**LITHUANIAN UNIVERSITY OF HEALTH SCIENCES**

APPROVED
Kaunas University of Medicine
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1 May 2026

# INTERCELLULAR INTERACTIONS

DOCTORAL STUDIES PROGRAMME

Subject programme coordinator:

NI Molecular Neurobiology Laboratory, Senior Researcher, Prof. Dr. Ilona Sadauskienė _____
Name of department, position of supervisor, academic title, academic degree, first name, surname Signature

Departments participating in the subject programme:

1. NI Molecular Neurobiology Laboratory, Dr. Paulina Vaitkienė_____
   name of department, academic degree of head, first name, surname signature

2. NI Biochemistry Laboratory, Prof. Dr. Vilmantė Borutaitė _____
   name of department, academic title of head, academic degree, first name, surname signature

3. NI Neurophysiology Laboratory, Dr. Gytis Svirskis_____
   Name of department, academic degree of head, first name, surname Signature

Kaunas, 2026

**Subject programme data**

| | |
|---|---|
| Field of science | Natural sciences (N 000),<br>Medical and health sciences (M 000) |
| Field of science (code) | Biology – N 010, Biophysics – N 011,<br>Medicine – M 001 |
| Subject name | Intercellular interaction |
| Programme scope | 160 hours (6 ECTS) |
| Lectures | 60 hours |
| Seminars | 16 hours |
| Independent work | 84 hours |

**Subject programme development group**

| No. | Pedagogical title, first name, surname | Position | Tel (work) | Email |
|---|---|---|---|---|
| 1 | Prof. Dr. Algimantas Kriščiukaitis | Prof. | +37069804824 | algimantas.krisciukaitis@lsmu.lt |
| 2. | Dr. Gytis Svirskis | vr. m. d. | +37037302958 | gytis.svirskis@lsmu.lt |

**Subject programme description:**

Need for the subject programme. Normal functioning of the body requires precise interaction between individual components. In a multicellular organism, this is achieved through cell-to-cell communication and intercellular signalling systems. The disruption of these systems impairs normal body function and ultimately manifests itself in various biochemical, morphological and functional changes that can cause many diseases. Therefore, we believe that knowledge of the mechanisms of cell-cell interactions can be useful for doctoral students, both those studying the normal functioning of the body and those investigating the origins and mechanisms of various pathologies.

The study programme consists of three parts:

Part 1. Biological basis of cell interactions.
Part 2. Research methods.
Part 3. Mechanisms of signal transmission in nerve cells.

## Part I. **BIOLOGICAL BASICS OF CELL INTERACTIONS**

(Responsible: Prof. Dr. I. Sadauskienė)

Objectives: In a multicellular organism, cells must coordinate their behaviour depending on the intracellular and extracellular environment. To this end, evolutionary mechanisms have developed that enable cells to communicate with each other and coordinate their behaviour for the benefit of the organism as a whole. The importance of such "social control" is demonstrated by cancerous processes, in which cells divide when they should not and occupy space that they should not occupy. In most cases, this leads to the death of the multicellular organism.

Tasks: To understand the principles of cell activity in a multicellular organism and to elucidate the molecular mechanisms of cell communication.

Scope: 40 hours, including 16 hours of lectures, 4 hours of seminars and 20 hours of independent work.

THEORETICAL PART

| No. | Lecture title | Duration | Lecturer |
|---|---|---|---|
| 1. | General principles of cell signalling | 2 hours | I. Sadauskienė |
| 2. | Trimeric G proteins transmit signals from receptors to cells | 2 hours | I. Sadauskienė |
| 3. | Cyclic AMP-mediated effects | 2 hours | I. Sadauskienė |
| 4 | Inositol phospholipid signalling pathway | 2 hours | I. Sadauskienė |
| 5. | Signalling via receptors linked to enzymes | 2 hours | I. Sadauskienė |
| 6. | Ras proteins form the most important link in signalling cascades | 2 hours | I. Sadauskienė |
| 7. | Target cell adaptation | 2 hours | I. Sadauskienė |
| 8. | Intracellular signalling logic | 2 hours | I. Sadauskienė |

THEORETICAL-PRACTICAL PART

| No. | Seminar topic title | Duration | Lecturer |
|---|---|---|---|
| 1 | Differences and advantages of neural and endocrine signalling | 1 hour | I. Sadauskienė |
| 2. | $Ca^{2+}$ions as secondary intracellular messengers | 1 hour | I. Sadauskienė |
| 3 | Specifics of G-protein and Ras protein activation and function | 1 hour | I. Sadauskienė |
| 4 | Consequences of receptor tyrosine kinase gene mutations | 1 hour | I. Sadauskienė |

INDEPENDENT WORK

1. Extracellular and intracellular signalling molecules.
2. Types of surface receptor proteins.
3. Intracellular signalling cascades.
4. Structure and properties of G proteins.
5. Secondary messengers.
6. c-AMP and inositol triphosphate-mediated signalling pathways.
7. Structure and function of enzyme-linked receptors.
8. Ras protein-mediated signalling to the nucleus.
9. The relationship between signalling disorders and cancer processes.
10. Target cell adaptation mechanisms.
11. Adaptation of bacterial chemotaxis.
12. Functional similarities between intracellular signalling networks and neural networks.
13. Possibilities for the compensation of signalling networks.

## Part II. **RESEARCH METHODS**

(Responsible: Dr. J. Liobikas)

Objectives: Intercellular connections are responsible for the performance of many of the body's basic functions. Intercellular connections are realised by special proteins – connexins – located in the cell membrane and arranged in a hexagonal structure, forming channels through which relatively large molecules or ions (up to several hundred kD molecular weight) can travel between cells. Currently, 21 families of connexins are known. The diversity of the structure and properties of these proteins allows for the formation of intercellular connections with very different characteristics and ensures a wide variety of body functions. Intensive fundamental research into intercellular connections has been conducted over the last 20 years. The obtained results revealed the causes of many diseases and led to the development of highly effective treatment methods. Therefore, it is essential for doctoral students in the field of biomedical sciences to familiarise themselves with these research methods and the main results of the research.

Tasks: To familiarise doctoral students in the field of biomedical sciences with the structure and main characteristics of intercellular communication channels. To familiarise them with the main methods of intercellular communication research, to perform a practical evaluation of recorded signal samples and measurements of certain parameters.

Scope: 40 hours, including 16 hours of lectures, 6 hours of practical work and 18 hours of independent work.

THEORETICAL PART

| No. | Lecture title | Duration | **Lecturer** |
|---|---|---|---|
| 1. | Gap Junctions, overview | 4 hours | J. Liobikas |
| 2. | Methods for studying intercellular communication: | | |
| 2.1 | Electrical intercellular communication studies | 4 hours | J. Liobikas |
| 2.2 | Research on molecular diffusion (dye diffusion) | 4 hours | J. Liobikas |
| 2.3 | Study of intercellular contacts using an electron microscope | 4 hours | J. Liobikas |

THEORETICAL-PRACTICAL PART

| No. | Seminar topic title | Duration | Lecturer |
|---|---|---|---|
| 1 | Methods of intercellular communication research: | | |
| 1.1 | Electrical intercellular communication research | 2 hours | J. Liobikas |
| 1.2 | Research on molecular diffusion (dye diffusion) | 2 hours | J. Liobikas |
| 1.3 | Examination of intercellular contacts using an electron microscope | 2 hours | J. Liobikas |

INDEPENDENT WORK

1. Methods of studying intercellular communication:
1.1 Studies of electrical intercellular communication;
1.2 Molecular diffusion studies (dye diffusion);
1.3 Investigation of intercellular contacts using an electron microscope.
2. Special signal processing methods, popular programmes.

3. Immunohistochemical labelling and investigation of intercellular communication channels.
4. Possible intercellular communication disorders and diseases caused by them.

## Part III. **MECHANISMS OF SIGNAL TRANSMISSION IN NERVE CELLS**

(Responsible: Dr. G. Svirskis)

Objective: The brain as an organ is characterised by an exceptional diversity of cell types and functions. This diversity allows us to summarise the importance of molecular mechanisms in living organisms in terms of function and pathology.

Tasks. To familiarise doctoral students with the molecular mechanisms of nerve cell activity that allow specific changes in the electrical properties of nerve cells and enable nerve cells to perform the functions of information processing, transmission and storage. To show how disturbances in molecular mechanisms lead to functional disorders and diseases.

Scope: 80 hours, including 28 hours of lectures, 6 hours of seminars and 46 hours of independent study.

THEORETICAL PART

| No. | Lecture title | Duration | Lecturer |
|---|---|---|---|
| 1 | *Features of nerve cell function*. Structure of nerve cells. Types of signal transmission in the brain. Protein expression and transport. | 2 hours | G. Svirskis |
| 2 | *Electrical signal transmission in neurons.* Nernst potential. Maintenance of ion concentration gradients. Membrane currents. Ion channels. Conductance equation. Types of signals. Action potential in axons. Dendritic signal attenuation. | 2 hours | G. Svirskis |
| 3 | *Transmission of electrical signals in neurons.* Ion channels as membrane proteins. Research methods. Cloning. Channel structure. Relationship between structure and function. Ion selectivity. Channel activation and inactivation. | 2 hours | G. Svirskis |
| 4 | *Transmission of electrical signals in neurons.* Variety and properties of voltage-gated ion channels. Sodium channels. Calcium channels. Potassium channels. Spike generation. | 2 hours | G. Svirskis |
| 5 | *Transmission of electrical signals in neurons.* Different types of spiking in neurons. Phasic spiking in auditory neurons. Burst response in thalamic neurons. Burst response in Purkinje cells. Dendritic spiking in pyramidal cortex cells. Bistability in spinal motor neurons. | 2 hours | G. Svirskis |
| 6. | *Interneuronal signal transmission.* Synapses and chemical junctions. Molecular mechanisms of neurosecretion. | 2 hours | G. Svirskis |
| 7. | *Interneuronal signal transmission.* Neurotransmitters and neurohormones. Directly activated synaptic receptors. Diversity of glutamate, GABA, and acetylcholine receptors. | 2 hours. | G. Svirskis |
| 8. | *Interneuronal signal transmission.* Receptors and transduction mechanisms. Indirectly acting receptors. G proteins. Phosphorylation. Secondary messengers: calcium, cAMP, cGMP. | 2 hours | G. Svirskis |

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|---|---|---|---|
| 9 | *Interneuronal signal transmission.* Receptors and transduction mechanisms. Secondary messengers: IP3, NO, CO. Examples of modulation of neuron properties. Motoneuron, cortical pyramidal neuron. | 2 hours | G. Svirskis |
| 10 | *Interneuronal signal transmission.* Sensory signal transduction. Mechanoreceptors, photoreceptors, chemoreceptors. | 2 hours | G. Svirskis |
| 11 | *Interneuronal signal transmission.* Molecular mechanisms of brain dysfunction. Epilepsy, Parkinson's disease, schizophrenia. | 2 hours | G. Svirskis |
| 12 | *Interneuronal signal transmission.* Molecular mechanisms of brain dysfunction. Alzheimer's disease, depression, drug addiction. | 2 hours | G. Svirskis |
| 13 | *Neuron development and plasticity.* Neuron growth. Trophic factors. Axon pathway formation. Synapse formation. Membrane adhesion molecules. | 2 hours | G. Svirskis |
| 14 | *Neuron development and plasticity.* Plasticity of chemical synapses. Memory. Mechanisms of synaptic facilitation and depression. | 2 hours | G. Svirskis |

THEORETICAL-PRACTICAL PART

| No. | Seminar topic title | Duration | Lecturer |
|---|---|---|---|
| 1 | General structural properties of voltage-sensitive membrane channels | 1 hour | G. Svirskis |
| 2 | The influence of ionic currents on the firing properties of pyramidal neurons | 1 hour | G. Svirskis |
| 3 | Modulation mechanisms of motor neurons in the spinal cord | 1 hour | G. Svirskis |
| 4 | Molecular mechanisms of Alzheimer's disease | 1 hour | G. Svirskis |
| 5. | Molecular mechanisms of depression | 1 hour | G. Svirskis |
| 6. | Molecular mechanisms of drug addiction | 1 hour | G. Svirskis |

INDEPENDENT WORK

1. Protein expression and transport.
2. Action potential in the axon. Dendritic potential extinction.
3. Relationship between channel structure and function. Channel activation and inactivation.
4. Gap junctions and chemical junctions.
5. Properties and diversity of glutamate, GABA, and acetylcholine receptors.
6. Secondary messengers: NO, CO, calcium, cAMP, cGMP, IP3.
7. Mechanoreceptors, photoreceptors, chemoreceptors.
8. Memory. Mechanisms of long-term facilitation and depression of synaptic connections.

Appendix No. 1

**Recommended reading**

| No. | Title | Author | Year of publication and publisher |
|---|---|---|---|
| 1 | Molecular Biology of the Cell | B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter | Garland Publishing, Inc. 2014 |
| 2. | Cell Biology | T.D. Pollard, W.C. Earnshaw | Saunders, 2002 |
| 3. | Life. The Science of Biology | W.K.Purves, G.H.Orians, H.C.Heller, D.Sadava | W. H. Freeman, 2012 |
| 4. | Single-channel recording | Ed. B. Sakmann and E. Neher | Plenum Press, New York and London, 2009. |
| 5. | Patch-clamp applications and protocols | Ed. A. A. Boulton, G. B. Baker W. Walz. | Humana Press, Neuromethods Ser, v.26. 1995 |
| 6. | Ionic Channels of Excitable Membranes | B.Hille | Sinauer Ass; 2001. |
| 7. | Handbook of Medical Informatics | J.H.van Bemmel (ed) M.A. Musen | Springer-Verlag, 2002. |
| 8. | Fundamental neuroscience | L. Squire, D. Berg | Academic Press. 2012 |
| 9. | Basic Neurochemistry | S.T. Brady, G.J. Siegel | Academic Press. 2012 |
| 10 | Human Physiology | Compiled by E. Kevelaitis, M. Illert, H. Hultborn | Kaunas University of Medicine Press 2006 |

Appendix No. 2

List of prospective lecturers:

1. Professors or senior researchers who will teach the subject programme:
    1. Prof. Dr. Ilona Sadauskienė
2. Associate professors or senior researchers who will teach the subject programme:
    1. Dr. Gytis Svirskis
    2. Dr Julius Liobikas