward

Week 11: Neurological Disorders I

- Lecture 21: Cerebral ischemia/trauma: ischemic and hemorrhagic stroke. Treatments: reperfusion therapies, cerebroprotective and neuroreparative strategies. Inflammation and immunity. Demyelinating diseases: multiple sclerosis.
- Lecture 22: Proteinopathies: Abnormal protein folding, aggregation and proteolysis failures. Alzheimer's disease and other dementias.

Week 12: Neurological Disorders II

- Lecture 23: Parkinson's disease, synucleinopathies and Huntington's disease.
- Lecture 24: Spinal motor neuron diseases: amyotrophic lateral sclerosis. Spinal cord injury. Therapeutic strategies: regenerative therapy.

Week 13: Ethical Issues in Neuroscience Research

- Lecture 25: Ethical Considerations in Neuroscience Research: Animal research ethics, informed consent and human subjects research
- Lecture 26: Application of animal models in Neuroscience. Ethical requirements and current legislation (RD53/2013 and 2010/63/EU). Main animal models used in Neuroscience. Transgenic models in Neuroscience (knock-in, knock-out). Neurobehavioral analysis. Influence of age, sexual dimorphisms and biological rhythms.
- Lecture 27: Techniques and methods of analysis in neuroimaging: CT, MRI, fMRI, PET/SPECT. Microscopy techniques: electronic, confocal, fluorescence.

TEACHING METHODOLOGY

1. **Lectures:** Traditional lectures can provide students with a foundation of knowledge in neuroscience and neurology. These lectures can cover topics such as neuroanatomy, neurophysiology, molecular and cellular neuroscience, neuropharmacology, and higher cognitive functions. The lectures should be interactive, engaging, and supplemented with visual aids such as slides, diagrams, and videos to enhance understanding.
2. **Discussion Groups:** Small-group discussions allow students to actively engage with course material, ask questions, and participate in critical thinking exercises. Discussion topics can include recent research findings, case studies of neurological disorders, ethical dilemmas in neuroscience, and applications of neuroscience in society. These discussions encourage collaboration, communication, and the development of analytical skills.
3. **Problem-Based Learning:** Problem-based learning (PBL) involves presenting students with real-world problems or case studies related to

neuroscience and challenging them to find solutions using their knowledge and critical thinking skills. PBL encourages active learning, problem-solving, and application of theoretical concepts to practical scenarios. Students can work in groups to analyze case studies, propose hypotheses, and develop research proposals or treatment plans.

4. **Guest Lectures:** Inviting guest speakers, such as neuroscientists, clinicians, and researchers, to present lectures or seminars can provide students with insights into current research trends, career opportunities, and real-world applications of neuroscience. Guest lectures expose students to diverse perspectives and foster connections between academic concepts and professional practice.
5. **Research Projects (written work):** Research projects allow students to delve deeper into specific topics of interest within neuroscience and develop research skills such as experimental design, data collection, analysis, and interpretation. Students can work individually or in groups to conduct literature reviews, design experiments, collect data, and present their findings in written reports or oral presentations. Research projects encourage independent inquiry, creativity, and scientific inquiry.

By incorporating these teaching methodologies, instructors can create a dynamic and engaging learning environment that fosters students' curiosity, critical thinking, and passion for neuroscience.

SUBJECT OBJECTIVES

Subject objectives:

1. Introduction to Neuroscience.
2. Neuroanatomy.
3. Neurophysiology, Cellular, and Molecular Neurobiology.
4. Neuropharmacology.
5. Neural Plasticity and Nervous System Regeneration.
6. Higher Cognitive Functions.
7. Neurological Disorders.
8. Ethical Issues in Neuroscience Research.

By addressing these objectives, students will gain a comprehensive understanding of key concepts and principles in neuroscience/neurology, as well as develop critical thinking skills and ethical awareness relevant to the field. For more details, see Main objectives (page 1) and Course schedule (page 3).

EVALUATION AND QUALIFICATION CRITERIA

PARTIAL EXAM: 20%

FINAL EXAM: 20%

WRITTEN WORK OR PRESENTATIONS: 20%

PROBLEM-BASED LEARNING: 20%

CLASS PARTICIPATION: 20%

ASSESSMENT: Assessments should be varied and aligned with course objectives to measure students' understanding and mastery of neuroscience

concepts. Assessment methods can include quizzes, exams, research papers, laboratory reports, presentations, group projects, and participation in discussions. Providing constructive feedback on assessments helps students identify areas for improvement and promotes continuous learning and development.

ATTENDANCE: It is mandatory. From the second absence without justification, a point will be lowered in the Spanish grading system (for example, an 8 will drop to a 7). In the case of the Spanish Cinema class, missing one class will be equivalent to two absences.
Likewise, lateness will also be penalized, more than 15 minutes late will be equivalent to an absence. Excused absences are considered those documented by the appropriate physician or program director.

ACADEMIC INTEGRITY: Plagiarism, the use of materials not permitted in exams and tests, copying answers from another classmate, falsification or misappropriation of information for assignments, submission of the same assignment or sections of it in more than one course, helping a student who is cheating, etc. The penalty will be left to the discretion of the subject professor and the student's Program Director, in accordance with their campus policies and procedures.

GUIDE AND INDICATIONS FOR WRITTEN WORK

A computer-based research paper of approximately 2,000 words will be required. For this purpose, the student will be provided with bibliography, accessible either in bookstores or in university libraries. The date of delivery of the work must appear in the syllabus of the course. The teacher will grade the paper and write comments on it. The work must follow the following guidelines:

1. **Formatting and Structure:**
   - Use a clear and legible font (e.g., Times New Roman, Arial) and a standard font size (e.g., 12-point).
   - Include a title page with the title of the assignment, student's name, course name, instructor's name, and date of submission.
   - Organize the content logically with clear headings and subheadings to enhance readability.
2. **Content and Research:**
   - Ensure that the written work addresses the specific prompts or questions provided in the assignment instructions.
   - Support arguments and claims with evidence from credible sources, such as peer-reviewed journals, textbooks, and reputable websites.
   - Use a combination of primary sources (original research articles) and secondary sources (review articles, textbooks) to provide a comprehensive overview of the topic.
   - Provide proper citations for all sources used in the assignment, following a standard citation style (e.g., APA, MLA, Chicago).
3. **Clarity and Organization:**
   - Write in clear, concise language, avoiding unnecessary jargon or technical terms unless defined or explained.
   - Organize the content logically, with a clear introduction, body paragraphs, and conclusion.
   - Ensure coherence and cohesion by maintaining a consistent writing

style and linking related ideas together.

4. **Critical Thinking and Analysis:**
   - Analyze and evaluate the evidence presented, considering its relevance, reliability, and implications.
   - Demonstrate critical thinking skills by questioning assumptions, considering alternative perspectives, and synthesizing information from multiple sources.
   - Provide well-reasoned arguments and interpretations supported by evidence and logical reasoning.
5. **Originality and Academic Integrity:**
   - Ensure that all written work is original and free from plagiarism by properly citing and referencing all sources used.
   - Avoid copying or paraphrasing text from sources without proper attribution.
   - Acknowledge the ideas and contributions of others through appropriate citations and references.
6. **Revision and Proofreading:**
   - Revise and edit the written work to improve clarity, coherence, and effectiveness of communication.
   - Check for grammatical errors, spelling mistakes, and typographical errors, and correct them before submission.
   - Proofread the document carefully to ensure accuracy and professionalism.
7. **Submission and Deadlines:**
   - Submit the written work by the specified deadline, following the submission instructions provided by the instructor.
   - Keep a copy of the assignment for your records and ensure that it is saved in a format that can be easily accessed and retrieved.

By following these guidelines, students can produce high-quality written work that demonstrates their understanding of neuroscience concepts, critical thinking skills, and ability to communicate effectively in a scholarly manner.

MANDATORY BIBLIOGRAPHY AND OTHER RESOURCES

BIBLIOGRAPHY.

The following textbooks cover various aspects of neuroscience, neurology, psychiatry, including cellular and molecular biology, neuroanatomy, pharmacology, and laboratory methods in research, providing updated information for students and researchers in the field.

1. Anschel DJ. Neurology: PreTest Self-Assessment and Review. McGraw-Hill Education. **2012**. 8th Ed.
2. Bradley WG, Daroff RB, Fenichel GM, Jankovic J. Neurology in Clinical Practice. Elsevier. **2021**. 8th Ed.
3. Brunton LL, Chabner BA, Knollmann BC. Goodman & Gilman's. The Pharmacological Basis of Therapeutics. McGraw Hill. **2017**. 13rd Ed.
4. Byrne JH, Heidelberger R, Waxham MN. From Molecules to Networks. An introduction to cellular and molecular neuroscience. Elsevier Academic Press. **2014**. 3º Ed.
5. Daroff RB, Jankovic J, Mazziotta JC, Pomeroy SL. Bradley's Neurology in Clinical Practice. Elsevier. **2021**. 8th Ed.
6. Golan D, Armstrong EJ, Armstrong AW. Principles of Pharmacology:

The Pathophysiologic Basis of Drug Therapy. Wolters Kluwer. **2016**. 4th Ed.
7. Jones HR Jr., Allam GJ, De Vivo DC. Merritt's Neurology. Lippincott Williams & Wilkins. **2015**. 13th Ed.
8. Kandel ER, Schwartz JH, Jesell TM, Siegelbaum SA, Hudspeth AJ. Principles of Neural Science. McGraw Hill Companies Inc. **2013**. 5th Ed.
9. Kempermann G. Adult neurogenesis: stem cells and neuronal development in the adult brain. Oxford Univ. Press, **2011**.
10. Kiernan J, Rajakumar Raj. Barr's The Human Nervous System. Lippincott Williams & Wilkins. **2013**. 10th Ed.
11. Levitan I, Kaczmarek LK. The Neuron, Cell and Molecular Biology. Oxford University Press. **2015**. 4th ed.
12. Nieuwenhuys R, Voogd J, Huijzen CV. The Human Central Nervous System. Springer. **2016**. 4th Ed.
13. Ritter JM, Flower RJ, Henderson G, Loke YK, McEwan D, Rang HP. Rang & Dale's Pharmacology. Elsevier. **2023**. 10th Ed.
14. Ropper AH, Samuels MA. Adams and Victor's Principles of Neurology. McGraw-Hill Education. **2023**. 12th Ed.
15. Rowland LP, and Pedley TA. Merritt's Neurology. Lippincott Williams & Wilkins. **2023**. 13th Edition.
16. Sanes DH, Reh TA, Harris WA. Development of the Nervous System. Academic Press Elsevier. **2012**. 3rd Ed.
17. Sobotta. Atlas of anatomy. Elsevier. **2023**. 17th Ed.
18. Watson C, Kirkcaldie M, Paxinos G. The Brain. An Introduction to Functional Neuroanatomy. Academic Press. Elsevier Inc. **2010**. 1st Ed.
19. Williams SA y col. Laboratory investigations in Molecular Biology. Jones and Bartlett Publishers. **2007**.
20. Xiong H, Gendelman HE (Eds.) Current Laboratory Methods in Neuroscience Research. Springer. **2014**.

Some of the most cited journals in the field of neuroscience, neurology and psychiatry are the following:

Nature Neuroscience, Nature Neurology, JAMA Neurology, Neuron, Neurology, Annals of Neurology, Journal of Neuroscience, Trends in Neurosciences, Annual Review of Neuroscience, Brain, Cerebral Cortex, Brain Research, NeuroImage, Molecular Psychiatry, Biological Psychiatry, Stroke American Journal of Psychiatry, JAMA Psychiatry, Schizophrenia Bulletin

These journals cover a wide range of topics within neuroscience, neurology and psychiatry and are highly regarded for publishing high-quality research articles that contribute significantly to the advancement of the field.