


Ministry of Education and Science of the Russian Federation
Federal State Autonomous Educational Institution of Higher Education
Lobachevsky State University of Nizhni Novgorod
National Research University

The school of "Neurobiotechnology"

APPROVED:

The head of the school of
"Neurobiotechnology"

 V.B. Kazantsev
«30» 10 2014 г.

Work program of the module

MATHEMATICAL MODELS OF NEURON-GLIAL SYSTEM
Name of the module

Area of Studies

01.04.03 "Radiophysics", 03.01.02 "Biophysics"

General profile of training with instruction in English

Core Module

PhD-student

Form of training
full-time

Nizhni Novgorod

2014

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1. Learning goals and objectives for the module

Learning goals and objectives for the module is to understand and apply the modern approaches to modeling the processes of generation and propagation of bioelectric signals in neurons and neural networks of the brain.

2. Place of the module in the structure of the general education program

Prerequisite knowledge for the learning of this subject: Differential Equations, Physics, - Mathematics, Molecular biology, Biophysics, The theory of oscillations and waves

3. The structure and content of the module

The overall workload of the module is 3 credits, 108 hours.

3.1. Structure of the module

Name of the module	Semester	Workload (hours)						Type of final certification
		Total	Total classroom	Including classroom			Self-organized work	
				Lectures	Lab./seminars	Practice		
MATHEMATICAL MODELS OF NEURON-GLIAL SYSTEM	1	108	72	36	36	0	36	Examination, Test

3.2. Contents of the module

3.2.1. Sections of the module and types of classes

№	Section (discipline) of the module	Semester	Types of classes, workload (hours)			Self-organized work
			Lectures	Lab./Seminars	Practice	
1.	MATHEMATICAL MODELS OF	1	36	36	0	36

	NEURON-GLIAL SYSTEM					
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3.2.2. The content of the sections (disciplines) of the module

1. INTRODUCTION (8 hours/8 hours)

Review of mathematical models of neural networks of the brain. Concepts of mathematical models

2. BIOPOTENTIALS (10 hours/10 hours)

Generation of biological potentials in neurons, model description

3. MODELS OF MEMBRANE EXCITABILITY (12 hours/12 hours)

Nonlinear effects models of membrane excitability

4. EXCITABLE SYSTEMS (6 hours/6 hours)

The response of excitable systems to an external data signal, integrative and resonance effects

4. Educational technologies

Lectures on discipline taught using multimedia equipment. Discussion on the results of independent work of students on practical training in the form of a seminar.

There is a wide use of active and interactive forms of acquisition of new knowledge, including the module-rating system, educational discussions, "Brain storming" in which the learning material is divided into logical parts (modules), after studying which provides for the certification exam

5. Methodological support for students' self-organized work. Evaluation tools for monitoring students' current progress and for interim assessment based on the learning of the module material

As a kind of independent work of the student selected out-of-class independent work in the form of the creative brief is writing an essay. The control procedure of doing the work is a regular test.

5.1. Topics for self-organized work

1. INTRODUCTION (10 hours)

2. BIOPOTENTIALS (9 hours)

3. MODELS OF MEMBRANE EXCITABILITY (9 hours)

4. EXCITABLE SYSTEMS (8 hours)

5.2. Test questions

1. Approaches to modeling the functional activity of the brain.
2. Models of cells and cellular interactions.
3. Classification neuron models.
4. Building models for description of specific phenomena, specific cell types and specific network architectures.
5. Types of models by the dynamic properties.
6. Basic definitions of the theory of dynamical systems: phase space, attractors, stability.
7. Ionic Currents and Conductances
8. Equivalent Circuit
9. Resting Potential and Input Resistance
10. Action Potential
11. Propagation of the Action Potentials
12. The dynamic properties of Hodgkin-Huxley model.
13. The dynamic properties of FitzHugh-Nagumo model.

5.3. Assessment criteria

"Excellent" – the student displays in-depth knowledge of the main material without any mistakes and errors, has acquired all the competences (parts of competences) relating to the given subject completely and at a high level, a stable system of competences has been formed;

"Good" - the student has the knowledge of the main material with some noticeable mistakes and has acquired in general the competences (parts of competences) relating to the given subject);

"Satisfactory" - the student has the knowledge of the minimum material required in the given subject, with a number of errors, can solve main problems, the competences (parts of competences) relating to the subject are at the minimum level required to achieve the main learning objectives;

"Unsatisfactory" - the knowledge of the material is insufficient, additional training is required, the competences (parts of competences) relating to the subject are at a level that is insufficient to achieve the main learning objectives;

"Poor" - lack of knowledge of the material, relevant competences have not been acquired.

The grades "excellent", "good", "satisfactory" are considered positive.

6. Methodological and information support for the module

6.1. Main literature:

1. — 1. J. Malmivuo, R. Plonsey. Bioelectromagnetism. // 1995 Oxford University press. 471 p.

6.2. Additional literature:

1. P. Dayan, L.F. Abbott. Theoretical neuroscience. // 2000, 432 p.

2. C. Gold, D.A. Henze, Ch. Koch. Using extracellular action potential recordings to constrain compartmental models. // *J. Computational neuroscience*. 2007, p.39
3. Ch. Kayser, M.A. Montemurro, N.K. Logothetis, St. Panzeri. Spike-Phase Coding Boosts and Stabilizes Information Carried by Spatial and Temporal Spike Patterns. // *Neuron*. 2009, p.597
4. M. Rossum. Neural Computation. // *Lecture Notes for the MSc/DTC module*. 2007, 113 p.
5. N. Wisniewski. Local Field Potential. A modeling Study. // *Research Notebook Koch Laboratory*. 2006, 103 p.
6. K.H. Pettersen, G.T. Einevoll. Amplitude variability and extracellular low-pass filtering of neuronal spikes. // *Biophysical journal*. 2008. Vol. 94, № 3. p. 784.
7. G.R. Holt. A Critical Reexamination of Some Assumptions and Implications of Cable Theory in Neurobiology. // *Thesis*. 1998, 132 p.
8. A.N. Pisarchik, R. Jaimes-Rea' tegui, R. Sevilla-Escoboza, J.H. Garcí'a-Lopez, V.B. Kazantsev. Optical Fiber Synaptic Sensor. // *Optics and Lasers in Engineering*. 2001. Vol. 49, p. 1.
9. A. Cingöz, D. C. Yost, T. K. Allison, A. Ruehl, M. E. Fermann, I. Hartl, J. Ye1. Broadband phase noise suppression in a Yb-fiber frequency comb. // *Optics Letters*. 2001. Vol. 36 № 5, p. 743.
10. A.N. Pisarchik, R. Jaimes-Reategui. Control of basins of attraction in a multistable fiber laser. // *Physics Letters A*. 2009. Vol. 374, p. 228
11. H. Q. Lam, R. Li, K. E. K. Lee, V. Wong, P. Shum. Mode locking of an erbium-doped fiber laser with intra-cavity polarization modulation. // *Optics Communications*. 2010. Vol. 284, p. 1026
12. J.M. Saucedo-Solorio, A.N. Pisarchik, A.V. Kir'yanov, V. Aboites. Generalized multistability in a fiber laser with modulated losses. // *Journal of the Optical Society of America B*. 2003. Vol. 20, №3, p. 490
13. G. Huerta-Cuellar, A. N. Pisarchik, A. V. Kir'yanov, Yu. O. Barmenkov, and J. del Valle Hernández. Prebifurcation noise amplification in a fiber laser. // *Physical Review*. 2009. Vol. 79, p.1
14. Arellano-Sotelo H. et al. The use of nonlinear dynamics of erbium-doped fiber laser at pump modulation for intra-cavity sensing // *Optics & Laser Technology*. Elsevier, 2011. Vol. 43, № 1. p. 132.
15. Huerta-Cuellar G., Pisarchik A., Barmenkov Y. Experimental characterization of hopping dynamics in a multistable fiber laser // *Physical Review E*. 2008. Vol. 78, № 3. p. 1.
16. Arthur J.V., Boahen K. Silicon neurons that inhibit to synchronize // 2006 IEEE International Symposium on Circuits and Systems. Ieee. p. 4.
17. S. Binczak, S.Jicquir, J.M. Bilbault, V.B. Kazantsev, V.I. Nekorkin. Experimental study of electrical MFHN neurons. // *Neural Networks*. 2006. Vol. 19. p. 684.
18. V.B. Kazantsev, V.I. Nekorkin, V.I. Makarenko, R Ilinas. Olivo-cerebellar cluster-based universal control system. // *PNAS*. 2003. Vol. 100 № 22, p.13064
19. A. Pimashkin, I. Kastalskiy, A. Simonov, E. Koryagina, I. Mukhina, V. Kazantsev.

Spiking signatures of spontaneous activity bursts in hippocampal cultures. // Frontiers in computational neuroscience. 2011. Vol. 5. p. 46.

7. Logistical support for the module

Lectures using multimedia technologies will be presented in classrooms 417 (UNN Building 1) and 3^d floor (UNN Building 7), equipped with an overhead projector and a screen.

Authors: Kazantsev V.B.



Head of the school of "Neurobiotechnology"



The program is approved by the methodological commission of the school of "Neurobiotechnology".

Minutes of the meeting No. 3 dated 30.10.2014

Chairman of the methodological commission of the school of "Neurobiotechnology"

