Course code	Course group	Volume in ECTS credits	Course hours
BIO 6011	C	6	160

Course type (compulsory or optional)	**Compulsory**
Course level (study cycle)	**Master**
Semester the course is delivered	**3rd, Fall**
Study form (face-to-face or distant)	**Face-to-face**

Course title in Lithuanian

SISTEMŲ BIOLOGIJA

Course title in English

SYSTEMS BIOLOGY

Short course annotation in Lithuanian

Sistemų biologijos tikslai, reikšmė, istorija, dėsniai. Biologinių sistemų dinaminė elgsena, jos analizės metodai. Duomenų pirminiai šaltiniai, jų gavimo metodai ir duomenų bazės. Sistemų biologijos įrankiai, duomenų ir modelių formatai, analizės algoritmai, vizualizavimas. Sistemų biologijos principų taikymas biologinėms sistemoms analizuoti (metabolinių, signalų transdukcijos ir baltymų sąveikos tinklų analizė), medicinoje, biofarmacijoje, biotechnologijoje, toksikologijoje ir kt. Moksliniai ir technologiniai sistemų biologijos iššūkiai, perspektyvos.

Short course annotation in English

Introduction to Systems Biology. The importance and history of systems biology. Laws of systems biology. Dynamic behaviour of biological systems and the methods for its analysis. Experimental methods for acquiring the data used in systems biology. Tools and methods of systems biology. Data and model formats, visualization. Perspectives of systems biology. After the completion of this course, students will be able to: understand basic ideas, tools and applications of systems biology in biology, biotechnology and medicine.

Prerequisites for entering the course

Molecular Biology BIO 5001, Bionanotechnology and Biomodeling BIO 6002, Integral Analysis of Biological Systems BBK 6003

Course aim

The aim of the course is to provide knowledge on basic ideas, methods, and application of systems biology in biology, biotechnology, medicine and biopharmacy as well as the ability of using this knowledge in everyday research and practice.

Content (Topics)

1. Introduction. Object of Systems Biology. History of Systems Biology.
2. Principles and Laws of Systems Biology: Similarities and Discrepancies Between the Laws of Systems Biology and Physics. Research Methods of Systems Biology: from Separation to Integration, from Molecules to Networks.
3. Kinetic Behaviour of Biological Systems, Methods of its Analysis. Models of biological systems: from simple chemical reactions to complex biological systems. Point and Spatially Distributed Systems; Deterministic and Stochastic Models (Markov Chains, Microscopic, Mezoscopic, and Macroscopic Models, etc.); Methods of the Description of the Behaviour of Biological Systems by Differential Equations. Time-Scale Hierarchy in Biological Systems. Non-equilibrium Thermodynamics. The Onsager Relations. Prigogine’s Theorem.
4. Qualitative Analysis of the Biological Systems Described by Differential Equations. Stability, Stationary State, Bifurcation. Phase Plane and Phase Trajectories, Method of Isoclines, Singular Points. Noise and Perturbation of Biological Systems and Their Impact on System Stability. Noise in Enzymatic Systems.
5. Examples of the kinetic behavior of biological systems: autocatalytic chemical reaction, simple and complex enzymatic reactions, Michaelis-Menten equation, bistable trigger systems, nonlinear systems, interaction of populations (Volterra-Lotka and other models), mesoscopic kinetics of protein synthesis.
6. Primary sources and data acquisition methods of the data used in systems biology: classic methods, microarray, microfluidic systems, omics analysis (genomics, proteomics, metabolomics, etc), etc.
7. Systems biology databases: reaction kinetics, metabolic pathways, signal transduction, nucleic acids, proteins, and models (*BRENDA*, *BIND*, *BioCarta*, *SigPath*, *IntAct*, *GRID*, *CSB.DB*, *CellCircuits*,

	BioModels, *NCBI*, etc.).
8.	Systems biology tools: hardware and software (from *CAIN* to *VCELL*, *SimBiology*, *METATOOL*, *CellDesigner*, *SBW*, etc.), data models and formats (XML, SBML, CellML, etc.), analysis of algorithms, visualization (Cytoscape, Navigator, Osprey, et al.), etc.
9.	*Cytoscape*: open- source platform for analysis and visualization of complex networks. *CELLWARE* – the first web tool for modeling and simulation of biological systems.
10.	*Systems Biology Workbench* (*SBW*), its possibilities. Electronic cell system *E-Cell* - software for the simulation of a whole cell. Current *E-Cell* opportunities: dynamic simulation of *in vitro* multi-enzyme and cell metabolism systems, modeling of organelles, the application of the analysis of pathological states
11.	Application of the principles of systems biology for the analysis of biological systems (1): analysis of gene regulation and metabolic networks, signal transduction pathways; networks of protein interactions. Integration of metabolic and signaling networks.
12.	Application of the principles of systems biology for the analysis of biological systems (2): analysis of the cell cycle, cell development, apoptosis. Systems biology of stem cells.
13.	Application of the principles of systems biology in medicine (forecast of disease-related genes by using metabolic networks, disease-related subnets, personalized medicine, the whole body pharmacokinetic modeling (PK-Sim), the virtual patient, etc.) and bio-pharmacy (application of metabolic networks for the search of selective targets for drugs, simulation of the response of a whole human body to the treatment (*PhysioLab*), etc.) .
14.	Applying the principles of systems biology in biotechnology (improvement of the properties of microorganisms, optimization of biotechnological processes, etc.), toxicology, neuroscience, etc.
15.	Scientific and technological challenges of systems biology, improvements require. Systems biology perspective (synthetic biology, virtual/electronic cells, organs, humans, etc.).

Practical works

1. Introduction to *CellDesigner*. Basic Features.
2. Modeling of Chemical Reactions with *CellDesigner*.
3. *CellDesigner*: Modeling and Analysis of the Reaction of Decomposition of Hydrogen Peroxide.
4. *CellDesigner*: Creation and Analysis of Mathematical Rules in Models.
5. *CellDesigner*: Modeling and Analysis of the Circadian Clock Model.
6. *CellDesigner*: Connection to External Databases of Models
7. *CellDesigner*: Connection to External Databases
8. Introduction to *Systems Biology Workbench* (*SBW*)
9. *SBW*: Basic Features and Tools of *JDesigner*.
10. *SBW*: Creation and Analysis of the Model of Brusellator with *JDesigner*
11. *Virtual Cell*: Basic Features and Tools.
12. *Virtual Cell*: Creation and Analysis of the Model of Water Transport through the Membrane
13. *Cytoscape*: Basic Features
14. *Cytoscape*: Network Visualization and Analysis

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

Lectures – 30 hours, Laboratory Work – 30 hours, Individual Work – 93 hours, Assessments – 7 hours. Total: 160 hours.

Structure of cumulative score and value of its constituent parts

Final assessment sums the assessments of written mid-term examination (23%), assessment of laboratory works (27%), and written final examination (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	2014	G. Saulis „Systems Biology“ (lecture materials)	e-copy			
2	2012	E. O. Voit, *A First Course in Systems Biology*, Garland Science (), 445 pp.	Taylor & Francis Group, New York		1	
3	2005	Alberghina L., Westerhoff H.V. (Eds.), *Systems Biology: Definitions and Perspectives*.	Springer, Berlin		1	
4	2001	Kitano H. (Ed.), *Foundations of Systems Biology*	The MIT Press, Cambridge		1	
Supplementary materials						
1	2007	Alon U., *An Introduction to Systems Biology: Design Principles of Biological Circuits*,	Chapman & Hall/CRC, Boca Raton			
2	2006	Szallasi Z., Stelling J., Periwal V. (Eds.), *System Modeling in Cellular Biology: From Concepts to Nuts and Bolts*	The MIT Press, Cambridge			
3	2006	Wilkinson D.J., *Stochastic Modeling for Systems Biology*	Chapman & Hall/CRC, Boca Raton			

Course programme designed by

Prof. Dr. Gintautas Saulis, Faculty of Natural Sciences, Department of Biology