Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Teoretična biofizika
Course title:	Theoretical Biophysics

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika 2. st.		1,2	1,2,3,4
Physics 2nd degree			

Vrsta predmeta / Course type	izbirni/elective
Univerzitetna koda predmeta / University course code:	

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
45	15	15	15		210	10

Nosilec predmeta / Lecturer:	Aleš Fajmut

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian
	Vaje / Tutorial:	slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Jih ni.	None.

Vsebina:	**Content (Syllabus outline):**
METODOLOGIJA RAZISKOVANJA V SISTEMSKI BIOLOGIJI (eksperimentalne biološke, biokemijske in biofiziklane metode raziskovanja, fizikalni in matematični principi in metode, računalniška orodja za matematično modeliranje, baze podatkov (genoma, genskih ekspresij, struktur proteinov, celičnih modelov)) DETERMINISTIČNO MODELIRANJE BIOLOŠKIH SISTEMOV (zahtevnejša biokemijska in encimska kinetika, kompleksne metabolične mreže,	METHODOLOGY OF RESEARCH IN SYSTEMS BIOLOGY (experimental biological, biochemical and biophysical methods of research, physical and mathematical principles and methods, computer tools for mathematical modeling, databases (genome, gene expressions, protein structures, cell models)) DETERMINISTIC MODELING OF BIOLOGICAL SYSTEMS (complex biochemical and enzymatic kinetics, complex metabolic networks, sensitivity

senzitivnostna analiza, struktura, funkcija in dinamika signalizacije ter medcelične in znotrajcelične komunikacije, napredni večshrambni fiziološko podprti farmakokinetični modeli, kompleksne oscilacije v bioloških sistemih, stabilnostna analiza, celostni modeli, sistemski pristopi k modeliranju, sklopitve celic in mehanizmov na različnih skalah in ravneh)	analysis, structure, function and dynamics of signaling and intercellular and intracellular communication, advanced multi-store physiologically supported pharmacokinetic models, complex oscillations in biological systems, stability analysis, integrated models, systems approach to modeling, coupling of cells and mechanisms on different scales and levels)
STOHASTIČNO MODELIRANJE BIOLOŠKIH SISTEMOV (Gillespijev in drugi algoritmi, primerjava makroskopskih hitrostnih konstant in tistih, pridobljenih s stohastičnimi modeli, primeri stohastičnih modelov v bioloških sistemih)	STOHASTIC MODELING OF BIOLOGICAL SYSTEMS (Gillespie's and other algorithms, comparison of macroscopic rate constants and those obtained with stochastic models, examples of stochastic models in biological systems)
V okviru seminarja študent izbere eno izmed razpisanih tem za projektno nalogo, ki ima obliko krajšega strokovnega prispevka. Študent po izdelavi in pregledu naloge pripravi predstavitev pred kolegi.	The seminar is intended for the presentations of student projects, which should have the form of a shorter professional paper. After preparing and reviewing the project, the student prepares a presentation in front of colleagues.
Vsebina seminarskih in laboratorijskih vaj: - delo z računalniškimi orodji, kot so npr. Mathematica, MatLab, Madonna, Gepasi, PLAS, Model Maker, Virtual Cell… - delo z računalniškimi podatkovnimi bazami in orodji na svetovnem spletu kot so npr. BRENDA, Swiss-Prot, TrEMBL, UniProt… - modeliranje izbranih bioloških sistemov - reševanje matematičnih modelov in vizualizacija rezultatov s pomočjo računalniških orodij - nadgradnja in povezovanje obstoječih modelov	*Contents of tutorials and laboratory work:* - working with computer tools such as Mathematica, MatLab, Madonna, Gepasi, PLAS, Model Maker, Virtual Cell ... - working with computer databases and tools on the Internet, such as BRENDA, Swiss-Prot, TrEMBL, UniProt ... - modeling of selected biological systems - solving mathematical models and visualizing results using computer tools - upgrading and linking the existing models

Temeljni literatura in viri / Readings:

Klipp E., Herwig R., Kowald A., Wierling C., Lehrach H. Systems Biology in Practice, Wiley-VCH, Weinheim 2005

Kitano H. Foundations of Systems Biology, MIT Press, Cambridge 2001

Dodatna literatura / Additional Readings:

Voit E.O. Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists, Cambridge University Press, New York 2000
Ignalls B.P. Mathematical modeling in systems biology, An introduction, MIT Press, 2013, Cambridge
Sauro H. M. Enzyme kinetics for systems biology, Ambrosius Publishing, 2011, Seattle

Cilji in kompetence:

Študent je po uspešno opravljenem izpitu zmožen:
- razumeti obravnavane zahtevnejše teoretične biofizikalne koncepte in metode modeliranja živih sistemov od ravni medmolekularnih interakcij do ravni delovanja celice, tkiva in organizma
- identificiranja in obravnave izbranih kompleksnejših problemov v bio-znanostih ter pristopa k iskanju njihovih rešitev s pomočjo metod teoretičnega biofizikalnega modeliranja
- strokovnega sodelovanja, komunikacije ter prenosa znanj na področju naravoslovnih interdisciplinarnih ved

Objectives and competences:

After passing the exam, the student is able:

- to understand the discussed complex theoretical biophysical concepts and methods of modeling of living systems from the level of intermolecular interactions to the level of the cell, tissue and organism functioning
- to identify and treat the selected complex problems in bio-sciences and to find strategies for their solutions with methods of theoretical biophysical modeling
- of professional cooperation, communication and transfer of knowledge in the field of interdisciplinary natural sciences

Predvideni študijski rezultati:

Znanje in razumevanje:
Po zaključku predmeta je študent zmožen:
- kvalitativno in kvantitativno (s fizikalno-matematičnimi odvisnostmi) opisati obravnavane zahtevnejše teoretične biofizikalne koncepte
- aplicirati te koncepte na konkretnih primerih kompleksnejših modelov bioloških sistemov
- pridobiti podatke o parametrih modelov z analizo meritev v člankih ali iz podatkovnih baz
- analitično ali z računalniškimi orodji rešiti konkretne kompleksne obstoječe modele bioloških sistemov, z njimi napovedati rezultate, jih interpretirati, primerjati in nadgraditi
- na podlagi rezultatov matematičnega modeliranja oblikovati in napovedovati enostavnejše hipoteze

Intended learning outcomes:

Knowledge and Understanding:
Upon completion of the course, the student is able:
- to qualitatively and quantitatively (with physical and mathematical dependencies) describe selected complex theoretical biophysical concepts
- to apply these concepts on selected examples of complex models of biological systems
- to acquire data on model parameters by analyzing measurements in articles or from databases
- to analytically or with help of computer tools to solve selected complex existing models of biological systems, predict the results, to compare them and interpret them
- to predict simpler hypotheses on the basis of the results of mathematical modeling

Prenesljive/ključne spretnosti in drugi atributi: - sposobnost napredne uporabe računalniških orodij za modeliranje, za analitično in numerično računanje ter analizo podatkov - sposobnost napredne analize izmerjenih podatkov iz znanstvenih objav in zavedanje o njihovem pomenu za modeliranje bioloških sistemov - zavedanje o pomenu in koristnosti biofizikalnih teoretičnih pristopov k obravnavi bioloških sistemov za razvoj novih eksperimentov	Transferable/Key Skills and other attributes: - the ability to use advanced computer modeling tools, as well as tools for analytical and numerical computation and data analysis - ability of advanced analysis of measured data from scientific publications and awareness of their importance for modeling of biological systems - awareness of the importance and usefulness of biophysical theoretical approaches for the treatment of biological systems accounting for the development of new experiments

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja podkrepljena s simulacijami Seminar; pisne in ustne predstavitve projektnih nalog iz izbrane teme Seminarske in laboratorijske vaje (delo z računalnikom).	Lectures, supported by simulations Seminar; oral and written presentations of projects from selected topics Tutorials and laboratory work (work with computer)

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Ustni izpit ProjektIzdelan in predstavljen projekt je pogoj za pristop h končnemu preverjanju.	50 50	Oral exam Project Written and presented project is required for the approach to the final examination.

Reference nosilca / Lecturer's references:

1. FAJMUT, Aleš, PAL, Kaushik, HARKAI, Saša, ČREŠNAR, Dejvid, KUTNJAK, Zdravko, KRALJ, Samo. The core structure of a laboratory-made dust devil-like vortex and its condensed matter analogs. Journal of molecular structure. [Print ed.]. 2021, vol. 1237, str. 30335-1-30335-8. ISSN 0022-2860. DOI: 10.1016/j.molstruc.2021.130335. [COBISS.SI-ID 58279171]
2. ŠTERK, Marko, MARKOVIČ, Rene, MARHL, Marko, FAJMUT, Aleš, DOBOVIŠEK, Andrej. Flexibility of enzymatic transitions as a hallmark of optimized enzyme steady-state kinetics and thermodynamics. Computational biology and chemistry. [Print ed.]. Apr. 2021, vol. 91, str. 1-10. ISSN 1476-9271. DOI: 10.1016/j.compbiolchem.2021.107449. [COBISS.SI-ID 52543491]
3. FAJMUT, Aleš. Molecular mechanisms and targets of cyclic guanosine monophosphate (cGMP) in vascular smooth muscles. V: SAKUMA, Kunihiro (ur.). Muscle cell and tissue : novel molecular targets and current advances. London: IntechOpen, cop. 2021. Str. 1-31. ISBN 978-1-83968-651-1, ISBN 978-1-83968-650-4, ISBN 978-1-83968-652-8. https://www.intechopen.com/chapters/76823, DOI: 10.5772/intechopen.97708. [COBISS.SI-ID 79467011]