COURSE DESCRIPTION

2021

HELLENIC REPUBLIC

NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS

DEPARTMENT OF BIOLOGY

Athens International Master's Programme in Neurosciences

CONTENTS

INTRODUCTION

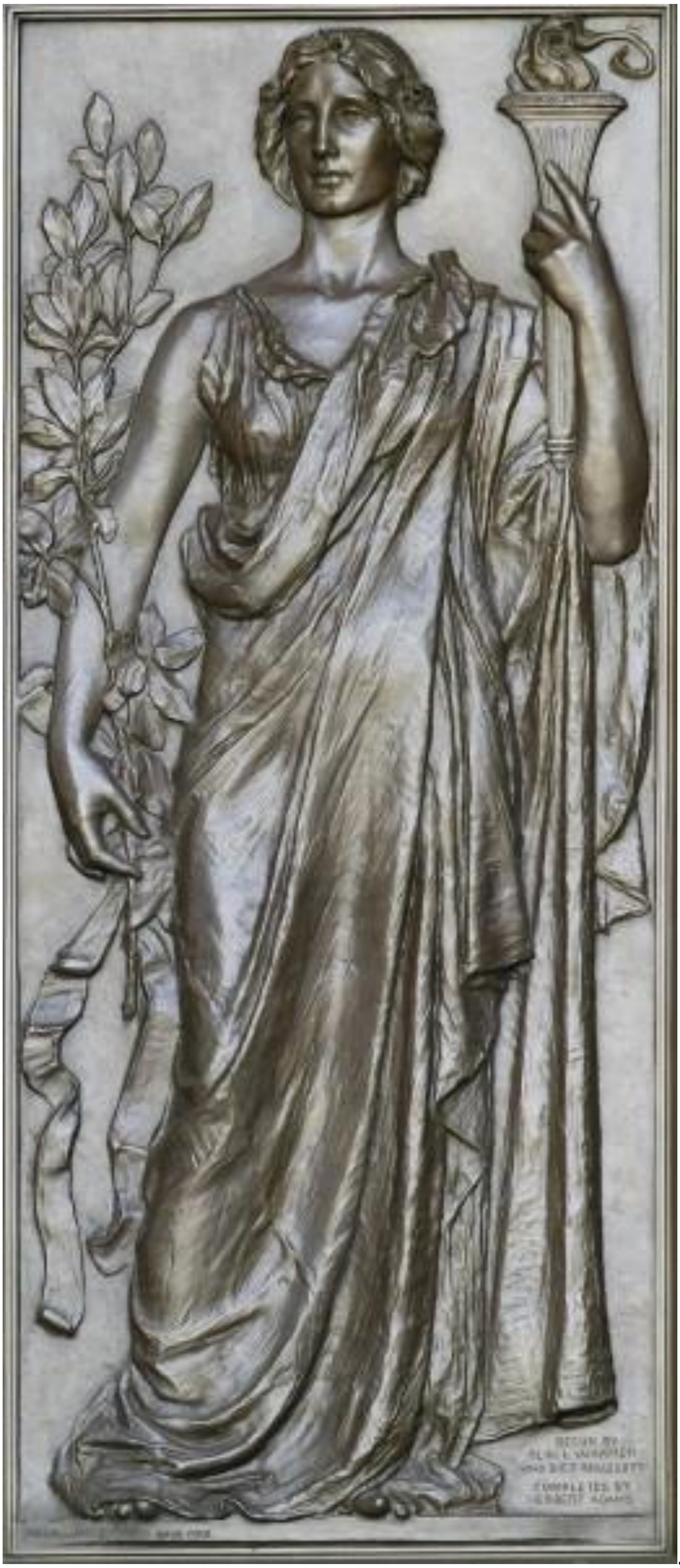
The purpose of the postgraduate programme «Athens International Master's Programme in Neurosciences» is to provide high quality graduate education at the Master of Sciences (M.Sc.) level in the scientific field of neuroscience.

The postgraduate program of studies leads in the award of a "Postgraduate Specialization degree" in Neurosciences (Master of in Neurosciences) after full and successful completion of studies based on the curriculum.

The "Athens International Master's Programme in Neuroscience" is operated jointly by the:

Department of Biology of the National and Kapodistrian University of Athens
Department of Nursing of the National and Kapodistrian University of Athens
Department of Dentistry of the National and Kapodistrian University of Athens
School of Medicine of the National and Kapodistrian University of Athens
Foundation for Biomedical Research of the Academy of Athens
The National Center for Scientific Research "Demokritos"
The Hellenic Pasteur Institute
The Biomedical Sciences Research Center “Alexander Fleming”
The National Hellenic Research Foundation

The Goddess of Research



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DESCRIPTION OF THE COURSES OF THE INTERNATIONAL MASTER'S PROGRAMME IN NEUROSCIENCES

FIRST SEMESTER

DEVELOPMENTAL NEUROSCIENCE

Coordinators

Rebecca Matsas, Research Director, Head of Department of Neurobiology, Hellenic Pasteur Institute

Panagiotis Politis, Principal Investigator, Biomedical Research Foundation, Academy of Athens

Teaching hours and weekly schedule

This is a 1st semester course lasting about 2 weeks and corresponds to 4 ECTs and 29 total hours of lectures including student presentations.

The course will take place in October-November and the weekly schedule includes about 4 hours of teaching per day every afternoon.

Description

This is an intensive two-week course focused on cellular, molecular and biochemical aspects of developmental neurobiology and neuroscience. The courses will include lectures by established researchers with diverse and complementary academic profiles. The main emphasis of the course will be on the complex cellular events and signaling cascades that occur during embryogenesis that lead to generation of the nervous system. Our goal is to provide a systematic introduction to the molecular mechanisms that control cell fate specification, differentiation, and function of neural cells during mammalian brain development. An additional aim is to discuss nervous system plasticity in the adult brain and particularly how the presence of adult neural stem cells may contribute to brain repair strategies. Special attention will be given to describe the key methodological advances and research tools, developed in the last few years, which have changed our view about the formation of the mammalian brain. Therefore, this course will provide a contemporary overview of neural development for post-graduate students with some background in cell biology.

Course Overview

This course aims: a) to introduce participants to the major issues of developmental neuroscience, b) to familiarize students with the wide range of research approaches, tools and methodology currently used to study the development of the mammalian nervous system, c) to discuss the concept of neural stem cells during development and in the adult and d) to encourage students to develop the skills required for a meaningful appreciation of experimental strategies and research articles.

This course will cover recent advances in understanding the molecular and cellular events underlying cell fate specification and differentiation, migration, axon guidance, synapse formation, the critical role of neurotrophic factors, and cell death as a developmental process. Pathologies arising from failures of these processes will be discussed. In particular, the lectures will cover the following general subjects:

- Neural Induction
- Neural tube formation and patterning
- Cortical & Cerebellar Neurogenesis
- Regulatory mechanisms of cell cycle progression/exit
- Neuronal migration and differentiation
- Axon Guidance & Adhesion Molecules
- Trophic factors and programmed cell death during nervous system development
- Synapses: formation, function and plasticity
- Development of neural circuits
- Development of the neuroimmune system
- Gliogenesis, myelination, remyelination
- Neural stem cells, adult neurogenesis & neuroregeneration
- Advanced Methods in Developmental & Regenerative Neurobiology

Titles of lectures and names of the lecturers

A/A	Developmental Neuroscience	Lecturer
1	Neural Induction / Neural tube formation and patterning	Panos Politis
2	Cortical Neurogenesis	Myrto Denaxa
3	Cerebellar Neurogenesis & Adult Neurogenesis	Rebecca Matsas
4	Gliogenesis & myelination	Florentia Papastefanaki
5	Axon Guidance & Adhesion Molecules	Maria Gaitanou
6	Development of neural circuits and plasticity	Laskaro Zagoraiou
7	Synapse: formation and function	Nondas Doxakis
8	Development of the neuroimmune system	Era Taoufik
9	Modeling human brain development "in a dish"	Georgia Kouroupi
10	Trophic factors and programmed cell death during nervous system development	Giannis Charalampopoulos
11	Advanced methods in developmental & regenerative neurobiology	Myrto Denaxa

GROSS AND MICROSCOPIC ANATOMY OF THE NERVOUS SYSTEM

Coordinators

Maria Panayotacopoulou, Professor of Neurobiology, 1st Psychiatric Clinic, Medical School of the National & Kapodistrian University of Athens
Anastasia Tsingotjidou, Associate Professor of Anatomy, School of Veterinary Medicine, Aristotle University of Thessaloniki
Dimitrios Mytilinaios, MD, PhD, Head of Content @ Kenhub GmbH - Medical Examiner, Medical School of the National & Kapodistrian University of Athens

Teaching hours and weekly schedule

This a 1st semester course of about 3 weeks that corresponds to 3,5 ECTs and 32 total hours of lectures.

Description

This is an intensive three-week course focused on neuroanatomy that includes lectures and laboratory sessions. All material will focus primarily on learning the structure of the nervous system with related focus on function for general neuroscientists. Special attention will be given to chemical neuroanatomy in order to identify and describe the neurotransmitter systems of the brain and their connections. The goal of this intensive course is that students become well versed in the structure and function of the nervous system in health and disease. Hands on laboratory sessions will allow students to learn through direct experience.

Course Overview

Interdisciplinary study of the nervous system, with the overarching theme that nervous system disorders can be understood in terms of neuroanatomical mechanisms. The course covers general principles of the development, connectivity, neurotransmitter and receptor systems, blood supply, central nuclei and tracts of the central nervous system.

- Major topographical features of the brain
- Describe the major anatomical subdivisions and functions of cerebral cortical systems
- Major interrelationships between primary brain structures
- Localize and identify brainstem nuclei
- Localize and identify brainstem tracts
- Localize and identify major somatomotor systems
- Localize and identify major somatosensory systems

- Localize and identify central sensory systems (visual, auditory and vestibular pathways)
- Localize and understand cranial nerves
- Understand and localize hypothalamic subnuclei and autonomic systems
- Understand and localize the limbic system and diencephalon
- Understand and localize the basal ganglia
- Localize and identify the blood supply of the brain, the ventricular system and meninges
- Understand the basic immunohistochemical methodology that permits the localization of neurons on the basis of their neurotransmitter expression
- Understand the basic concept of in situ hybridization for the study of gene expression in chemically identified neurons that permits the molecular investigation of the nervous system in health and disease.

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Describe and identify the components of the nervous system and the sensory organs.
2. Identify the structures of the brain, spinal cord and peripheral nervous system.
3. Describe the relationship of the structure of the nervous system to its functions: movement, sensory systems- basic functions of a living organism.
4. Describe and identify the structure and functions of the autonomic nervous system and the cranial nerves.
5. Relate the chemical and molecular anatomy of the nervous system to clinical syndromes and diseases.

Titles of lectures and names of the lecturers

A/A	Gross and Microscopic Anatomy of the Nervous System	Lecturer
1	Introduction to Neuroanatomy: Overview of the human brain	G. C. Papadopoulos
2	Topographic anatomy of the cerebral cortex-functional mapping	D.Mytilineos
3	Functional Neuroanatomy of Cognition	N. Foroglou
4	Structures and Mechanisms of Language	C. Potagas
5	Hypothalamus and the pituitary gland	M. Panayotacopoulou
6	Structure and function of the limbic system	K.Tsamis
7	Brain Stem and Cerebellum	D. Mytilinaios

8	Thalamus: connections and role in sleep and consciousness	P.Bargiotas
9	Basal Ganglia	M. Xilouri
10	Spinal Cord and pathways (+ autonomic NS)	A.Tsingotjidou
11	Peripheral nervous system	I.Grivas
12	Motor and sensory pathways	A. Chatzisotiriou
13	Chemical and Molecular Neuroanatomy/ Electron Microscopy	M.Panayotacopoulou, M. Chrysanthou
14	Vision and Visual Cortex (+ plasticity)	E. Skaliora
15	Microscopic Anatomy of the Human brain	M. Panayotacopoulou, M.Chrysanthou
16	Gross and Microscopic Anatomy of the rodent brain	A. Polysidi/ M.Xilouri
17	Comparative Neuroanatomy (pig, sheep, rodents)	A.Tsingotjidou/C. Bekiari

CELLULAR AND MOLECULAR NEUROSCIENCE

Coordinators

Dimitra Mangoura, Professor-Investigator A, Biomedical Research Foundation of the Academy of Athens
Zafiroula–Iro Georgoussi, Research Director, National Center for Scientific Research "Demokritos", Athens

Teaching hours and weekly schedule

This a 1st semester course of about 3 weeks that corresponds to 5,5 ECTs and 50 total hours of lectures including student presentations.

Description

This course is designed to introduce graduate students to major processes, principles, and mechanisms associated with Cellular and Molecular Neurobiology. Therefore the material will range from the mechanistic details of neuronal signaling and cellular function to how such properties utilized during normal brain function and neuropathology or substance abuse. The Course involves a series of overview lectures by leading researchers in the field, a total of fifteen Instructors from Greece and across Europe, and opportunities of presenting primary research or literature review papers by students.

More specifically, this Course will include the following major topics: overview of the neuron as the fundamental unit; cell biology of neurons and glia; ion channels and electrical signaling;

synaptic transmission, integration, and chemical systems of the brain; molecular properties of neurotransmitters and their receptors; and sensory systems, from transduction to perception. Students will emerge with a great awareness of how individual nerve cells function, and neurons communicate with other cells, and of the ways that neurotransmission can provide insight into basic scientific questions, all in preparation for students own contributions as neuroscientists and biologists.

Course Overview

This is a comprehensive introductory course in Molecular and Cellular Neuroscience. Basic principles of organization and function of the nervous system will be discussed and frequent reference will be made to pathophysiology of neurological and other disorders.

- General principles of Nervous System
- Synaptic Transmission, Neurotransmitters and their Receptors
- Molecular Aspects of Neuronal Cells

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to know the fundamental principles on:

1. Neural cell biology
2. Synapse formation and neural plasticity
3. Intracellular trafficking and cytoskeleton-related processes
4. Interconnections to form nerve circuits for the passage of electric signals
5. Small molecules coupling to their cognate membrane receptors to regulate intracellular responses and biological outcomes
6. Major intracellular signalling pathways
7. Molecular biology of the sensory systems
8. Energy brain metabolism

Titles of lectures and names of the lecturers

A/A	Cellular and Molecular Neurobiology	Lecturer
1	Overview of the Nervous System	Mimika Mangoura
2	Cell Membrane Structures and Functions	Mimika Mangoura
3	The cytoskeleton of neural cells	Mimika Mangoura
4	Intracellular Trafficking	Mimika Mangoura
5	Axonal transport	Mimika Mangoura
6	Protein synthesis and posttranslational modifications	Mimika Mangoura

7	Passive/active properties (Action potential, cable theory)	Christos Consoulas
8	Synapses (NMJ, central), signal integration	Christos Consoulas
9	Basis of excitability, resting potential	Irene Skaliora
10	Cellular Plasticity, LTP/LTD	Irene Skaliora
	Synaptic Transmission and Signalling	
11	Neurotransmitters, Receptors, G proteins	Iro Georgoussi
12	Effectors, signaling intermediates, drug design	Iro Georgoussi
12	Neurobiology of addiction	Katia Befort, France
12	Neurotransmitters II: Gas neurotransmitters	Spiros Efthimiopoulos
13	Neurotransmitters I: Cannabinoid receptors	Ismael Galve-Roperh, Spain
13	Brain energy	Juan Pedro Bolaños, Spain
14	Phosphoinositides	George Leondaritis
14	Neurotransmitters III: GABA	Haralambos Lambrakakis
15	Neurotransmitters V: Peptide neurotransmitters	Iro Georgoussi
16	Neurotransmitters IV: Acetylcholine	Paraskevi Zisimopoulou
17	Neurotransmitters V: Glutamate	Costas Vekrellis
17	Neurotransmitters VI: Catecholamines	Costas Vekrellis
18	Glycobiology of the nervous system	Alex Prinetti, U Milano
19	Ca2+ signaling and Homeostasis	Panagiota Papazafiri

TECHNICAL COURSES

It is subdivided into the following parts:

A) **Technical courses I: Methodological approaches in Neuroscience, Statistics (SPSS, R programming, graphpad)**
B) **Technical courses II: Molecular Biology-Omics**
C) **Technical Courses III: Methodological approaches in Neuroscience , Microscopy-neuroimaging**
D) **Technical courses VI: Methodological approaches in Neuroscience , Experimental animal models in Neuroscience**
E) **Technical courses V: Methodological approaches in Neuroscience, Elements of Bioinformatics (big data bases)**

Teaching hours and weekly schedule

This is a 1st semester course of about 3 weeks that corresponds to 5 ECTs and 44 total hours of lectures.

A) Technical courses I: Methodological approaches in Neuroscience, Statistics (SPSS, R programming, graphpad)

Coordinators

Eleni Konsolaki, PhD Psychologist in the Psychiatric Clinic at Sotiria General Hospital

Description

This course is intended to cover the basic statistical principles usually applied in the biological sciences. The goal of the course is to provide the students with the ability to choose and apply the appropriate statistics for their studies.

Course Overview

The course will begin with an analysis of the hypothesis test, a statistical test used to compare two data sets for the purpose of rejecting a null hypothesis and not to indicate the more likely of two hypotheses. The students will also be introduced in the process of randomization, of making something random, for example on how to select a random sample of a population. In addition, the course will provide detailed information on some of the most commonly used distributions and an analysis of the central limit theorem which establishes that the sum of independent random variables tends toward a normal distribution although the original variables may not. Time will be allocated in the presentation of parametric and nonparametric tests and their comparison in order for the students to understand the prerequisites for applying one or the other. Special attention will be given to the multiple comparison problems and means to overcome it. The problem arises from the fact that when you are performing multiple statistical tests a fraction of them is false positives. The application of Linear, Logistic and Cox models will be also presented.

B) Technical courses II: Molecular Biology-Omics

Coordinators

George Panayotou, Researcher A'. BSRC Alexander Fleming

Description

These series of lectures will provide

A) an overview of Next Generation Sequencing (NGS) and the most relevant biomedical NGS applications: Targeted sequencing, Whole-exome sequencing, Whole-genome sequencing, RNA-seq (mRNA-seq, smallRNA-seq, etc., approaches to study RNA structure and RNA-protein interactions), approaches to interrogate the composition and structure of chromatin (ChIP-seq, ATAC-seq, chromosome conformation capture techniques, etc.).

B) an introduction to proteomic methodologies and their application to the study of human diseases.

C) an introduction of the significance but also the challenges of applying metabolomic analysis in neurophysiology research. The students will be presented with the major changes in the way problems in life sciences are now approached in the context of the systems biology and the omic analyses revolution, focusing on brain research and the field of systems neurophysiology. The muti-step metabolomic analysis will be described and its contribution to the reconstruction of an accurate metabolic physiology map for the brain will be discussed. Experimental and computational protocol standardization challenges that need to be addressed for its vast deployment in neurophysiology research and practice will be described. An example of brain metabolomic analysis in a mouse model will be presented.

D) Examples of genetic and biochemical approaches to develop agents interfering with protein aggregation. Many neurodegenerative diseases are associated with protein misfolding and protein self-assembly, which lead to the formation of protein oligomers and/or higher-order aggregates with neurotoxic properties. Thus, understanding these pathogenic processes is of fundamental importance for neurobiology. Furthermore, chemical and biological agents interfering with protein aggregation are much sought-after factors in the quest for effective drugs against these conditions.

Course Overview

The course will cover basic principles of NGS technologies, description of the omic analysis revolution and the consequent fundamental changes in the way problems in life sciences are now approached, mass spectrometry and applications involving differential proteomics, identification of post-translational modifications and analysis of protein complexes as well as of metabolomics. Description of the multi-step experimental and computational analysis process that needs to be carefully designed and standardized for its accurate and vast application in neurophysiology research.

Furthermore, biochemical, biophysical and biological assays, which can be utilized for high-throughput screenings of chemical and biological libraries so as to discover modulators of protein aggregation will be described. Furthermore, the design, development and outcomes of recently developed biotechnological platforms for producing chemical libraries with greatly expanded diversities and for identifying chemical rescuers of pathogenic protein misfolding and aggregation in an ultrahigh-throughput fashion will also be covered.

Skills & Learning Outcomes

The objective will be to familiarize students with

1. the principles underlying NGS and the main biomedical applications in which NGS is employed
2. the experimental design of proteomic experiments and current challenges in their application to the study of human diseases

3. the holistic perspective of biological system analysis gained from systems and network biology research and shown the complementary role of the various omic analyses in deciphering the complexity of brain function
4. metabolomic analysis and it's various experimental and computational components
5. network reconstruction and how this could contribute to the elucidation of brain metabolic physiology and the reconstruction of the entire brain connectome
6. the experimental and computational challenges that need to be considered for accurate application of metabolomics in brain research
7. state-of-the-art high-throughput approaches for monitoring neurodegeneration-associated protein aggregation and for identifying chemical and biological inhibitors of these processes
8. recently developed biotechnological approaches for the discovery of chemical rescuers of protein misfolding and aggregation with potentially therapeutic effects against major neurodegenerative diseases

C) Technical Courses III: Methodological approaches in Neuroscience, Microscopy-neuroimaging

Coordinators

Dimitra Thomaidou, Senior Investigator, Department of Neurobiology, Hellenic Pasteur Institute
Stamatis Pagakis, Senior Research Scientist, Basic Research Center, Foundation for Biomedical Research of the Academy of Athens
Nikolaos Smyrnis, Associate Professor, Psychiatry Department, Medical School, National and Kapodistrian University of Athens

Description

This is an intensive three-week course centered around the study of neuroimaging technologies, that includes lectures, laboratory/hands-on sessions and participation in the acquisition and analysis of neurophysiological/neuroimaging data. All material will focus primarily on learning the different imaging systems and technologies used to study the nervous system, from conventional microscopy to advanced in vivo imaging both in laboratory animals and humans. Attention will be given on learning current digital image processing tools used to analyze/ quantify imaging data. The goal of this intensive course is to provide students with knowledge of novel, state-of-the-art imaging approaches currently used to study nervous system function. Hands on laboratory sessions will allow students to learn through direct experience.

Course Overview

Teaching and some hands-on training of a wide range of imaging tools and technologies currently used to study nervous system morphology, function and dysfunction, both in laboratory animals and humans. The course covers general principles of microscopy (both optical and electron), nuclear and MR imaging, image processing and analysis, as well as advanced neurophysiological and functional neuroimaging approaches linking microscopic analysis with behavior. More specifically, the topics covered include:

- Introduction to human brain function imaging techniques
- Anatomical Neuroimaging
- Live cell dynamics imaging
- FLIM-FRET
- FRAP, in vivo FRAP
- Mechanosensors
- Multiphoton confocal microscopy
- Intravital imaging
- Calcium imaging at whole animal level
- Optogenetics
- Neurophysiology: EEG/MEG
- PET/SPECT Imaging
- fMRI Imaging
- Electron microscopy
- Image Processing (ImageJ, Imaris, Icy)
- Image Data analysis (MATLAB)
- Functional Imaging data preprocessing and analysis (SPM)
- Neurophysiological (EEG/MEG) data preprocessing and analysis (EEGLAB)

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Know the basic principles of microscopy and the imaging systems used to study the nervous system.
2. Know the latest applications of imaging technology currently used to answer scientific questions related to nervous structure and function and dynamic cellular interactions.
3. Get in touch with software used for the processing of digital images/videos.
4. Get hands-on training on advanced microscopy and Image Analysis systems currently available in the labs of the participating course instructors.
5. Understand the design of experimental procedures used in neurophysiological (EEG/MEG) and functional neuroimaging fMRI) experiments to study human cognition

6. Introduction to the preprocessing and analysis software tools used to analyze neurophysiological and functional neuroimaging data used in the labs of participating instructors.

D) *Technical courses IV: Methodological approaches in Neuroscience, Experimental animal models in Neuroscience*

Coordinators

Efthimios M.C. Skoulakis, Researcher A', Neurobiology Division BSRC Alexander Fleming
Spiros Georgopoulos, Researcher B', Biomedical Research Foundation of the Academy of Athens

Description

This is an intensive lecture course focused on popular experimental models used on Neurobiological research. The course aims to explore the main attributes of various experimental systems that makes them suitable to or preferable to address particular types of questions and the depth and generality of answers thus obtained.

Course Overview

Interdisciplinary approach to functional neurobiology and its tools including transgenics, RNA interference, particular usefulness and contributions of selected model systems.
Each system will be examined/presented along the following axes:

1. Usefulness of the model/ contributions
2. Manipulations to make transfectants/transgenics
3. Models/ examples of Neurochemistry
4. Models/ examples of Cognitive and Neurodegenerative diseases.

Models will include

1. Neuronal cells in culture
2. Caenorhabditis elegans
3. Drosophila melanogaster
4. Mouse/Rat

Detailed syllabus

1. Cultured neuron models
Advantages, uses, transfections
Models and examples for Neurochemistry, cultured systems as discovery tools

2. C elegans:
Advantages for Neurobiological research, transgenics, RNAi
Signaling, aging, disease models

3. Drosophila
Advantages for Neurobiological research, transgenics, tools
Neurogenetics, sensory and cognitive models
Cognitive and neurodegenerative disease models, pharmacogenetics

4. Mouse
Advantages for Neurobiological research, transgenics
Cognitive models and methods, neuropharmacology
Neurodegenerative models and applications
Rat models, cognitive and neuropharmacology models

Technical courses V: Methodological approaches in Neuroscience, Elements of Bioinformatics (big data bases)

Coordinators

Aristotelis Chatziioannou, PhD, Principal Investigator, Metabolic Engineering & Bioinformatics Program, National Hellenic Research Foundation,
Eleftherios Pilalis, PhD,Chief Technical Officer, e-NIOS Applications PC

Description

This is an intensive two and a half week course focused on computational analysis and robust interpretation of molecular data streams, generated by a broad spectrum of high-throughput experimental technologies, termed as -omics. Overall these technologies revolutionize the landscape of modern biological research, enabling adoption of holistic approaches in the study and modification of biological mechanisms, yet their efficient integration in the discovery cycle entails great challenges, due to their immense complexity. The derivation of the instrumental molecular networks, behind disease emergence and progression, requests the intelligent utilization of powerful, computational strategies, in order to single out of the millions of biological measurements, those pivotal for the disease interrogated. Moreover, it is crucial to prioritize the important cellular events, in order to be able to propose a rational, combinatorial therapeutic approach, targeting these events, with novel combinations of compounds. In this direction, the various pillars of computational analysis that aid efficient and robust integration, analysis and interpretation of high-dimensional, omic data, potentially from multiple layers of dissection (cross-omics) will be examined, as well as the respective experimental technologies they support.

Course Overview

Ultimate goal of this intensive course is that students are gaining familiarization with this broad pool of experimental technologies, under the umbrella of -omics, together with the various sorts of bio-informatic analytical algorithms and workflows, deployed at different stages and for different data-types. In addition, emphasis will be given in the meaningful integration and robust functional interpretation, in terms of the active emergent molecular modules that shape the phenotypic landscape of the biological problem interrogated, as well as the reliable association of molecular with phenotypic markers. The course will review the application of these concepts in the field of epidemiological stratification, pharmacogenomics analysis and personalized medicine.

Topics to be discussed will cover

- Next generation sequencing technologies, providing an introduction coupled by an overview of the main Next Generation sequencing methodologies (Gen-Seq, Exome seq, RNA- Seq, ChIP-Seq, etc), from the point of view of the computational analysis (de-novo / Reference Genome-based Assembly, Filtering, Signal Estimation, Differential Expression, Statistical Selection, Variant Calling)
- Microarray technologies and their processing (background correction, signal estimation, normalization, filtering and statistical selection)
- Bioinformatic methodologies for multi-layered structural and functional characterization of nucleotide and aminoacid sequences (homology based screening, ORF and gene function prediction, taxonomic and phylogenetic analysis, protein domain analysis, machine learning for functional characterization of proteins, regulatory motif analysis, hot-spot prediction, metagenomic screening)
- Translational, integrative bioinfomatic analysis of omic datasets, which highlight the critical biological processes implicated in the biological problem interrogated (integrative methodologies, enrichment statistics, ontologies and controlled vocabularies, resampling based correction, gene set analysis, pathway prioritization, pharmacogenomic knowledgebases)
- Target prioritization and diagnostic stratification discussing the methodologies for the inference of small-sized, highly informative signatures for diagnostic classification, pharmacogenomic analysis, combinatorial treatment (semantic networks, interaction networks, network inference and analysis, derivation of molecular signatures, classification and clustering methodologies, machine learning techiques)

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to define, describe and discern critical functional features of:

1. the main Next Generation Sequencing Methodologies and their fundamental computational steps.
2. the current state-of-the-art microarray technologies, popular platform configurations for various omic experimental designs, and the requisite algorithmic processing steps.
3. the main structural bioinformatic algorithmic tools that are available for the analysis and functional characterization of nucleotide and aminoacid sequences.
4. various molecular enrichment, gene set and pathway analysis tools / platforms.

5. Network based methodologies for target prioritization, connectivity with drug-related databases, geometric estimation of complexity (Principal Component Analysis) supervised (machine learning, Linear discriminant analysis, PLS) and unsupervised (clustering) classification of phenotypic categories

Titles of lectures and names of the lecturers

A/A	TECHNICAL COURSES: Statistics, Molecular Biology, Neuro-Imaging, Bioinformatics	Lecturers
1	Descriptive statistics, Normal and other distributions. Hypothesis testing: main principles. Errors. Meaning of statistical significance. Multiple comparisons. Central Limit Theorem	**Eleni Konsolaki**
2	Basic concepts of Behavioral Neuroscience	**Irini Skaliora**
3	Assessment of cognitive and motor function in rodent models	**Alexia Polissidis**
4	Univariate parametric and non-parametric tests. Confounding variables: presence and control of confounding effects- randomization	**Eleni Konsolaki**
5	High throughput assays-amyloid disassembly or prevention of protein aggregation	**George Skretas**
6	Multiple linear regression, logistic regression and Cox proportional hazards models in relation to study design and the distribution of the dependent variable	**Eleni Konsolaki**
7	Next Generation Sequencing and its applications in Biomedicine. Genomics	**Pantelis Hatzis**
8	Proteomics	**George Panayotou**
9	Animal models of stress and anxiety	**Antonis Stamatakis**
10	Next Generation Sequencing and its applications in Biomedicine. Genomics	**Pantelis Hatzis**
11	Human Neuroimaging methods. EEG/MEG, PET/SPECT Imaging	**N. Smyrnis**
12	Next Generation Sequencing and its applications in Biomedicine. Genomics	**Pantelis Hatzis**
13	fMRI Imaging	**N. Smyrnis**
14	Protein and DNA Sequence Analysis	**I. Michalopoulos**
15	Light Fluorescence Microscopy: Basic theory and Modern Techniques. Advanced techniques , FLIM-FRET, FRAP	**S. Pagakis**

16	C-elegans as experimental models in neuroscience	**Popi Syntihaki**
17	The drosophila model for studying neurodevelopment, learning and memory. Drosophila Models for studying cognitive and neurodegenerative diseases	**M. Skoulakis**
18	IMAGING: In vivo optical animal imaging (fluorescence / luminescence). Advanced imaging techniques- Light Sheet microscopy (SPIM)	**V. Kostourou**
19	Introduction in experimental models in neuroscience. Rodents as experimental models in neuroscience	**Spiros Georgopoulos**
20	Image Analysis: Extracting quantitative information from fluorescence microscopy images. Software presentation: Neurolucida/ImageJ	**S. Pagakis**
21	IMAGING: Advanced imaging applications in the CNS of living animals: Multiphoton confocal microscopy, Calcium imaging at whole animal level, Optogenetics. Data analysis with Imaris and ICY	**D. Thomaidou**
22	Introduction to Bioinformatics, Biological Data Types, Biological Repositories, Querying Biological Databases, sequence analysis, sequence-structure-function, taxonomic/phylogenetic analysis	**K. Voutetakis**
23	Analysis of Biological signals (Microarrays/ Next Generation Seq technologies), types of biological signals and workflows, processing steps	**G. Kontogianni**
24	Signature mediated interpretation, stratification, machine learning, precision medicine	**E. Pilalis**

LAB ROTATION I

Coordinators

Leonidas Stefanis, Professor of Neurology and Neurobiology, Medical School of Athens, National & Kapodistrian University of Athens

Spiros Efthimiopoulos, Professor of Neurobiology, Department of Biology, Division of Animal & Human Physiology, National & Kapodistrian University of Athens

Duration and total hours of laboratory presence

This is an 8-week laboratory practice that corresponds to 12 ECTs and 320 total hours of laboratory presence. The students have the obligation to make 2 paper presentations or 1 paper presentation and 1 presentation on the scientific projects performed in the lab that accepted them.

The Laboratory Rotation I usually takes place between February-March of each academic year.

SECOND SEMESTER

NEUROBIOLOGICAL BASIS OF DISEASES OF THE NERVOUS SYSTEM

Coordinators

Leonidas Stefanis, Professor of Neurology and Neurobiology, Medical School of Athens, National & Kapodistrian University of Athens

Spiros Efthimiopoulos, Professor of Neurobiology, Department of Biology, Division of Animal & Human Physiology, National & Kapodistrian University of Athens

Teaching hours and weekly schedule

This is a 2nd semester elective course of about 3 weeks that corresponds to 6 ECTs and 53 total hours of teaching including student presentations.

Description

This is an intensive three and a half-week course focused on the Genetics, the general processes that operate in several different neurological disorders, the pathology of neurological disorders, their molecular basis, as well as experimental therapeutics. The goal of this intensive course is that students become well versed with the genetic and molecular basis of the disorders of the nervous system.

Course Overview

The course covers general principles that apply to several disorders of the nervous system as well as the description and the pathology and the molecular basis of individual diseases.
General principles include:

- Protein misfolding and aggregation
- protein degradation
- Inflammation
- Neurotoxic and neurotrophic pathways

Examples of the diseases of the nervous system that will be covered include:

- Alzheimer's disease
- Parkinson's disease
- Motor Neuron Disease
- Schizophrenia
- Depression
- Triple repeat disorders
- Epilepsy
- Addiction
- Nervous System Cancers
- Brain and Spinal Cord injury

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Understand the common mechanisms involved in various diseases of the nervous system
2. Understand the genetics of neurological diseases
3. Understand and describe the molecular pathways that operate in specific disorders of the nervous system

Titles of lectures and names of lecturers

A/A	Neurobiological Basis of Diseases of the Nervous System:	Lecturer
1	Neurodegenerative diseases as proteinopathies	Kostas Vekrellis
2	Molecular and Cellular Biology of Parkinsons's Disease and related synucleinopathies	Leonidas Stefanis
3	Molecular and Cellular Biology of Alzheimer's Disease	Spiros Efthimiopoulos
4	Neurodevelopmental and neuronal migration disorders of the human brain	Christina Kyrousi
5	Protein degradation in neurodegenerative diseases	Maria Xilouri
6	Mechanisms of Addiction	Styliani Vlachou, Alexia Polissidis
7	Brain and Spinal Cord injury	Florentia Papastefanaki
8	Motor Neuron Disease	Laskaro Zagoreou
9	Neuroprotection in neurodegenerative diseases	Dimitris Vassilatis
10	Molecular Basis of taupathies	Katerina Papanikolopoulou
11	Biomarkers of neurodegenerative diseases	Elisavet Kapaki
12	Cognitive functions and behavior in dementias	Sokratis Papageorgiou
13	Molecular Basis of taupathies	Efthimios Skoulakis
14	Life style and neurodegeneration	Nikos Scarmeas
15	Epilepsy	Anastasios Bonakis
16	Triple repeat disorders	George Koutsis
17	Molecular and genetic basis of schizophrenia	Alex Hatzimanolis
18	Cognitive deficits in schizophrenia and depression	Nikos Smyrnis
19	Biology of Depression	Christina Dalla, Nikolaos Kokras
20	Nervous System Cancers	Mimika Mangoura

NEUROPSYCHOPHARMACOLOGY

Coordinators

Christina Dalla, Assistant Professor of Psychopharmacology, Dept. of Pharmacology, Medical School, NKUA

Nikolaos Kokras, Psychiatrist/Psychopharmacologist, Dept. of Pharmacology, Medical School of Athens, National & Kapodistrian University of Athens

Teaching hours and weekly schedule

This is a 2nd semester elective course of about 3 weeks that corresponds to 6 ECTs and 53 total hours of teaching including student presentations.

Description

This is an intensive three-week course focused on neuropsychopharmacology that includes lectures from pharmacologists, clinicians, neuroscientists and other specialties. The course will also accommodate student's presentations on specific neuropsychopharmacological issues, as well as written-exercises on pharmacological experimental design.

The lectures will focus on basic principles of pharmacology (such as pharmacokinetics and pharmacodynamics), information on drug design and discovery, treatment of neuropsychiatric disorders, as well as drug-induced changes in functioning of the nervous system. Additionally, the lecturers will give an overview of the techniques and models used for the study of neuropharmacology, as well as the basics of CNS clinical research, including regulations and statistical principles.

The goal is that students will become accustomed with neuropsychiatric treatment, modelling and research. Ultimately, they will be able to pose relevant neuropsychopharmacological questions and contribute to the design of preclinical and clinical studies.

Course Overview

The course will include lectures on drug design/discovery, as well as principles of neuropsychopharmacology preclinical and clinical studies. Students will have the opportunity to present specific neuropsychopharmacological issues, as well as to perform written-exercises on pharmacological experimental design and analysis.

Most importantly, an interactive approach, with the use of poll-machines, will be used for the teaching of the neuropsychopharmacological basis, study and mechanism of action of:

- Antipsychotics
- Antidepressant drugs and mood stabilizers
- Antiepileptics
- Cognitive enhancers
- Drugs of abuse
- Antiparkinsonian drugs and drugs for the treatment of neurodegenerative diseases
- Neuroimaging ligands

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Understand basic pharmacological principles
2. Know about most classes of neuropsychopharmacology drugs
3. Know about adverse effects, drug interactions and genomics of CNS-acting drugs
4. Identify new targets for CNS treatments and pose relevant questions
5. Understand the methods used in preclinical and clinical neuropsychopharmacology
6. Contribute to the design of preclinical and clinical neuropsychopharmacology studies

Titles of lectures and names of lecturers

A/A	Neuropsychopharmacology	Lecturer
1	Introduction and assignments	Christina Dalla, Stella Vlachou
2	Drug design/discovery	Dimitrios Vassilatis
3	Pharmacokinetics/Pharmacodynamics	Nikos Kokras
4	Neuroimaging ligands	Ioannis Pirmettis
5	Treatment of Neurodegenerative disorders (PD) and new targets	Neny Pervanidou
6	Neurodevelopmental disorders (ADHD, autism etc) and treatment	Leonidas Stefanis
7	The use of novel analytical techniques in medical research and drug discovery	Antonis Tsarbopoulos
8	Pharmacokinetics/Pharmacodynamics	Nikos Kokras
9	Antiepileptics	Christina Dalla, Marinos Sotiropoulos
10	Treatment of Neurodegenerative disorders (MS) and new targets	Harris Alexopoulos
11	Neuropsycho-pharmacogenomics	Dimitris Dikaios
12	Treatment of Neurodegenerative disorders (AD) and new targets	Ioannis Sotiropoulos
13	Neurobiology of Addiction, Alcohol	Foteini Delli
14	CNS Stimulants, Cannabis	Katerina Antoniou and Alexia Polissidis
15	Addiction and Nicotine	Stella Vlachou
16	Opioids and Psychedelics	Alexia Polissidis
17	Antipsychotics and lithium	Nikos Kokras
18	Anxiolytics and Antidepressants	Nikos Kokras, Christina Dalla
19	Pharmacoepidemiology	Giota Touloumi
20	Basics in clinical research	Eirini Griva

BEHAVIOURAL NEUROSCIENCE IN ANIMALS

Coordinators

Efthimios Skoulakis, Researcher A, Biomedical Science Research Centre "Alexander Fleming"
Antonios Stamatakis, Associate Professor of Biology-Biology of Behaviour, Faculty of Nursing, National and Kapodistrian University of Athens

Teaching hours and weekly schedule

This is a 2nd semester elective course of about 3 weeks that corresponds to 6 ECTs and 53 total hours of lectures, including student presentations.

Description

This course will explore the general themes and important questions in the field of animal behavior including the underlying molecular and cellular mechanisms. Topics will include the underlying genetics of behavior, behavioral development, various forms of learning, decision making, social interaction, sexual and parental behavior. The goal of this course to familiarize students with animal models emulating emotional and cognitive functions of humans.

Course Overview

- Attention & Habituation
- Learning & Memory I: Aplysia-molecular concepts
- Learning & Memory II: Mammals – Hippocampus
- Learning & Memory III: LTP & place cells
- Learning & Memory IV: Adult neurogenesis
- Learning & Memory V: Drosophila
- Learning & Memory VI: Zebra fish
- Emotions and the limbic system
- Motivation and the reward system of the brain
- Prefrontal cortex: Decision making, working memory and monitoring of behavior
- Social Interaction & aggression I-Non mammalian species 12. Social Interaction & aggression II-Mammals
- Sexual behavior
- Maternal/Parental behavior
- Effects of early life experiences on emotion and cognition

Skills & Learning Outcomes

At the end of the course the students will be acquainted with the scientific research on animal behavior and will understand the complexity of the mechanisms controlling behavior.
Goals will be to:

1. Gain knowledge of common biological terms and principles used in the study of animal behaviour

2. Comprehend behavioral terms and principles and demonstrate this comprehension via interpretation of material in lecture
3. Apply studied behavioral terms and principles to new situations
4. Analyze behavioral principles based on the ability to distinguish between facts and inferences
5. Synthesize general principles from different sub-fields of behavior to solve problems using creative thinking
6. Evaluate behavioral principles in a study of the behavioral literature

Titles of lectures and names of the lecturers

A/A	Behavioral Neuroscience in Animals	Lecturer
1	Social Interaction & aggression I-Non mammalian species	Efthimios Skoulakis
2	Social Interaction & aggression II-Mammals	Antonis Stamatakis
3	Sexual behavior and Maternal/Parental behaviour	Antonis Stamatakis
4	Emotions and the limbic system	Irini Skaliora
5	Motivation and the reward system of the brain	Antonis Stamatakis
6	Prefrontal cortex: Decision making, working memory and monitoring of behaviour	Antonis Stamatakis
7	Attention & Habituation	Efthimios Skoulakis
8	Learning & Memory I: Aplysia-molecular concepts	Efthimios Skoulakis
9	Learning & Memory II: Drosophila-1	Efthimios Skoulakis
10	Learning & Memory III: Drosophila-2	Efthimios Skoulakis
11	Learning & Memory IV: Mammals –Hippocampus	Irini Skaliora

NEUROIMMUNOLOGY

Coordinators

Konstantinos Kilintireas, MD, Professor of Neurology, Medical School of Athens, national & Kapodistrian University of Athens

Lesley Probert, PhD, Research Director, Department of Immunology, Hellenic Pasteur Institute

Teaching hours and weekly schedule

This a 2nd semester, 2-week elective course that corresponds to 3 ECTs and 27 total hours of lectures including student presentations.

Description

This is an intensive three-week course focused on neuroimmunology that includes lectures and student presentations. All material will focus on learning the interactions between the immune and nervous systems and their relevance to the pathology of diseases, particularly those of the central nervous system (CNS). The course will teach basic principles of immune system function, and evidence for its involvement in nervous system function and dysfunction from the study of experimental disease models and clinical data from patients with autoimmune and neuroinflammatory diseases. The goal is that students become conversant with the extent of immune system involvement in nervous system under physiological and pathophysiological conditions. The course will be interactive, with students actively participating through their own research into, and presentations of, currently developing areas in this field.

Course Overview

The course will combine basic research and clinical experience in the field of neuroimmunology to study the involvement of the innate and adaptive immune systems in the CNS under physiological and pathophysiological conditions. The course covers the general principles of peripheral and CNS immune systems, neuroimmune interactions in health and disease, animal models for the study of autoimmune and neuroinflammatory diseases of the CNS, human neuroimmune diseases and clinical experience with current immunotherapeutics for their treatment.

- Basic principles of the immune system
- Cell migration into the CNS and antigen presentation
- CNS immune system and functions in physiology and disease
- Neurodegeneration and neurorepair
- Animal models- critical appraisal as models for human neuroinflammatory diseases
- Human neuroimmune diseases
- Immunotherapeutic approaches for neurodegenerative diseases

Skills & Learning Outcomes

Upon successful completion of this course, students will:

1. Understand the structure and functions of the peripheral immune system with relevance to neuroimmune interactions.
2. Understand the components and functions of the endogenous CNS immune system.
3. Be able to critically analyse results from experimental models and assess their relevance for human disease.
4. Be conversant with the extent of immune involvement in neurological disease.
5. Be able to appreciate the benefits and limits of current immunotherapeutics, and understand open needs for new therapies, for the treatment of human diseases.

Titles of lectures and the names of lecturers

A/A	Neuroimmunology	Lecturer
	Basic principles of the immune system	

1	Innate immune system with relevance to nervous systems: Neutrophils, NK cells, Macrophages, Relevance for diseases of PNS and CNS	Ourania Tsitsilonis
2	Adaptive immune system I: T cells, Antigen presentation, APC, dendritic cells, CNS Ags	Ourania Tsitsilonis
3	Adaptive immune system II: B cells, T cell-dependent/ T cell independent responses, B regs, Relevance for diseases of PNS and CNS	Harris Alexopoulos
	Neural immune cells	
4	Microglia	Vasiliki Kyrargyri
5	Structure and function of BBB, participation in CNS autoimmunity	Dimitris Kitsos
	Blood-brain barrier	
6	CNS-directed autoimmunity	Marina Boziki
7	Microbiome control of neuroinflammation	Marina Boziki
8	Medical Imaging of human CNS	Dimitris Kitsos
	Human neuroimmune diseases I	
9	Autoimmune encephalitis	Harry Alexopoulos
10	B cell-mediated diseases- T cell-dependent/ T cell-independent	Konstantinos Kilintireas
11	Neuroinflammation in neurodegerative disease	Spiros Georgopoulos
	Human neuroimmune diseases II	
12	Immuno-modulating drugs in CNS autoimmune neurological diseases	Elma Evangelopoulos
13	Immunosuppression in neurological diseases	Mary Anagnostouli
14	Inflammatory mechanisms in the CNS	Konstantinos Kambas
	Animal models- relevance for human immunopathology	
15	Models for multiple sclerosis: EAE- a model for the autoimmune components of MS	David Baker
16	MS models: Translational approach	David Baker
17	Live imaging T cell interactions with the BBB	Naoto Kawakami
	Immunotherapies	
18	Immunotherapy of MS I: T cells and standard concept of autoimmunity	David Baker
19	Immunotherapy of MS II: B cell targeting	David Baker

NEUROENDOCRINOLOGY

Coordinators

Fotini Stylianopoulou, Professor Emeritus of Biology, Faculty of Nursing, School of Health Sciences, National & Kapodistrian University of Athens
Efthymia Kitraki, Professor of Biology, School of Dentistry, National & Kapodistrian University of Athens

Teaching hours and weekly schedule

This is a 2nd semester elective course of about 3 weeks that corresponds to 3 ECTs and 27 total hours of lectures including student presentations.

Description

This is an intensive 2-week course focused on Neuroendocrinology that includes lectures and students' presentations. All material will focus primarily on the neuroendocrine axes that control reproduction, metabolism, stress and pain responses, water & electrolyte balance and sleep-awakening rhythms. The impact of genetic and epigenetic factors on axes' function and their interactions will be also addressed. The course aims to provide a comprehensive canvas on the mechanisms of hormonal control of the nervous system function in health and disease. Students' presentations on selected topics will enhance understanding through active learning.

Course Overview

The course covers the general principles of hormone actions in the central nervous system by providing the underlying mechanisms and the different levels of regulation. More specifically, lectures and students' presentations will enable to:

- Understand the central and peripheral centres participating in the neuroendocrine control
- Understand the positive and negative feedback loops participating in the neuroendocrine axes' regulation
- Understand the molecular mechanisms of neuroendocrine control
- Understand the interactions among different neuroendocrine axes
- Understand the role of genetic and epigenetic factors in the modification of neuroendocrine function
- Understand how deregulation of neuroendocrine function is linked to disease

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Describe the function of the major neuroendocrine axes in mammals
2. Describe the possible interactions among the different neuroendocrine axes
3. Describe the genetic and epigenetic impact on axes' function
4. Relate the neuroendocrine axes' dysfunction with health outcomes

Titles of lectures and names of the lecturers

A/A	Neuroendocrinology	Lecturer
1	Basic principles and overview of the course	Fotini Stylianopoulou
2	The hypothalamic-pituitary-adrenal axis and the regulation of the stress response	Efthymia Kitraki
3	The hypothalamic-pituitary-gonadal axis and reproduction regulation	George Mastorakos
4	Neuroendocrine control of growth	Melpomeni Peppa
5	Hormones in the sexual differentiation of the brain	Efthymia Kitraki
6	Circadian rhythms	Anastasia Repouskou
7	Neuroendocrine control of pain	Antonis Stamatakis
8	Neuroendocrine control of water and ion balance	Antonis Stamatakis
9	Neuroendocrine control of food intake	Constantinos Tsigos
10	Interactions of the neuroendocrine axes	Fotini Stylianopoulou
11	Epigenetics in neuroendocrine functions	Fotini Stylianopoulou

NEUROELECTROPHYSIOLOGY

Coordinators

Irene Skaliora, Professor of Neuroscience and Cognitive Science, Department of History and Philosophy of Science, National & Kapodistrian University of Athens and Biomedical Research Foundation of the Academy of Athens

Consoulas Christos, Associate Professor of Experimental Physiology, Laboratory of Physiology, Medical School of Athens, National & Kapodistrian University of Athens

Teaching hours and weekly schedule

This is a 2nd semester elective course of about 2,5 weeks that corresponds to 3 ECTs and 27 total hours of lectures including student presentations.

Description:

This two-week course will focus on cellular and molecular neuroscience. It will cover the mechanisms that operate to regulate neuronal excitability, dendritic and synaptic function; plasticity and neural circuits. This is an intensive course focused on cellular neurophysiology. The main aim of the course is to understand the principles of signal generation, modulation and transmission, both at the cell and circuit level.

Learning Resource

Kandel ER, Schwartz JH, Jessell, TM, et al. Principles of Neural Science 5th Edition (2012). McGraw-Hill NY. ISBN 0071390111

Course Overview

- Introduction lecture
- Ion channels
- Membrane potential, Nernst Equation, Goldman Equation
- Electrotonic potential
- Passive membrane properties
- Action potential
- Na+, K+, and Ca++ channels and currents
- Mechanisms of pre-synaptic release
- Synaptic transmission - ligand gated and G-protein synaptic transmission
- Neuromuscular Junction
- CNS synaptic transmission 1- excitation Glutamatergic
- CNS synaptic transmission 2- inhibition - GABAergic and Glycinergic
- CNS synaptic transmission 3- synaptic integration.
- Neural Circuits: methods of recording and analysis
- Modulation of Neural Circuits

Titles of lectures and names of the lecturers

A/A	Neuroelectrophysiology	Lecturer
1	Cellular excitability, capacitance, input resistance, resting and action potentials, cable theory, voltage clamp	Christos Consoulas
2	NMJ & Quantal Release	Christos Consoulas
3	Central Synapses: Excitatory and inhibitory, short and long term plasticity, paired pulse facilitation & depression, LTP/LTD	Irene Skaliora
4	Neurophysiology of brain networks: methods of recording and analysis	Irene Skaliora
5	Calcium channels in synapses	Carsten Duch
6	The complexity of epilepsy	Andrew Trevelyan
7	Epilepsy: the price we pay for cortical function	Andrew Trevelyan

COMPUTATIONAL NEUROSCIENCE

Coordinators

Efstratios K. Kosmidis, Assistant Professor of Neurophysiology, Laboratory of Physiology, Department of Medicine, Aristotle University of Thessaloniki

Vassilis Cutsuridis, Affiliated Researcher, FORTH, Senior Lecturer, School of Computer Science, University of Lincoln, UK

Teaching hours and weekly schedule

This is a 2nd semester elective course of about 2 weeks that corresponds to 3 ECTs and 31 total hours of lectures including student presentations.

Description

This course provides an introduction to basic computational methods for understanding what nervous systems do and for determining how they function. We will explore the computational principles governing neural function from the single neuron to the neural network level. Specific topics will cover synaptic plasticity, learning and memory in the brain. We will make use of C++/Matlab/NEURON demonstrations and exercises to gain a deeper understanding of concepts and methods introduced in the course. The course is aimed to students of all ages eager to learn how the brain processes information.

Course Overview

Computational neuroscience is the intersection of neurophysiology, neuroanatomy, mathematical modeling and computer science. Its primary target is to describe how the brain "computes" by simplifying neuronal biology to a set of equations. As most branches of Science, it contains elements of Philosophy and Art. Emphasis will be given on mathematical descriptions and computational techniques used to study and understand neurons and network of neurons. Weekly assignments will allow students to learn through direct experience. The course will provide a glimpse of this exciting field aiming to motivate the young mind by covering the following topics:

- Mathematical modeling in neurophysiology. An introduction.
- Classical, membrane potential theory
- Electrical analogue of the cell membrane – The Lapique model (Leaky Integrate and Fire)
- Action potential theory. The Hodgkin – Huxley model
- Cable theory, multi-compartmental single neuron model
- Models of synaptic transmission (AMPA, NMDA, GABAA, GABAB)
- Models of synaptic plasticity (LTP/LTD, STDP, Hebbian, Delta rule, backpropagation, etc)
- Models of neural networks (feedforward, feedback, competitive, etc)
- Computational tools (NEURON and MATLAB)

Skills & Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Understand and appreciate the integral role of computational techniques and concepts in neuroscience. Study and critique review papers relating the use of computational techniques to the broader development of theories and experimental methods in neuroscience.
2. Understand basic concepts for ion channel and single cell modeling, possibly including:

   a. I-V curves, the Hodgkin-Huxley model of action potential generation, and simple kinetic models of ion channels, integrate-and-fire approximation
   b. Mathematical representations of conductances, currents, and their relationship to dynamic changes in nerve cell behavior
3. Use these models and associated methods to predict qualitative functional outcomes or quantitative state changes when varying parameters or changing structural properties of the models.
4. Use one or more software tool that facilitates the calculation of such predictions.

Titles of lectures and names of the lecturers

A/A	Computational Neuroscience	Lecturer
1	Math foundations	Ioannis Dellis (Leeds)
2	Neural data analysis	Ioannis Dellis
3	Intro to neyrophys	Stratos Kosmidis (AUTH)
4	Conductance based neuron models	Stratos Kosmidis
5	Minimal neuron models	Stratos Kosmidis
6	Synaptic models	Vassilis Cutsuridis (UoL)
7	Network models	Vassilis Cutsuridis
8	Synaptic plasticity models	Vassilis Cutsuridis
9	Models of dendrites	Nassi Papoutsi/Spiros Chavlis (FORTH)

LABORATORY ROTATION II

Coordinators

Leonidas Stefanis, Professor of Neurology and Neurobiology, Medical School of Athens, National & Kapodistrian University of Athens
Spiros Efthimiopoulos, Professor of Neurobiology, Department of Biology, Division of Animal & Human Physiology, National & Kapodistrian University of Athens

Duration and total hours of laboratory presence

This is an 8-week laboratory practice that corresponds to 12 ECTs and 320 total hours of laboratory presence. The students have the obligation to prepare 2 paper presentations or 1 paper presentation and 1 presentation on the scientific projects performed in the lab that accepted them.

The Laboratory Rotation II usually takes place during June-July of each academic year.

RESEARCH THESIS PROJECT

Coordinators

Leonidas Stefanis, Professor of Neurology and Neurobiology, Medical School of Athens, National & Kapodistrian University of Athens

Spiros Efthimiopoulos, Professor of Neurobiology, Department of Biology, Division of Animal & Human Physiology, National & Kapodistrian University of Athens

Duration-ECTs and Sites

This research project corresponds to 60 ECTs. The duration of the Research Thesis Project is at least 11 months and maximum 18 months from its assignment to the student. Extension can only be given in exceptional cases after the student's request and the decision of the Special Interdepartmental Committee (SIC), with the consent of the supervisor.

The execution of the Thesis can be carried out either in domestic Universities and research centers or Universities and Research Institutes abroad, participating or cooperating with the programme. It can also be performed in non-partner Universities or research institutions both foreign and domestic after the decision of the SIC.