Y1

Research Master Neuroscience Programme

Course Outline

Course Code	RMNS-1.2
Course Name	Neural signalling and computational neuroscience
Teaching Methods	Lectures, workshops, self-study, group discussion
Aim of the Course	To prepare students to contribute to an actual debate about neuronal computations in both theoretical and experimental domains.
Learning Goals	This module aims to achieve the following learning goals: 1. **Understand** how diversity in expression patterns leads to morphological and functional neuronal diversity in health and disease. 2. **Explain** the structural basis of the main properties of ion channels. 3. **Apply** principles of ion flux in neurons to the generation of the resting membrane potential, synaptic potentials, action potentials. 4. **Evaluate** the scientific literature on an ion channel toxin and summarize it in an accessible manner. 5. **Create** a physical model of passive neuronal properties; **create** a simulation of action potential generation and of synaptic transmission. 6. **Make** an informed choice on the level of complexity required to model various stages of neural signalling. 7. **Describe** the following concepts in cellular and computational neuroscience: quantal analysis, cable theory, GHK and Hodgkin Huxley models, SNARE cycle, vesicle cycle, short-term plasticity, synaptopathies, Field theory, Balanced networks.
Target Group	MSc Neuroscience students
Organisation	Erasmus MC – Department of Neuroscience
Level Credits Study load	2 (Master) 6 ECs 168 hrs
Testing:	Written exam (Goal 1,2,3,6,7) Assignments (Goal 4) Workshop assignments (Goal 5)
Language	English
Number of Participants	1st year students MSc Neuroscience curriculum
Location	Erasmus MC – Education Center
Date	October
Registration	This course is part of the MSc Neuroscience curriculum. Separate registration is not necessary for admitted students.
Absent	If you are unable to attend class, you are kindly requested to report your absence in advance via masterneuroscience@erasmusmc.nl.
Responsibility	Erasmus MC – Department of Neuroscience

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Coordination	Prof Dr J.G.G. Borst and Dr D. Narain.
Contact	E. Buitenhuis-Linssen E-mail: masterneuroscience@erasmusmc.nl
Alumni	LinkedIn Group RM Neuroscience, Erasmus MC https://www.linkedin.com/groups/8133912

Information

Summary of the Course

In this course you will learn how neurons exchange information and how they integrate incoming signals from other neurons. Special emphasis will be put on biophysical models of these processes.

Teaching Methods

Lectures, workshops, self-study and group discussion.

Programme

Content

In this module you will learn how the activity of a neuron is shaped by the integration of information from other neurons. While this integration is itself a dynamical process, it is heavily influenced by the passive properties of neurons. You will learn how electrical signals propagate passively using Cable theory and by constructing a physical model of the neural axon, you will also learn how these signals depend on the electrical properties of the neuronal membrane. Further, you will study detailed models that will give insight into how electrical signals are integrated within neurons depending on the morphology of their dendritic tree.

After studying signalling within one neuron, you will learn how information can be transmitted from one neuron to the next. Ion channels form the basis of such neural communication. You will learn the structural and functional properties of these ion channels that enable the electrical signalling processes in our brain and how these channels can be selectively inactivated using toxins.

We will then proceed to studying the codes by which neurons communicate. Hodgkin and Huxley showed how the biophysical properties of certain ion channels are sufficient to explain the generation of an action potential and you will explore their model in detail to learn how diverse ion channels can create a rich palette of firing patterns. You will learn how to measure this firing code using intra- and extracellular methods and the significance of these diverse patterns in various in vivo contexts.

Then you will take a closer look at the mechanism of neuronal communication – transmission across the synapse. You will learn about chemical transmission across the synapse, including the role of calcium ions in triggering release, the vesicle cycle, the existence of different neurotransmitters and different types of short-term plasticity. A major goal here is to demonstrate how a complicated structure such as the synapse can be viewed as the logical result of placing relatively few constraints on neuronal communication, leading to significant evolutionary advantages.

After discussing signalling across the synapse, we discuss the postsynaptic effects of neurotransmitters on neurons. You will learn about the working mechanism of inhibitory and excitatory transmitters. Most brain diseases manifest themselves as disorders of the synapse, which will be exemplified by the pharmacological treatment of a few neurological and psychiatric disorders.

After studying communication between two neurons, we will move to small networks of neurons and how communication is regulated among these. You will learn what are the conditions under which neurons can stably encode and exchange information through feedforward and feedback loops. Finally, we will discuss modern approaches to understanding how neural activity in individual and populations of neurons encodes behaviour.

Duration of the Course

7 weeks

	Expected Resources for Students ▪ Purves (6th edition): selected chapters ▪ Handouts provided by coordinator
	Teachers Prof Dr J.G.G. Borst, Dr D. Narain & team.
	Graduate Attributes Upon completion of this course, if you have attended and actively participated in the classes, and when you passed the written exam with sufficient results, you are awarded 6 ECs.
Testing and Assessments	
	Testing 1) Written exam with essay questions. The exam will cover learning goals 1,2,3,4 and 7. 2) Wikipedia assignment will cover learning goal 4. 3) Successful workshop participation will cover learning goal 5.
	Testing Procedure The test will be assessed by a MSc faculty member. You will receive a grade on a scale from 1 (worst) to 10 (best). Grade appeal is subject to the rules laid out in the Teaching and Examinations Regulations of Erasmus MC. On every component of the assessment a 5,5 or higher must be scored!
Quality Management	
	Course evaluation and development The MSc programme co-ordinators are open for suggestions from course participants on possible improvements. Course adjustments can be made on the basis of your direct feedback. Additionally, at the end of the course, you will receive an invitation for an online survey on the contents and setup of the course. Course contents and setup are re-evaluated periodically, at least once a year, by the course directors and MSc programme chair members.