COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8001	6	VMU	FNS	Biochemistry

Course title in Lithuanian

Biochemija

Course title in English

Biochemistry

Study methods	Volume in ECTS credits
Lectures	
Consultations	
Seminars	
Individual work	

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų dviejų kursų doktorantams, siekiantiems gilinti bendrosios biochemijos žinias, būtinas biomedicinos ir biotechnologijos studijoms. Dalyko turinys skirtas perteikti žinias apie gyvų sistemų funkcionavimo dėsningumus, fermentų veikimo mechanizmą ir kinetiką, biologinių membranų sandus ir jų funkcijas, pagrindinius medžiagų apykaitos kelius ir jų erdvėskyrą ląstelėje, gyvų sistemų funkcionavimo dėsningumus. Derinant teorines ir praktines žinias diegti problemų sprendimo įgūdžius

Short course annotation in English (up to 500 characters)

The aim of course is to deepen 1st or 2nd year doctoral student's knowledge in biochemistry which are necessary for biomedical and biotechnology studies. The course provides knowledge about functioning patterns of living systems, enzyme kinetics and mechanism of their action , components of biological membranes and their functions, the main metabolic pathways and their copartmentation in cell. The combination of theoretical and practical knowledge inculcate a problem-solving skills.

Relevance of the course

Doctoral students in Biochemistry program must have a thorough understanding of metabolic processes in the cell, to know their mechanisms and to understand their regulation. This course is relevant, because VMU doctoral studies in Biochemistry are popular not only among masters in biochemistry and molecular biology, but as well as among masters in biotechnology and environmental science. These students have studied biochemistry only one semester and have no deep knowledge in biochemistry to be able easily interpret the results of research work, rationally choose the most appropriate methods for experimental work. Furthermore this program is focused on the biochemical processes in plants, and designed to deepen one's understanding of the biochemical transformation not only in prokaryotic or animal cells but also of biochemical reactions (their mechanisms and regulation) taking place in plants. This course could help to doctoral students to fill knowledge gaps in biochemistry and plant biochemistry.

Course aims

The aim of the course is to deepen understanding of the biochemical processes and their regulation in the cells, gain knowledge of specific biochemical processes in plants.

Content (topics) and methods

I. **Introduction.** Biochemistry it the study ofnlife on molecular level. Composition and functioning principles of the living systems. Historical perspectives of Biochemistry.
II. **Molecular components of cells.** Biologically important properties of water. The main classes of biomolecules , their structure and biological role .
III. **Proteins.** Amino acids. Their classification and physical and chemical properties. Nonstandart amino acids. Oligopeptides. Proteins: biological functions, covalent structure, secondary, tertiary and quaternary structure. Molecular chaperones. Fibrous proteins, structure and role in organisms. Protein complexes.
IV. **Enzymes.** Enzyme nomenclature and classification. Role of enzymes. The kinetics of enzyme Catalysis. Enzyme inhibition. Coenzymes. Mechanism of enzyme action. The regulation of enzyme activity. Enzymes in the cell.
V. **Nucleotides and nucleic acids.** DNA and RNA chemical structure, base composition and biological functions. Genetic information storage. Replication transcription and translation.

VI. **Carbohydrates.** Classification, nomenclature and their role in living organism**.** Monosaccharides, oligosaccharides and polysaccharides their structure and functions. Glycoproteins, glycolipids and proteoglycans.

VII. **Lipids.** Biological role of lipids. Lipids classification. Molecular structure and behavior of lipids. Fatty acids. Triacylglycerols (fats). The amount of unsaturated fatty acids in fats. Iodine value. Waxes. Phospholipids. Steroids (cholesterol, and plant sterols). Fat soluble plant pigments (chlorophyll, carotenoids**,** lutein). Structure and properties of biological membranes. Transport across membranes.

VIII. **Introduction to metabolism.** Nutrients - the organism's energy source. Phosphate compounds their role in metabolism. Thermodynamics of life.

IX. **Anaerobic and aerobic cleavage.** Glycolysis. Fermentation. Metabolism of glycogene and regulation. Pyruvatedehydrogenase complex. The tricarboxylic (TCA) acid cycle enzymes of TCA and location in cell. Regulation of TCA. Glyoxylate cycle in plants

X. **Energy transduction in biomembranes.** Oxidative phosphorylation. ATP synthesis. Control of ATP production. Inhibitors of oxidative phosphorylation system. Rotenone insensitive NAD(P)H oxidase and cyanide insensitive oxidase in plants.

XI. **Biosynthetic pathways.** The pentose phosphate pathway regulation and it importance in biosynthesis. Gluconeogenesis. Regulation of gluconeogenesis. Glycogen biosynthesis. Photosynthesis. Absorbtion of light. The light harvesting system. Cyclic and noncyclic electron transport pathways. The Calvin cycle. Photorespiration and C_4 cycle. Synthesis of sucrose and starch. Photosynthesis without chlorophyll. The role of rodopsin in vision process. The role of reactive oxygen species in cell metabolism.

XII. **Amino acid and protein metabolism.** Enzymatic hydrolysis of proteins. Proteases: Hydrolysis of Peptide Bonds: Specificity and Mechanism. Intracellular protein degradation - the lysosome and 26S proteasome system. Metabolic pathways of degradation and synthesis of amino acids. Central role of transamination. Oxidative deamination, role glutamate dehydrogenase. Other deamination mechanism. Excretion of ammonia. Urea cycle. The regulation of amino acids metabolism. Nitrogen fixation. The main plant nitrogen sources. Ammonia and its uptake. Nitrate and nitrite reduction in plants. Amino acids biosynthesis.

I. **Lipid metabolism.** Lipid digestion absorbtion and transport. Fatty acid oxidation. Oxidation of unsaturated and odd-chain fatty acids. Peroxisomal β-oxidation of fatty acids. Ketogenesis. Oxidation of ketone bodies. Fatty acids biosynthesis. Elongation of fatty acid chain. Fatty acid desaturation. Biosynthesis of triacylglycerols. Cholesterol metabolism. Cholesterol biosynthesis. Control of cholesterol biosynthesis and transport. Cholesterol utilization.

II. **Nucleotide metabolism.** Synthesis purine and pirimidine ribonucleotides. Formation of deoxyribonucleotides. Nucleotide degradation.

III. **The unity of the body's metabolism.** The relationship between carbohydrates, protein and fat metabolism. The role of hormones in the regulation of metabolism. Signal transduction pathways in the cell. The compartmentalization of biochemical processes in the cell .

Structure of cumulative score and value of its constituent parts

Final sore consists of:
referate (literature review on the selected topic) -75%; and exam – 25%; or
seminare presentation (oral and ppt presentation on the selected course topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1	Garrett R.H., Grisham C.M. Biochemistry. International Student Edition, Thomson Learning, 2005.
	Bob B. Buchanan, Wilhelm Gruissem, Russell L. Jones. Biochemistry and molecular biology of plants. American Society of plant biologists, 2009.
	Voet J.G., Voet C.W. Fundamentals of Biochemistry. Second edition, John Wiley & Sons, Ltd Printed in the USA, 2006

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication

1	Jurgis Kadziauskas. Biochemijos pagrindai. Vilniaus universiteto leidykla, 2012.
	Thomas M. Devlin Texbook of biochemistry with clinical corelations. John Wiley & Sons, 2010.

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Zita Naučienė	VDU	doc., dr.	z.nauciene@gmf.vdu.lt
2.	Vida Mildažienė	VMU	Prof. habil.dr.	v.mildaziene@bs.vdu.lt
3.	Rimantas Daugelavičius	VMU	Prof. habil.dr.	r.daugelavičius@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8002	6	VMU	FNS	**Biochemistry**

Course title in Lithuanian

Molekulinė ląstelės biologija

Course title in English

Molecular cell biology

Study methods	Volume in ECTS credits
Lectures	1,7
Consultations	
Seminars	0,55
Individual work	3,75

Short course annotation in Lithuanian (up to 500 characters)

Dalyko turinys skirtas perteikti naujausias žinias apie ląstelių evoliuciją, struktūrą, veikimo principus, ląstelės savitų vidinių sistemų integravimą, šiuos procesus susiejant ne tik su svarbiausiais molekulinio ir viršmolekulinio lygmens vyksmais, bet ir su organizmų normalaus funkcionavimo sąlygomis, patologinių būsenų geneze ir praktinio taikymo biotechnologijai ir biomedicinai galimybėmis. Siekiama derinti teorines ir praktines žinias bei diegti problemų sprendimo įgūdžius.

Short course annotation in English (up to 500 characters)

The topics of the course are selected to achieve the following objectives: to provide current knowledge on evolution, structure and function, specialization and integration of cellular systems uncovering mechanisms and processes that occur on molecular and supramolecular level and also to unravel the importance of cellular processes in ensuring the normal functioning of organisms, causing pathogenesis and providing basis for practical applications in biotechnology and biomedicine. The course is based on combination of theoretical and practical knowledge and the development of skills for problem solving.

Relevance of the course

Molecular Cell Biology is provides an essential basis for modern knowledge for the most subjects in biochemistry, biotechnology and biomedical. Modern biochemistry has become an integral part of systems biology, since the majority of biochemical and other molecular processes (metabolism, biocatalysis, operation of systems for transmission of hereditary information, signal reception and response systems) are disposed of in the vital activity of specific cellular context. Biochemical knowledge (molecular structural organization level) is given meaning by molecular cell biology on systems in specialized cells and tissues level, in turn, knowledge of the molecular and supramolecular cellular processes are necessary for understanding the higher hierarchical levels of biological systems (the body's organs and organisms), functioning patterns of prokaryotic and eukaryotic organisms. The cpourse provides for students the latest knowledge about the universal structure of living organisms – cell - its composition, internal structures and processes that comprise the vital activity of an integrated whole.

Course aims

The aim of course is to deepen 1st or 2nd year doctoral student's knowledge in Molecular Cell Biology that provides essential basis for biomedicine, biotechnology and biochemistry studies.

Content (topics) and methods

Theme I. *The cell theory. Basic cell properties, types, investigation methods. Evolution of prokaryotes and eukaryotes. Organelles of eukaryotic cell, their functions and biogenesis.* This topic locates the Molecular Cell Biology in the system of life sciences and composes of the introduction of the subject, specifying the key concepts, provides the updated information about research methods. Theme II. Biomolecules. Cytoplasm and cytosol. Structure and function of plasmic membrane. Transport of substances to the cell. Endocytosis. Exocytosis. The topic concerns the universal structures relevant for all cell types, their composition features and functions. Molecular mechanisms of membrane transport and vesicular transport as important determinants for the homeostasis of the internal cell environment and for the interaction with the external environment.
Theme III. *The machinery of protein synthesis and management of its function in cellular*

environment. Protein sorting and targeting. Molecular chaperones. This topic puts emphasis on one of the most important group of biomolecules – proteins, principles of their biogenesis, folding, distribution, quality control and importance of these processes for organelle biogenesis in eukaryotic cells.

Theme IV. *Cytoskeleton. Cell movement.* This topic provides an overview of cytoskeletal elements (microtubules, microfilaments and intermediate filaments), composition, structure, dynamics and interactions with other molecules and structures, multiple functions and possible consequences of their dysfunction. As one of the key functions of cytoskeleton the molecular mechanisms of various movement types is discussed including tubular transport and amoeboid cell movement, importance of universal axoneme structure for the movement of flagella and cilia.

Theme V. *Nucleus, its structure and interaction with other parts of the cell.* Principles of packing cellular genetic material, chromatin structure and dynamics, territories of chromosomes in nuclear matrix. Organization and structure of nuclear envelope, nuclear transport of biomolecules as mean for communication between nucleus and cytosol, its management and role in realization of cell genetic program.

Theme VI. *Endoplasmic reticulum and Golgi apparatus.* Two important parts of the endomembrane system of eukariotic cell are considered: the structure of endoplasmic reticulum and Golgi complex, functions of specific enzyme systems for continuous protein modification and sorting, other important functions, and biological importance of these organelles for normal cell functioning.

Theme VII. *Lysosomes. The ubiquitin/26S proteasome system. Autophagy.* Various intracellular digestion systems are compared: the structure and functions of lysosomes and the 26S proteasome are highlighted with specific emphasis on their biological importance. Overview of recent knowledge about the system of autophagy and its functions in management of cellular processes is presented.

Theme VIII. *Peroxisomes. Mitochondria, mitochondrial DNA structure and heredity.* The structure of peroxisomes and their function in animal and plant cells, peroxisome biogenesis and protein transfer is discussed. Mitochondrial structure, compartmentation of multiple functions and principles of biogenesis are considered along with genetic autonomy, peculiarities of mtDNA inheritance, basic features of mitochondrial protein transport systems.

IX theme. *Peculiarities of plant cells.* The distinctive features of plant cell are discussed in this theme: the plant wall structure and its function ensuring interactions with other cells and the environment, the role for plant nutrition and growth; structure and functions of vacuole, types, function and importance of plastids; systems of transport of proteins into chloroplasts.

X theme. *Intercellular communication. Extracellular matrix and cell adhesion.* Molecular structures ensuring intercellular contacts and interactions, their diversity. Extracellular matrix and organization of cells to tissues in animal and plant organisms.

XI theme. *The cell cycle.* This theme broadens the knowledge about the main mechanisms and stages of cell cycle, characterizes their morphological features, emphasizing the complexity of the control of cell cycle and key biological importance, cell cycle genes and disorders of cell cycle.

XII theme. *Apoptosis.* The theme presents the latest knowledge on the mechanism of programmed cell death, biological functions of apoptosis and its regulation, discusses the role of apoptosis in pathogenesis of various diseases.

XIII theme. *Signal transduction.* The theme concerns an important issues of multiple cellular interactions with the environment, the diversity of molecular systems of signal transduction and reception, the structure of complex networks determining response on intracellular level (protein kinase cascades, Ca^{2+}, cAMP, cGMP and other signal transmitter systems). The basics on transmission of neural impulse are also presented.

XIV theme. *Oxidative stress and aging.* The molecular systems generating reactive oxygen species and other similar molecules (nitrogen, sulfur, lipid radicals) are discussed as well as their biological functions. Oxidative stress, impact of ROS overproduction on cellular biomolecules, structures and processes as the main cause of aging, the most important systems of antioxidant defense in animal and plant cells are presented.

XV theme. *Stem cells. Malignant cell transformations.* The concepts of cell differentiation are presented in the light of recent advances on stem and tumour cell research. Biological importance of stem cells and their potential applications for the regenerative therapy are discussed. The modern knowledge on cell transformation diseases (cancer), the heterogeneity of their causes and structure,

along with problems on diagnostics and technologies for therapy.

Structure of cumulative score and value of its constituent parts

Final sore consists of:
referate (literature review on the selected topic) -75%; and exam – 25%; or
seminare presentation (oral and ppt presentation on the selected course topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1	V.Mildažienė, S. Rudaitienė, R. Daugelavičius. Ląstelės biologija, VDU leidykla, 2004.
2	G.Karp. Cell and Molecular Biology: Concepts and Experiments, Willey, 2013.
3	B. Alberts, D. Bray, K. Hopkin, A.D. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. Essential Cell Biology, Garland Science, 2013
4	D. P. Clark, N. J. Pazdernik Molecular Biology, Elsevier, 2012.
5	H. Lodish, A.Berk, C.A. Kaiser, M. Krieger, A. Bretscher, H. Ploegh, A. Amon, M.P. Scott. Molecular Cell Biology, 7th ed., Freeman, 2012.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1	M. Becker, J.B. Reece, M.F. Poenie. The world of the cell. The Benjamin/Cummings Publishing Company. 2008.
2	Recent reviews on the relevant topics published in scientific journals

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1	Vida Mildažienė	VMU	Prof. habil.dr.	v.mildaziene@bs.vdu.lt
2	Rimantas Daugelavičius	VMU	Prof. habil.dr.	r.daugelavičius@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8003	6	VDU	FNS	Biochemistry

Course title in Lithuanian

Bioenergetika ir membranų biologija

Course title in English

Bioenergetics and membrane biology

Study methods	Volume in ECTS credits
Lectures	1.7
Consultations	0.55
Seminars	
Individual work	3.75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų dviejų metų doktorantams, siekiantiems gilinti žinias biologinių membranų ir bioenergetikos srityse, kurios yra būtinos biomedicinos, biotechnologijų, molekulinės mikrobiologijos studijoms. Dalyko turinys orientuotas į ląstelės energijos apykaitos, kaupimo bei transformacijos, membranų ir bioenergetikos tyrimo metodų esminį supratimą. To siekiama derinant teorines ir praktines žinias bei diegiant problemų sprendimo įgūdžius. Perteikiamas termodinamikos principų veikimo biologinėse sistemose suvokimas, detaliai nagrinėjama biologinių membranų sudėtis ir savybės, jų įvairovė. Analizuojami ATP sintezės molekuliniai mechanizmai, metabolitų pernaša ir kaupimas, organizmų termoreguliacijos ir ląstelinių "motorų" darbo principai, membaninių kanalų veikimo mechanizmai.

Short course annotation in English (up to 500 characters)

The aim of course is to deepen 1st - 2nd year doctoral student's knowledge in biological membranes and bioenergetics, that is required for studies of biomedicine, biotechnologies, molecular microbiology. The topics of the course are selected to achieve the following objectives: to introduce and to explain the basic concepts in structure and functions of biological membranes as well as bioenergetics, to understand how principles of thermodynamics are applied for living systems, to gain insight about the main laws of cellular energy metabolism, storage and transformation. The molecular mechanisms of ATP synthesis, metabolite transport, thermoregulation, function of cellular motors and membrane channels are considered. The course is based on combination of theoretical and practical knowledge and the development of skills for problem solving.

Relevance of the course

The course provides understanding of the fundamental aspects of composition, structure and functioning of biological membranes and energy transformation in living organisms. It gives ability to state the laws of chemical thermodynamics, to describe the main terms, to understand energetical processes in living cells, biological role of membrane structures, and the associated energy transformation mechanisms. Also it helps to describe ways of energy transformation in animal and plant cells, archaea and bacteria, the membrane transport mechanisms, process of synthesis of ATP by chemiosmosis. This course gives ability to understand how artificial membranes are prepared, to describe the applications and limits of the membrane research methods. Knowledge and understanding of the possibilities to apply methods of studies of biological membranes and bioenergetics to solve fundamental problems in biomedicine and to use for the applied research in biotechnology are provided

Course aims

The aim of this course is to cover fundamenal aspects of the structure and function of biological membranes and energy transformation in living organisms at a molecular level with emphasis on modern methods of investigation.

Content (topics) and methods

Lectures:

1. Energy transduction and transformation in living systems
2. Thermodynamics of biological systems
3. Structure and composition of biological membranes
4. Mechanisms of transmembrane transport
5. Transport of macromolecules through biological membranes
6. Chemiosmotic processes in living systems
7. Biological electron transport chains
8. Energetical properties of plant cells. Photosynthesis
9. ATP-synthase
10. Energetics of extremophiles
11. Evolution of bioenergetics systems
12. Molecular motors
13. Methods for studies of biological membranes and bioenergetics
14. Thermoregulation of organisms
15. Proteomics of membranes. Membrane biogenesis. Oxidative damage of membranes.

Structure of cumulative score and value of its constituent parts

Final sore consists of:
Review of literature on selected topic -75% and exam - 25%; or
seminar presentation (oral and ppt presentation on selected topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	V.Mildažienė. Membranų ir bioenergetikos kurso paskaitų konspektai, 2007.
2.	R. Daugelavičius. Ląstelės molekulinė energetika (mokomoji knyga) Kaunas: Technologija, 2008, 152 p., iliustr.
3.	D.G.Nicholls, S.J. Ferguson. Bionergetics 4, Academic Press Inc, San Diego CA, 2013.
4.	The structure of biological membranes. Ed. P.L.Yeagle, CRC Press, 2005.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	Skulachev, V.P.. Membrane Bioenergetics. Springer Verlag, 1996.
2.	Garby, L., Larsen, P. S.. Bioenergetics. Cambridge University Press, 1995
3.	W.A. Cramer, D.B. Knaff. Energy transduction in biological membranes. Textbook of Bioenergetics. Springer-Verlag, 1991
4.	Haynie, D.T. Biological thermodynamics, Cambridge University Press, 2001
5.	http://www.samford.edu/schools/education/essm/PHED473/Bioenergetics/sld001.htm
6.	http://www.bmb.leeds.ac.uk/illingworth/oxphos/
7.	http://www.biophysics.org/btol/bioenerg.html
8.	http://members.tripod.com/mitoart/database/index/i-bioenr.htm

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Rimantas Daugelavičius	VDU	Prof. Dr.	r.daugelavicius@gmf.vdu.lt
2.	Vida Mildažienė	VDU	Dr.	v.mildaziene@bs.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8004	6	VMU	FNS	**Biochemistry**

Course title in Lithuanian

Biotechnologija ir genų inžinerija

Course title in English

Biotechnology and genetic engineering

Study methods	Volume in ECTS credits
Lectures	1,7
Consultations	
Seminars	0,55
Individual work	3,75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas perteikti doktorantams biotechnologijos mokslo principus, mikrobiologinių bei eukariotinių ląstelių ir audinių, rekombinantinės DNR bei genų inžinerijos taikymo žinias. Bus pristatyti medicininės, pramoninės, žemės ūkio ir aplinkosauginės biotechnologijos sričių pasiekimai. Bus aptarti biotechnologinių produktų saugumo ir etiniai klausimai svarbūs biotechnologijos tyrimams ir taikymui.

Short course annotation in English (up to 500 characters)

During the course, students will be introduced to principles of biotechnology, processes involving microbial, eukaryotic cells and tissue culture, use of recombinant DNA and genetic engineering. Developments in medical, industrial, agricultural and environmental biotechnological applications will be reviewed. Safety of biotechnological products and ethical issues important for biotechnology research and applications will be discussed.

Relevance of the course

Knowledge on principles of methods of tissue and cell culture, molecular biotechnology and genetic engineering are essential for many of modern biotechnological and biomedical research fields and biotechnology industry. Biotechnology is one of the fastest growing fields of research and industry. Processes and methods of traditional biotechnology provide means for biological synthesis of new materials. Methods of recombinant DNA and genetic engineering provide new perspectives for scientific research and for medical and industrial biotechnology. The course introduces to achievements of traditional biotechnology, as well as, provides knowledge about using modern molecular biology and genetic engineering techniques for problem solving in the field of molecular biotechnology. Ethical issues in biotechnology research and application and product commercialization are discussed.

Course aims

The aim of course is to introduce 1st or 2nd year doctoral student's to achievements in biotechnology research and to deepen knowledge in genetic engineering.

Content (topics) and methods

Theme I. *History, principles and definitions of biotechnology*. Introductory theme is intended to clarify the history of biotechnology and scientific discoveries important for achievements in field of biotechnology, to provide main definitions of biotechnology and to update the knowledge on the principles of classification of biotechnology research, its interdisciplinary nature and applications.

Theme II. *Isolation and propagation of cell and tissue culture. Principles of cell metabolism and calculation of growth parameters.* The topic introduces methodology and problems of cell and tissue isolation and propagation *in vitro*. Cultivation of prokaryotic cells, animal and plant cell culture *in vitro* is discussed.

Theme III. *Bioprocess. Bioreactors and fermentation.* This topic discusses principles and stages of bioprocess – upstream stage, fermentation and biotransformation, downstream stage. New developments in bioreactor technology and purification of products of fermentation and biotransformation are discussed.

Theme IV. *Genome libraries, sequencing and molecular markers.* This topic updates knowledge about development of genome libraries and applications of molecular markers. An overview of new methods of DNA sequencing and modern technologies of molecular markers is provided.

Theme V. *Molecular biotechnology and genetic manipulations.* Definitions and methods of molecular

biotechnology and genetic engineering are overviewed. Perspectives of application of recombinant DNA are discussed.

Theme VI. *Gene cloning.* The topic updates knowledge about principles and methods used for gene cloning and construction of recombinant DNA. New methods for rDNA development and perspectives of application of genetic engineering for genetic transformation of animal and plant cells is discussed. Application of transgenic animals in research is reviewed.

Theme VII. *Protein engineering.* Overview of principles and main methods used for protein engineering using rRNA technology. Application of new developments in the field for scientific research, pharmaceutical industry and medicine is discussed.

Theme VIII. *Methods of bioinformatics in biotechnology.* Information on application of databases for data storage and biotechnology research is provided. Tools for analysis of DNA and protein sequences and *in silico* gene annotation are introduced..

Theme IX. *Medical biotechnology.* The topic provides overview of areas for application of biotechnology in medicine and the latest achievements. Molecular medicine and diagnostics of genetic diseases. Gene therapy. Pharmacogenomics. Regenerative medicine – stem cells and tissue engineering.

Theme X. *Application of rDNA technology in pharmaceutical industry.* The current knowledge on development and production of pharmaceutical recombinant proteins is presented.

Theme XI. *Industrial biotechnology.* The topic presents information about achievements in industrial biotechnology, such as technologies for production of proteins and enzymes, amino acid and organic acids. Developments in processes for production of plant secondary metabolites is discussed. Application of biosensors in industry is presented.

Theme XII. *Biotechnology in food industry.* Fermentation and molecular biotechnology in modern food industry.

Theme XIII. *Agricultural biotechnology.* Application of molecular markers and genome information in breeding and genetic engineering of animals and plants are discussed. Genetically modified organisms.

Theme XIV. *Environmental biotechnology.* Recent advances in application of microorganisms and plants in bioremediation are presented.

Theme XV. *Ethical issues in biotechnology and product commercialization.* Ethical issues associated with biotechnology research and practical application in medicine, industry and agriculture are discussed. Overview of principles of intellectual property protection and product commercialization is presented

Structure of cumulative score and value of its constituent parts

Final sore consists of:
referate (literature review on the selected topic) -75%; and exam – 25%; or
seminare presentation (oral and ppt presentation on the selected course topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1	Walker J.M., Rapley R. Molecular biology and biotechnology. Cambridge : Royal Society of Chemistry. 2000.
2	Smith J.E. Biotechnology, 4th edition. Cambridge University Press. 2004.
3	Primrose S.B., Twyman R.M. Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing. 2006.
4	Glick B.R., Pasternak J.J. Molecular Biotechnology: Principles and Applications of recombinant DNA, 3rd edition. ASM Press. 2003.
5	Christou P., Klee H. Handbook of Plant Biotechnology, Vol. 1-2. John Wiley and Sons, Ltd. 2004.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1	Kun L.Y., Microbial Biotechnology: Principles and Applications, 2nd edition, World Scientific, 2006
2	Parekh S.R., , The GMO Handbook: Genetically Modified Animals, Humana Press Inc., 2004
3	Nicholl D.S.T., Introduction to genetic engineering, 2nd edition, Cambridge University Press, 2002
4	Ratledge C., Kristiansen B., Basic Biotechnology, Cambridge University Press, 2006
5	A. Sliesaravičius, V. Stanys. Žemės ūkio augalų biotechnologija**,** Vilnius: Enciklopedija, 2005
6	Recent reviews on the relevant topics published in scientific journals

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1	Danas Baniulis	LRCAF	dr.	d.baniulis@lsdi.lt
2				

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8005	6	VMU	FNS	**Biochemistry**

Course title in Lithuanian

Fermentinių sistemų reguliacija

Course title in English

Control of enzymatic systems

Study methods	Volume in ECTS credits
Lectures	1,7
Consultations	
Seminars	0,55
Individual work	3,75

Short course annotation in Lithuanian (up to 500 characters)

Dalyko turinys skirtas pirmųjų dviejų kursų doktorantams, siekiantiems gilinti suvokimą apie enzimologinius biologinių reiškinių aspektus: klasikinės enzimologijos žinios papildomos informacija apie fermentų veikimo ląstelės aplinkoje ypatumus, fermentinių ląstelės procesų valdymą ir Metabolinės Kontrolės teoriją, reguliacijos lygmenų ir mechanizmų įvairovę, užtikrinančią prisitaikymą prie aplinkos sąlygų ir išlikimą. Suteikiamas supratimas apie fermentų tyrimo metodus, derinant teorines ir praktines žinias bei diegiant problemų sprendimo įgūdžius.

Short course annotation in English (up to 500 characters)

The aim of course is to deepen 1st or 2nd year doctoral student's knowledge in Enzymology as required for biomedicine and biotechnology studies. The basic concepts in Enzymology, Cellular enzymology and Metabolic Control Analysis will be introduced. Classical enzymology including enzyme diversity, isolation and properties, enzyme kinetics as well as enzyme functioning in the living cell will be considered. The course is based on combination of theoretical and practical knowledge and the development of skills for problem solving.

Relevance of the course

Knowledge on principles of biocatalysis, operation of enzyme systems and their control within the cell is required for the understanding of processes in many areas of modern cell biology, biotechnology and biomedical research. Biocatalysis is essential feature of all living organisms, since their metabolism and formation of all structural elements is determined by enzymatic systems playing essential role in the integration of vital activities, whereas dysregulation of enzymes and enzymatic systems leads to a variety of pathological conditions. The problems of classical and modern enzymology are presented in the context of systems biology, the control and regulation of enzymatic processes in vivo is considered and modelling methods are discussed.

Course aims

The aim of course is to deepen 1st or 2nd year doctoral student's knowledge in Molecular Cell Biology that provides essential basis for biomedicine, biotechnology and biochemistry studies.

Content (topics) and methods

Theme I. *Structural diversity and clasification of biocatalists. Units of enzyme activity*. Introductory theme is intended to clarify the main concepts of enzymology, to update the knowledge on the principles of classification of enzymes, and units for assessment of enzyme activity.

Theme II. *Isolation and purification of enzymes. Enzyme structure and molecular parameters.* The methodology of preparative enzymology is presented and the problems of enzyme isolation, purification and molecular characterization are discussed.

Theme III. *Coenzymes.* This topic discusses the group of non-protein compounds that are of key importance for biocatalysis - coenzymes, their classification and biological functions.

Theme IV. *Thermodinamics of enzyme action.* This topic provides an overview of laws of thermodynamics, understanding of important concepts relevant to biocatalysis, discusses energetics of enzymatic processes.

Theme V. *Mechanisms of enzyme catalysis.* The main types of chemical mechanisms underlying processes of enzymatic catalysis are considered in more detail.

Theme VI. *Enzyme kinetics. Inhibitors. Enzyme activation.* The criteria for assessment of the efficiency of biocatalysis, main laws and constants of enzyme kinetics are presented along with physical and

chemical factors affecting enzyme activity, with particular emphasis on main types of enzyme inhibitors and activators.

Theme VII. *The diversity of regulative mechanisms in cellular metabolism. Feedback principle.* Overview of the key hierarchical levels in regulation of enzyme and enzymatic systems activity within the cell are discussed. Examples of the universal feedback principle in enzymatic systems are presented.

Theme VIII. *Allosteric enzymes.* Basic information on principles of allosteric regulation of metabolic pathways is presented, the mechanisms, models and quantitation criteria of allosteric interactions are discussed.

Theme IX. *Regulation of enzyme amount in the cell.* The modes for the regulation of enzymatic systems by changing amounts of enzymes in the cell are discussed: mechanisms for enzyme induction and repression, control on the level of enzyme maturation and enzyme turnover (synthesis versus degradation). Importance of protein induction and repression for hormonal regulation of enzymatic pathways.

Theme X. *Isoenzymes.* The current knowledge on enzyme isoforms, their origin, diversity, biological nomenclature, and the importance for the control and regulation of enzymatic systems is presented.

Theme XI. *Enzyme regulation by covalent modification.* The mechanisms for the control of enzyme activities, metabolic pathways and signal transduction cascades by posttranslational modifications is discussed, rules of enzyme conversion systems are presented. Importance of PTMs for hormonal regulation of enzymatic pathways.

Theme XII. *Enzymes in cellular environment.* Comparison of enzyme performance in vitro and in vivo.Impact of molecular crowding and compartmentation on enzyme operation within cell, Enzyme interactions with proteins and other macromolecules. Metabolic channeling and benefits of the direct metabolite transfer.

Theme XIII. *Control of metabolic pathways. Metabolic Control Theory.* The essential concepts and key theorems of metabolic control theory are presented, experimental applications of the Bottom up and top down methods are discussed.

Theme XIV. *Enzymology and proteomics.* Recent advances of proteomics relevant to enzymology are discussed with emphasis on biomedical subjects (application for disease prognostics, individual diagnostics, assessment of the therapy). Protein moonlighting in enzymology research.

Theme XV. *Enzymology and Systems biology.* The modelling approaches used for analysis of kinetics of enzyme systems, structural modelling techniques, combination of modeling and experimental research is discussed as well as integration of knowledge on classical enzymology and cell enzymology in systems biology research.

Structure of cumulative score and value of its constituent parts

Final sore consists of:
referate (literature review on the selected topic) -75%; and exam – 25%; or
seminare presentation (oral and ppt presentation on the selected course topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1	T.D.H. Bugg. Introduction to Enzyme and Coenzyme Chemistry. Wiley, 2012.
2	T. Davasena. Enzymology. Oxford University Press, 2012.
3	Cornish-Bowden A. Fundamentals of Enzyme Kinetics, Portland Press, 2012.
4	H. M. Sauro Enzyme Kinetics for Systems Biology. Ambrosius Publishing, 2012.
5	P.A. Frey and A.D. Hegeman. Enzymatic Reaction Mechanisms, 2007, Oxford University Press.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1	H. Bisswanger. Practical Enzymology. Wiley-Blackwell, 2013
2	R.A. Copeland. Evaluation of Enzyme Inhibitors in Drug Discovery: A Guide for Medicinal Chemists and Pharmacologists. Wiley-Interscience, 2013.
3	P. F. Cook, W.W. Cleland. Enzyme Kinetics and Mechanism. Garland Science, 2007.
4	A Illanes, L. Wilson, C. Vera. Problem Solving in Enzyme Biocatalysis. Wiley, 2013.
5	A.G. Marangoni. Enzyme Kinetics: A Modern Approach. Wiley-Interscience; 2002.
6	E. Voit. A First Course in Systems Biology. Garland Science, 2012.
7	Recent reviews on the relevant topics published in scientific journals

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1	Vida Mildažienė	VMU	Prof. habil.dr.	v.mildaziene@bs.vdu.lt
2	Zita Naučienė	VDU	doc.dr.	z.nauciene@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8006	6	VDU	FNS	Biochemistry

Course title in Lithuanian

Fizikocheminiai tyrimo metodai

Course title in English

Methods of physico-chemical analysis

Study methods	Volume in ECTS credits
Lectures	1.7
Consultations	0.55
Seminars	
Individual work	3.75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų dviejų kursų doktorantams, siekiantiems gilinti teorines ir praktines instrumentinių analizės metodų žinias biocheminės analizės srityje. Dalyko turinys skirtas perteikti žinias apie pagrindinius spektinės ir elektrocheminės analizės bei biomolekulių skirstymo metodus. Derinant teorines ir praktines žinias bus mokomasi diegti problemų sprendimo įgūdžius. Spektrinės analizės programa apima molekulinės absorbcinės, branduolių magnetinio rezonanso, liuminescencinės, masių spektroskopinę analizę. Elektrocheminių analizės metodų dalyje nagrinėjama konduktometrija, potenciometrija, voltamperometrija ir kulonometrija. Skirstymo metodų kurse nagrinėjama chromatografija (efektyvioji skysčių chromatografija, dujų chromatografija), elektroforezė, dvikryptė elektroforezė. Taip pat dėmesys skiriamas skirstymo metodų miniatiūrizavimui: kapiliarinei chromatografijai, elektrochromatografijai ir elektroforezei, mikrogardelių skirstymo ir analizės metodams. Bus nagrinėjamas nanotechnologijų panaudojimas analizėje, multidimensiniai/tandeminiai skirstymo ir analizės metodai, junginių identifikavimas duomenų bazių pagalba.

Short course annotation in English (up to 500 characters)

The aim of this course is to deepen knowledge of doctoral students in methods of physicochemical analysis that provides essential experimental basis for biochemical studies. The topics of the course provide current knowledge on the modern techniques of electrochemical, spectral and separation analysis combinations of these methods in hyphenated multidimentional/tandem analysis of biological samples. The course is based on combination of theoretical and practical knowledge and the development of skills for problem solving.

Relevance of the course

Doctoral students in Biochemistry program should have understanding of methods of instrumental analysis, to know mechanisms and to understand possibilities of application of such methods. This course is relevant, because VMU doctoral studies in Biochemistry are popular not only among masters in biochemistry and molecular biology, but also among masters in chemistry and environmental sciences. These students have to improve their knowledge in methods of biochemical analysis to be able to select right techniques and interpret the results of their research.

Course aims

The aim of the course is to deepen understanding of the biochemical processes and methods of their analysis, gain knowledge on specific instrumental techniques of physico-chemical analysis of biosystems

Content (topics) and methods

1.Introduction to spectral analysis. Electromagnetic radiation. The principles of quantum mechanics in spectroscopy. Atomic spectroscopy.
2. Molecular spectral analysis of ultraviolet and visible absorption spectrum. Analysis of fluorescence and luminescence. Molecular spectral analysis of infrared (IR) absorption.
3. Raman spectral analysis. Nuclear magnetic resonance (NMR) spectroscopy. ^{1}H NMR spectroscopy. ^{13}C NMR spectroscopy.

4. Two-dimensional (2D) NMR spectroscopy. Imaging in nuclear magnetic resonance. Mass spectrometry (MS). Mass spectrometers. Mass spectrometry in integrated analysis of biological systems.
5. The X-ray diffraction analysis. Complex methods of determination structures of organic compounds.
6. Methods of electrochemical analysis. Potentiometry. Electrolytic cell and galvanic elements. Diffusion potential. Indicatory and reference electrodes.
7. Polarization of electrodes. Measurements of electromotive force. Ionometric analysis. Potentiometric titrations.
8. Voltammetry. Classical polarography and principles of application. Amperometric analysis
9. Measurements of conductivity and coulometric analysis
10. Chromatographic analysis. Chromatographic process, the overall patterns. Classification of chromatographic methods. Theoretical considerations: physico-chemical processes in the column, retention, selectivity, resolution, efficiency.
11. High performance liquid chromatography. Equipment. Sorbents, their main properties. Solvents. Liquid chromatography, method of application.
12. Electrophoresis. Isoelectric focusing. Hardware. Capillary zone electrophoresis. Micellar electrokinetic chromatography. Gels for capillary electrophoresis.
13. Capillary isoelectric focusing. Isotachophoresis. Capillar electrochromatography
14. Chromatographic separation of biological materials, isolation and analysis. Comparative evaluation of physical and chemical methods of analysis.
15. Nanotechnologies in analysis. Multidimensional / tandem methods of distribution and analysis. Identification of compounds using databases.

Structure of cumulative score and value of its constituent parts

Final sore consists of:
Review of literature on selected topic -75% and exam - 25%; or
seminar presentation (oral and ppt presentation on selected topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	Žūkienė R. Spektrinė analizė. UAB TEV , 2012, *el. išteklius* http://etalpykla.vdu.lt
2.	Laurinavičius V. Biocheminiai analizės metodai. VU leidykla, 2012
3.	Mickevičius D. Cheminės analizės metodai. [1 ir 2 dalis] : vadovėlis / Vilnius: Žiburys, 1998, 1999. – 408 p., 352 p.
4.	K. V. Katti. Textbook of Nanomedicine: Methods of Biochemical Analysis. 2012. John Wiley & Sons Inc.
5.	Multidimensional Liquid Chromatography: Theory and Applications in Industrial Chemistry and the Life Sciences. 2008. Ed: S. A. Cohen, Wiley-Interscience, 468 p.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	Maruška A., Kornyšova O., Machtejevas E. Efektyviosios skysčių chromatografijos pagrindai: VDU vadovėlis/ Kaunas: VDU Leidykla, 2005. 198 p.
2.	Pavia D.L., Lampman G. M., Kriz G. S., Vyvyan J. R. Introduction to Spectroscopy. 4th ed. Brooks/Cole, 2009
3.	Buika G., Getautis V., Martynaitis V., Rutkauskas K. Organinių junginių spektroskopija. Vitae Litera 2007
4.	Hollas J. M. Basic Atomic and Molecular Spectroscopy. 4 ed. RSC, 2002. 184 p.
5.	De Hoffmann, E., Stroobant, V. Mass spectrometry: Principles and Applications. Wiley-Interscience. 2007, 3 ed.,

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Rimantas Daugelavičius	VDU	Prof. Dr.	r.daugelavicius@gmf.vdu.lt
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COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8007	6	VMU	Faculty of Natural Sciences	Department of Biochemistry

Course title in Lithuanian

Ląstelės ir molekulinė biofizika

Course title in English

Cellular and Molecular Biophysics

Study methods	Volume in ECTS credits
Lectures	1.7
Consultations	
Seminars	0.55
Individual work	3.75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas molekulinės ir ląstelės biofizikos žinioms, būtinoms biochemijos studijoms, gilinti. Dalyko turinys skirtas perteikti žinias apie molekulinių ir ląstelių sistemų funkcionavimo biofizikinius principus ir kinetiką, fizikos dėsnių vaidmenį šiose sistemose, šiuolaikinius biologinių sistemų modeliavimo metodus, bioelektrinių potencialų susidarymo principus, jų registravimo metodus, molekulinius mechanizmus. *Užsiėmimų formos* – paskaitos, individualus darbas, seminarai.

Short course annotation in English (up to 500 characters)

The aim of course is to deepen the knowledge in molecular and cellular biophysics. The topics: Biophysics of molecular interactions. Interactions of electric fields with cells, electrokinetics phenomena. Conformations of macromolecules. Non-equilibrium thermodynamics. Molecular modeling, quantum chemical simulations. Biophysics of sensory systems. Structure and functions of biomembranes. Origin of bioelectrical potentials. Molecular and cellular biomechanics. Molecular machines, motors.

Relevance of the course

Study program in Biochemistry emphasizes fundamental approaches to molecular and cellular aspects of how biological systems work. Biophysics is the science of physical principles underlying all processes of life, including the dynamics and kinetics of biological systems. The enormous progress recently has been made, especially in theoretical and molecular biophysics. This course spans biological organization from the molecular to the cellular level.

Course aims

The aim of the course is to provide an introduction to biophysics and to show that the same laws of physics, which govern the behaviour of the non-living world around us, also govern the processes inside the living organism.

Content (topics) and methods

I. Kinetic behaviour of biological systems. The approaches to model the biological systems and the basics of qualitative analysis of these models are studied.
II. Biophysics of Molecular Interactions. Various interactions between the molecules, which are responsible for the structure and behaviour of biological systems, are analyzed: Wan der Waal‘s interactions, hydrogen and halogen bonds, hydrophobic forces, hydration Forces.
III. Interaction of electric fields with cells, electrokinetic phenomena. Influence of electric fields on cells and electrokinetic phenomena, such as electrodeformation, electroorientation, electrorotation, dielectrophoresis, are analyzed.
IV. Introduction to a quantum theory of molecular structure**.** Conformations of biomolecules, folding of proteins.
V. Molecular modeling. Methods of vizualization, semiempirical, *ab-initio* and other models are analyzed, applications of quantum-chemical and molecular dynamics simulations for the analysis of molecules and their systems (ribosomes, membranes, vesicles) are discussed.
VI. Irreversible Thermodynamics of Biological Systems. Thermodynamics of the systems far from equilibrium, flows and forces are analyzed.
VII. Biophysical mechanisms of reception. Biophysical mechanisms of vision, hearing, vestibular system, electroreception, and magnetoreception are analysed.
VIII. Membrane biophysics. Phase transitions in the membrane, their role in anesthesia, changes of the membrane permeability are analysed.

IX. Transport of substances through the membranes, biophysics of osmosis. Osmolarity and tonicity, the role of osmosis in cell volume increase/decrease regulation, apoptosis, and cell migration are analyzed.
X. Bioelectric potentials, its registration. The origin of diffusion potential, trans-membrane potential, distribution of electric potential at the interface of two phases is analysed.
XI. Role of bioelectric potentials in cancer development, wound healing, and regeneration.
XII. Molecular and cellular mechanics. Physical mechanisms of the action of molecular electromechanical rotational motors are analized.

Structure of cumulative score and value of its constituent parts

Final assessment sums the assessments of a report (written review of the literature on the topic of the subject program) - 25% and written final examination – 75%
or – a seminar (oral presentation on the topic of the subject program) and written final examination (50%).

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	R. Glazer, *Biophysics: An Introduction*. Berlin: Springer Verlag, 2012, 407 p.
2.	Jackson M.B. *Molecular and Cellular Biophysics*, Cambridge University Press, 2006, 512 p.
3.	J. Malmivuo and R. Plonsey. *Bioelectromagnetism: Principles and Applications of Bioelectric and Biomagnetic Fields*, New York: Oxford University Press, 1995.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	F. Jensen. *Introduction to Computational Chemistry*. Chichester: John Wiley and Sons Ltd., 2006, 624 p.
2.	Davidovits P. *Biophysics in Biology and Medicine* (3rd edition), Academic Press, 2007, 336 p.

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Gintautas Saulis	VMU, Faculty of Natural Sciences	Prof. Habil. Dr.	g.saulis@gmf.vdu.lt
2.	Vytenis Arvydas Skeberdis	LHSU, Institute of Cardiology	Prof. Habil. Dr.	Arvydas.Skeberdis@lsmuni.lt
3.	Saulius Šatkauskas	VMU, Faculty of Natural Sciences	Assoc. Prof. Dr.	s.satkauskas@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8008	6	VDU	FNS	Biochemistry

Course title in Lithuanian

Mikrobiologija

Course title in English

Microbiology

Study methods	Volume in ECTS credits
Lectures	1.7
Consultations	0.55
Seminars	
Individual work	3.75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų dviejų studijų metų doktorantams, siekiantiems gilinti žinias mikrobiologijos srityje, kurios yra būtinos biomedicinos, biotechnologijų, ląstelės biologijos studijoms. Dalyko turinys orientuotas į mikroorganizmų molekulinės biologijos, fiziologijos ir mikrobiologinių tyrimo metodų esminį supratimą. To siekiama derinant teorines ir praktines žinias bei diegiant problemų sprendimo įgūdžius. Perteikiamas mikrobiologinio pasaulio vaizdas, detaliai nagrinėjama bakterijų ir mielių savybės, jų įvairovė. Analizuojami filogenetiniai ryšiai tarp mikroorganizmų grupių, mikroorganizmų morfologija, augimas ir reprodukcija, mikroorganizmų genetika. Nagrinėjami virusinės infekcijos mechanizmai, antimikronbinės medžiagos, jų veikimo mechanizmai. Nagrinėjams mikroorganizmų paplitimas gamtoje ir jų įvairovė, ekologinė mikrobiologija, pramonės ir maisto mikrobiologija, molekulinai mikroorganizmų identifikavimo ir genotipavimo metodai mikrobiologijoje.

Užsiėmimų formos – paskaitos, individualus darbas su literatūra, seminarai, konsultacijos.

Short course annotation in English (up to 500 characters)

Students will acquire basic theoretical and practical knowledge in microbiology. They will be able to handle microbiological cultures. The course content: The object of microbiology. History of microbiology. Microbiological methods. Morphology of microorganisms. Growth of microbial cultures. Reproduction of microorganisms. Microorganisms in biotechnology. Microbial evolution and phylogenetic relationships. Diversity of bacteria, archaea and eukaryotic microorganisms. Viruses and plasmids. Microorganisms and environment. Overview of microbial metabolism. Anaerobic respiration, microbial photosynthesis, phototrophic bacteria, fixation of nitrogen, fermentation. Pathogenic microorganisms, host-pathogen relationships. Symbiotic microorganisms.

Relevance of the course

Doctoral students in Biochemistry program should have basic understanding of microbiology, to know microbial cells and to understand possibilities of application of such methods. This course is relevant, because VMU doctoral studies in Biochemistry are popular not only among masters in biochemistry and molecular biology, but also among masters in chemistry and environmental sciences. These students have to improve their knowledge of microbiology to be able to use microorganisms in their experiments and to interpret results on bicrobial biochemistry.

Course aims

The aim of course is to deepen doctoral student's knowledge in microbiology that provides essential basis for biochemical studies. The topics of the course provide current knowledge on the modern techniques in microbiology, use of microorganisms in biotechnology. The course is based on combination of theoretical and practical knowledge and the development of skills for problem solving.

Content (topics) and methods

1. Overview of the history of microbiological research. Principles of classification in microbiology. The main bacterial groups
2. Diversity of bacteria, archaea and eukaryotic microorganisms. Phylogenetic relationships among the groups of microorganisms
3. Morphology of microorganisms
4. Genetics of microorganisms. Plasmids
5. Archaea diversity. Extremophile, their morphology and physiology features.
6. The eukaryotic microorganisms.
7. Microbial growth and reproduction. Growth control
8. Microbial examination techniques, The use of microorganisms in biotechnology

9. Metabolism of various microorganisms. Bacterial photosynthesis, chemolitotrophy, anaerobic respiration, nitrogen fixation, fermentation
10. The role of microorganisms in the environment
11. Microorganism and host relationships. Parasitic microorganisms, bacterial toxins.
12. Symbiotic microorganisms
13. Antimicrobial compounds, mechanisms of action
14. Viruses. Reproduction of virus particles. One-step infection cycle
15. Features of viruses, infecting bacteria, animals, plants

Structure of cumulative score and value of its constituent parts

Final sore consists of:
Review of literature on selected topic -75% and exam - 25%; or
seminar presentation (oral and ppt presentation on selected topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	Lasinskaitė – Čerkašina A., Pavilonis A., Vaičiuvėnas V. *Medicinos mikrobiologija ir virusologijos pagrindai*. Kaunas, 2005.
2.	Madigan M.T., Martinko J.M., Parker J., Dunlap P.V., Clark D. P. *Brock's Biology of Microorganisms*. San Fransisco, 2010.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1.	Masteikienė R. *Maisto produktų mikrobiologija*. Kaunas, 2002.
2.	Johnson T. R., Case C.L. *Laboratory Experiments in Microbiology*. San Fransisco, 2000.
3.	Frank, S. A. *Immunology and Evolution of Infectious Disease*. 2002.
4.	Buzaitė O. *Mikrobiologijos praktikos darbai*. http://gamta.vdu.lt/bakalaurai/bakalaurai.html (2006).

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Rimantas Daugelavičius	VDU	Prof. Dr.	r.daugelavicius@gmf.vdu.lt
2.	Odeta Buzaitė	VDU	Dr.	o.buzaite@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8009	6	VMU	FNS	Biochemistry

Course title in Lithuanian

Baltymų chemija ir proteomika

Course title in English

Protein chemistry and proteomics

Study methods	Volume in ECTS credits
Lectures	1.7
Consultations	0.55
Seminars	-
Individual work	3.75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų dviejų kursų doktorantams, siekiantiems gilinti baltymų chemijos ir proteomikos žinias, būtinas biomedicinos, biotechnologijos ir biochemijos studijoms. Dalyko turinys skirtas perteikti naujausias žinias apie sudėtingą ląstelės baltymų pasaulį ir šiuolaikinius jo analizės metodus: raiškos, struktūrinę, sąveikos ir funkcinę proteomiką, šių tyrimo krypčių ryšį su genomika, transkriptomika, metabolomika, interaktomika, bioinformatika bei sistemų biologija. Siekiama derinti teorines ir praktines žinias bei diegti problemų sprendimo įgūdžius.

Short course annotation in English (up to 500 characters)

The aim of course is to deepen 1st or 2nd year doctoral student's knowledge in protein chemistry and proteomics that provides essential basis for biomedicine, biotechnology and biochemistry studies. The topics of the course are selected to achieve the following objectives: to provide current knowledge on the complex world of proteins and modern technologies for broad scale protein analysis: expression, structural, interaction and functional proteomics, and relation of proteomics with genomics, transcriptomics, metabolomics, interactomics, bioinformatics and system biology. The course is based on combination of theoretical and practical knowledge and the development of skills for problem solving.

Relevance of the course

In the post-genomic era of molecular nature sciences the proteomic research generates huge amount of data concerning protein sequences, structure, biochemical and physiological functions, activity, localization and interaction with other molecules. The appropriate analysis of these data is the main tool for gene function determination, evaluation of the functions of complex biological object as a system, search for patologic state markers etc. Therefore a good knowledge of proteomics as a branch of integral biological system analysis („omics") is importante for modern biochemists.

Course aims

The aim of the course is to deepen 1st or 2nd year doctoral student's knowledge in proteomics that provides essential basis for biomedicine, biotechnology and biochemistry studies, forms system biology view, which is essential for the adequate perception of enzymatic processes and its regulation in normal and pathological living system state and for the methodology development in biotechnologies.

Content (topics) and methods

Theme I. *From genomics to proteomics.* In the introductory theme the birth of large-scale biology, the links between genome, transcriptome and proteome are analyzed. Functional genomics at the DNA and RNA levels and the need for proteomics is emphasized. The scope of different kinds of proteomics (sequence and structural proteomics, expression proteomics, interaction proteomics, functional proteomics) and the challenges of proteomics are overviewed.

Theme II. *Strategies for protein separation*. General principles of protein separation in proteomics by two-dimensional (2D) gel electrophoresis, liquid chromatography and multidimensional liquid chromatography are provided. The modifications of separation methods, method selection criteria, advantages and disadvantages of different separation methods are discussed.

Theme III. *Strategies for protein identification*. Protein identification with antibodies, by chemical degradation (complete hydrolysis, Edman degradation) and by mass spectrometry (MS) is

overviewed. Possible MS instrumentation combinations, working principles and analysis schemes for protein identification using data from MS (peptide mapping (peptide mass fingerprinting), fragment ion analysis, de novo sequencing) are considered in more detail.
Theme IV. *Strategies for protein quantitation*. Protein quantitation by 2D gel electrophoresis (image acquisition, spot detection, quantitation and comparison) and MS (ICAT, SILAC, MCAT methods) are discussed in this theme.
Theme V. *Proteomics and the analysis of protein sequences*. Evolutionary relationships of protein families and function prediction from sequence are disscussed. Basic parameters and principles of protein sequence comparison are considered: identity and similarity between protein sequences, substitution score matrices, pairwise similarity searching, the significance of sequence alignments, multiple alignments. Methods for finding more distant relationships (PSI-BLAST, pattern recognition (consensus sequences, motifs and blocks, domains) are introduced.
Theme VI. *Structural proteomics*. Structure-function concordance and nonconcordance is discussed. Techniques for solving protein structures (X-ray crystallography, nuclear magnetic resonance spectroscopy etc.) and techniques for modeling protein structures (predicting protein secondary structures from sequence data, tertiary structure prediction by comparative modeling, *ab initio* prediction methods, fold recognition (threading)) are introduced. Comparing protein structures and the structural classification of proteins. Structural proteomics: initiatives and results.
Theme VII. *Interaction proteomics.* Principles of protein-protein interaction analysis and methods (genetic, bioinformatic, affinity-based biochemical and physical methods) are analyzed. Library-based methods for global analysis of binary interactions and systematic complex analysis by MS are discussed. Protein interaction maps are presented. Interactions of proteins and small molecules are overviewed.
Theme VIII. *Protein modification in proteomics*. The diversity of biological protein modifications and their functions are overviewed. Phosphoproteomics, glycoproteomics, ubiquitinomics are considered in more detail.
Theme IX. *Protein chips and functional proteomics*. The information on different types of protein chips and its manufacture is given. Label-free detection and quantitation methods for proteins bound to protein chips and methods that require labels are compared. Emerging protein chip technologies (bead and particle arrays in solution, cell and tissue arrays) are presented.
Theme X. *Applications of proteomics*. Three main fields of proteomics applications are presented in this topic: medical proteomics (disease diagnosis), pharmaceutical proteomics (drug development), and proteomics in plant biotechnology.

Structure of cumulative score and value of its constituent parts

Final sore consists of:
referate (literature review on the selected topic) -75%; and exam – 25%; or
seminare presentation (oral and ppt presentation on the selected course topic) – 70%, exam – 30%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1	R.M.Twyman. Principles of Proteomics. 2013. Tylor&Francis, New York.
2	R.J. Simpson. Proteins and Proteomics. 2003. Cold Spring Harbor Laboratory Press, New York.
3	R. A. Meyers. System Biology. 2012. Wiley-VCH Verlag&Co.
4	Actual scientific articles.

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1	J. Lovric. Introducing proteomics: from concepts to sample separation, mass spectrometry, and data analysis. 2011. John Wiley&Sons, West Sussex.

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1	Rasa Žūkienė	VDU	Dr.	r.zukiene@gmf.vdu.lt
2	Vida Mildažienė	VDU	Prof., habil. dr.	v.mildaziene@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Volume in ECTS credits	Institution	Faculty	Department
BCH8010	4 kr.			

Course title in Lithuanian

SIGNALŲ PERDAVIMAS

Course title in English

SIGNAL TRANSDUCTION

Study methods	Volume in ECTS credits
Lectures	1.7
Consultations	0.55
Seminars	-
Individual work	3.75

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas pirmųjų dviejų kursų doktorantams, siekiantiems gilinti signalų perdavimo žinias, būtinas biomedicinos, biotechnologijos ir biochemijos studijoms. Dalyko turinys skirtas perteikti naujausias žinias apie signalų perdavimo kelius, supažindinti su pagrindinėmis molekulių klasėmis, dalyvaujančiose šiuose keliuose. Kursas taip pat skirtas susipažinti su specifiniais signalų perdavimo keliais, kurie yra svarbūs vystymosi biologijoje, neurobiologijoje, ląstelės biologijoje bei fiziologijoje. į ląstelių evoliuciją, struktūrą, veikimo principus, ląstelės savitų vidinių sistemų integravimą. Atskiras dėmesys skirtas susipažinti su molekuliniais taikiniais naujų vaistų kūrimui.

Short course annotation in English (up to 500 characters)

The process that cell stimulation by external signals leads to changes in gene expression is termed cell signal transduction. To transduce these signal cells elaborated various signal transduction pathways. This course is designed to provide an introduction to some of the most important classes of molecules that participate in common signal-transduction pathways. Specific signal transduction pathways from developmental biology, neurobiology, physiology, and cell biology will be considered. Molecular targets for drug development will be also discussed.

Relevance of the course

Cell response to external stimuli and processes within the cell are closely related with many different signaling pathways. A detailed understanding of these pathways is important revealing molecular cell physiology and pathology mechanisms leading to development of various diseases and searching for new molecular targets and methods allowing better control of these diseases.

Course aims

To provide with a knowledge about the main signaling pathways, describe plasma membrane receptors, characterize first and second signal messengers, ionotropic and metabotropic signal transduction mechanisms, signal transduction through serine, threonine and tyrosine protein kinases, cell signaling pathways during embryogenesis and development of nervous system, signal transduction in sensory systems.

Content (topics) and methods

I topic. Introduction to signal transduction. In this theme principal ligands and their receptors will be reviewed, second signal messengers structure and function will be analyzed.
II topic. Signal transduction through chemical and electrical synapses. In this theme structure, function of chemical and electrical synapses will be analyzes, ionotropic and metabotropic receptors, principal elements of these synapses will be described.
III topic. Intracellular signal amplification. In this theme GTP proteins, second messengers, protein kinases and phospahtases and interaction of these molecules will be analyzed.
IV tema. Signalo perdavimo per GTF sujungiančius baltymus komponentai. Šioje temoje analizuojama GTF aktyvinantys baltymai (GAP), Guanino nukleotidų pakeitimo faktoriai (Guanine Nucleotide Exchange Factors,GEFs), GDF disociacijos inhibitoriai (GDI).
IV topic. GTP associated proteins. In this theme structure, function and roles of GTP activating proteins (GAPs), guanine nucleotide exchange factors (GEFs), and GDP dissociation inhibitors (GDIs) will be analyzed.
V topic. Protein kinases. In this theme structure and activation of protein kinases will be analyzed. In addition, atypical protein kinases and pseudokinases will be considered.
VI topic. Signal transduction in participation of calcium ions. In this theme mechanism for calcium

homeostasis will be analyzed, calmodulin, calmodulin kinases and main signaling pathways will be described.
VII topic. TOR, WNT, Notch signaling pathways. In this theme main components, function and importance of these signaling pathways will be described.
VIII topic. Signal transduction in sensory systems. In this theme mechanisms of signal transduction in visual and olfactory systems will be analyzed.
IX topic. Signal transduction through receptor tyrosine kinases. In this theme structure, intracellular components of receptor tyrosine kinases will be described, main signaling pathways through these receptors will be reviewed.
X topic. Signal transduction and drug design. In this theme ERB receptor family and their ligands will be analyzed, participation of these pathways during development of cancer and drug design will be considered.

Structure of cumulative score and value of its constituent parts

Paper work on a specific topic – 25%; seminar – 25%, exam – 50%.

Compulsory reference materials

No.	Authors of publication, title, publishing house, year of publication
1	Gomperts, B.D., I.M. Kramer, and P.E.R. Tatham. (2009). Signal Transduction

Supplementary reference materials

No.	Authors of publication, title, publishing house, year of publication
1	Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2002). Molecular Biology of the Cell.
2	Lodish, H., Baltimore, D., Berk, A., Zipursky, S.L., Matsudaira, P., Darnell J. (2000). Molecular Cell Biology, 4th ed. NewYork.
3	Sanes D.H., T.A. Reh, W.A. Harris. (2005). Development of the Nervous System, Second Edition.

Course programme designed by

No.	Name, surname	Institution	Degree	E-mail address
1.	Saulius Šatkauskas	VDU	Prof. dr.	s.satkauskas@gmf.vdu.lt

COURSE DESCRIPTION

Course code	Course group	Volume in ECTS credits	Course valid from	Course valid to	Reg. No.
EDU 8110		6 ECTS			

Course type (compulsory or optional)	
Course level (study cycle)	
Semester the course is delivered	
Study form (face-to-face or distant)	

Course title in Lithuanian

AUKŠTOSIOS MOKYKLOS DIDAKTIKA

Course title in English

DIDACTICS OF HIGHER EDUCATION

Short course annotation in Lithuanian (up to 500 characters)

Dalykas skirtas analizuoti studijų turinio (curriculum) teorines koncepcijas, ypatingai akcentuojant aukštosios mokyklos didaktikos klausimus. Studijuodami šį modulį doktorantai susipažins su globalizacija, švietimo kaitos tendencijomis, aukštojo mokslo įsijungimo į bendrąją ES švietimo erdvę nuostatas ir tikslus, teorinių ir praktinių studijų metu gilinsis į studijų turinio (curriculum) aukštojoje mokykloje projektavimo, organizavimo ir valdymo tendencijas, principus, pagrindines problemas bei kokybės parametrus, įgis didaktines kompetencijas, reikalingas pradedančiajam dėstytojui.

Short course annotation in English (up to 500 characters)

Didactics of higher education is an applied branch of education science. The following issues are analyzed in this course: the main phenomena of education and their relationship; the most significant teaching and learning theories; learning by doing. Teaching methods and their applications are covered: lectures, learning in small groups, projects, case studies, discussions, workshops, debates, brainstorming, and etc. The other issues are teaching resources; teaching models for effective learning (consecutive and problem based), development of study programs and their logic, goals, tasks and structure; strategies for the development of productive learning environment; open and distance learning; control, assessment and evaluation of study results; assessment systems; problems of study quality assurance at university: dimensions, standards, criteria and methods.

Prerequisites for entering the course

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Course aim

The aim of the course is to ensure students to gain the abilities of study content (curriculum) design, of study course programme preparation and of study organization as well as to prepare students for lecturer's work at institutions of higher education.

Links between course outcomes, criteria of learning achievement evaluation and content

Course outcomes	Criteria of learning achievement evaluation	Content (topics)
To describe tendencies and peculiarities of studies of higher education.	Theoretical concepts of didactics of higher institutions were interpreted, scientific discussion emphasizing study development tendencies, was organized.	The impact of globalisation on the concept of education. The discourse of life – long – learning in education politics of the European Union. Didactics of higher education – a branch of education sciences. A study system of higher education. Study levels, forms, given degrees and qualifications.

To evaluate critically methodological concepts of content (curriculum) design of studies of higher education.		Concept and methodology of design of study content (curriculum). The structure of European qualifications of life – long – learning and the structure of Lithuanian national qualifications. Regulation of study fields and levels. Regulation of study types and levels. The main parameters of study content (curriculum) and their interrelation. A systematic aspect of study content.
To prepare an inventory of concrete programme/module of study. Parengti konkrečios studijų programos dalyko/modulio aprašą.	Learning outcomes of a concrete study programme identified and formed. Main parameters of study content (curriculum) determined and described. Evaluation methods which are adequate to the assessment of learning outcomes determined.	Methods of the design/renewal/improvement of programmes based on learning outcomes. Study programme – the main document describing main parameters of study content. The structure of programmes and the requirements of their design. Teaching and learning methods and their use in practice: reproductive, interpretative and creative teaching/learning methods and means. Open and distance studies. Testing, evaluation and assessment of learning outcomes. Evaluation systems: diagnostic, generalizing, formative, and cumulative.
To prepare and realize a didactic project of course content.	The choice of a theoretically based study strategy and module.	Teaching/learning models: consistent and problem solving which foster effective studies. The creation of strategy for productive study environment.
To describe the quality criteria of study content.	The concept of quality criteria explained. Five main quality criteria of study content explained.	The system of quality evaluation of study content and process. Research of study content: evaluation of the quality of study programme.
The plan for the development of personal didactic abilities (self-development) prepared.	Personal didactic abilities evaluated, didactic activity problems determined and the plan for the self – development of abilities prepared.	Functions and competences of lecturer's activities. Self – perception, evaluation of own activities, self – development and the design of future professional career.

Study (teaching and learning) methods

Teaching methods: explanation, demonstration, illustration, delivery of questions, moderation, consultation. Learning methods: analysis of literature and documents, case study, discussions, the preparation of learning projects individually and in groups.

Methods of learning achievement assessment

The systematic analysis of studying curriculum design, the observation of the presentation and its approval; The analysis of studying programme project, prepared in group, the observation of the presentation and its approval; The analysis of the description of studying subject.

Distribution of workload for students (contact and independent work in hours)

Lectures	**27 hours**
Seminars	**27 hours**
Group work	**27 hours**
Individual students work	**80 hours**
Total:	**160 hours**

Structure of cumulative score and value of its constituent parts

Learning achievements are assessed while applying a system of a cumulative grade. The final mark integrates (100 %): Individual work (curriculum description of studying subject) – 15 %, Team work (systematic analysis of studying curriculum design) – 15%, Mid term test – 20 %, Final exam (project of studying programme) – 50%

Recommended reference materials

No.	**Publication year**	**Authors of publication and title**	**Publishing house**	**Number of copies in**		
				University library	*Self-study rooms*	*Other libraries*
Basic materials						
1.	2009	Adelman C. *The Bologna Process for U.S. Eyes: Re-learning Higher Education in the Age of Convergence.*	Washington, DC: Institute for Higher Education Policy.	5	5	
2.	2009	ECTS Users' Guide.	Internet address: http://ec.europa.eu/education/lifelong-learningpolicy/doc/ects/guide_en.pdf			
3.	2006	Kennedy D., Hyland Á, Ryan N. *Writing and Using Learning Outcomes: a Practical Guide.*	Internet address: http://www.bologna.msmt.cz/files/learning-outcomes.pdf Page Accessed 13, July, 2010			
4.	2008	Laužackas R. *Kompetencijomis grindžiamų mokymo/studijų programų kūrimas ir vertinimas. Monografija.*	Kaunas: VDU.	8	2	

5.	2010	Lynne P.Baldwin. *Active Learning in Higher Education/*	SAGE journal on line http://alh.sagepub.com/content/11/3/163.full.pdf+html			
Supplementary materials						
6.	2003	Boud D., Feltti G. *The challenge of Problem – Based Learning.* London. Stirling	USA: Kogan Page.			
7.	2005	Marzano, R.J. *Naujoji ugdymo tikslų taksonomija.*	Vilnius: Žara.			
	2004	Moon J. *Linking levels, Learning Outcomes and Assessment Criteria.*	Internet address: http://www.bologna-bergen2005.no/EN/Bol_sem/Seminars/040701-02Edinburgh/040701-02Linking_Levels_plus_ass_crit-Moon.pdf.			
8.	2010	Kęstutis Pukelis, Laima Sajienė Izabela Savickienė ir kt. *Studijų rezultatų ir studijavimo pasiekimų įvertinimo koncepcijos integravimo į studijų procesą metodologiniai pagrindai.*	Internet address: http://skc.vdu.lt/downloads/projekto_rezultatsi/mv1_20100906_galutinis_sumaketuotas_110505.pdf			

Course programme designed by

Prof. dr. Laima Sajienė