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.		2	3
Physics 2nd degree		2	3

Vrsta predmeta / Course type izbirni/ optional

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
75	15	0	30	0	180	10

Nosilec predmeta / Lecturer: Aleš Fajmut, Milan Brumen

Jeziki / Languages:		
	Predavanja / Lectures:	slovenski/Slovenian in/and angleški/English
	Vaje / Tutorial:	slovenski/Slovenian in/and angleški/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Klasična in moderna fizika, Molekularna biofizika.	Classical and modern physics, Molecular Biophysics

Vsebina:

Splošni opis predmeta:
Vsebina predmeta temelji na aplikaciji najnovejših teoretičnih (fizikalnih, kemijskih, matematičnih in računalniških) metod in orodij na biološko orientirane probleme in situacije. Obravnava se delovanje različnih kompleksnih bioloških sistemov, kot so metabolični sistemi, signalne mreže, organele, celice, organi, organizmi in populacije z vidika študija in obravnave delovanja njegovih sestavnih delov. Na podlagi razumevanja odnosov in interakcij med podenotami kompleksnejšega sistema je na ta način mogoče sklepati tudi na delovanje sistema kot celote.

Vsebina predavanj:
- UVOD:
- osnovni biološki in biokemijski principi
- osnovni fizikalni in matematični principi
- osnove dela z računalniškimi orodji za matematično modeliranje in delo z bazami podatkov
- osnovne eksperimentalne metode raziskovanja
- STANDARDNI PRISTOPI K MODELIRANJU BIOLOŠKIH SISTEMOV:
- biokemijska in encimska kinetika
- metabolične mreže
- kontrolna analiza
- signalne mreže (struktura, funkcija in

Content (Syllabus outline):

General description of the subject:
The subject introduces theoretical and computational tools and cutting edge research approaches from physics, chemistry, mathematics and computer science in the context of biological problems and situations. Functioning of different complex biological systems such as metabolic system, signaling networks, organelles, cells, organs, organisms and populations is discussed from the point of view of studying their integral parts. On the basis of understanding the interactions and relationships between the systems subunits it is be possible to deduce to the functioning of the system as integrity.

Lectures outline:
- INTRODUCTION:
- basic principles from biology and biochemistry
- basic principles from physics and mathematics
- basic principles of working with computer tools for mathematical modeling and working with databases
- basic experimental methods in systems biology
- STANDARD APPROACHES IN MODELING BIOLOGICAL SYSTEMS
- biochemical and enzyme kinetics
- metabolic networks

dinamika signalizacije ter medcelične in znotrajcelične komunikacije)
- IZBRANI PRIMERI MODELIRANJA BIOLOŠKIH SISTEMOV:
- oscilacije v bioloških sistemih
- prenos signalov
- krčenje gladkih in skeletnih mišic
- modeliranje delovanja celic in organov
- celični cikel
- staranje
- ekspresija genov
- evolucija in samoorganizacija
- APLIKACIJE VÉDENJA O BIOLOŠKIH SISTEMIH IN POGLED V PRIHODNOST

Vsebina seminarja:
Študent izbere eno izmed tem, ki jih razpiše predavatelj. Projektna naloga ima obliko krajšega znanstvenega prispevka. Študent po izdelavi in predavateljevem pregledu naloge pripravi predstavitev pred kolegi.

Vsebina laboratorijskih vaj:

- spoznavanje z računalniškimi orodji, kot so npr. Mathematica, MatLab, Madonna, Gepasi, PLAS, Model Maker, Virtual Cell…
- spoznavanje 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

- control analysis
- signal transduction pathways (structure, function and dynamics of signalling and inter- and intra-cellular communication)
- SELECTED EXAMPLES OF MODELING BIOLOGICAL SYSTEMS:
- oscillations in biological systems
- signal transduction
- skeletal- and smooth-muscle contraction
- whole cell modeling and modeling of organs
- cell cycle
- aging
- gene expression
- evolution and self-organization
- APPLICATION OF KNOWLEDGE FROM SYSTEMS BIOLOGY AND PERSPECTIVES FOR THE FUTURE

Seminar outline:
Student chooses one of the themes offered by the lecturer. Project has a form of short scientific contribution. After the review of the final version student presents his project for the colleagues.

Laboratory work outline:

- basic work with computer tools like Mathematica, MatLab, Madonna, Gepasi, PLAS, Model Maker, Virtual Cell…
- basic work with computer databases from the internet like BRENDA, Swiss-Prot, TrEMBL, UniProt…
- modeling of selected problems from systems biology
- solving of mathematical models and visualization of the results with help of computer tools

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
Voit E.O. Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists, Cambridge University Press, New York 2000
Vodovnik L., Miklavčič D., Kotnik T. Biološki sistemi, Univerza v Ljubljani, Fakulteta za elektrotehniko, Ljubljana 1998

Cilji in kompetence:

- Pri študentih razviti razumevanje kako in zakaj je teoretični pristop k obravnavi bioloških sistemov koristen za razvoj novih eksperimentov
- Študentom prikazati kako lahko dajo teoretični rezultati nov vpogled v delovanje bioloških sistemov
- Študente seznaniti z aktualnimi raziskovalnimi teoretičnimi metodami s področja bio-znanosti
- Študent spozna, da se da z matematičnim

Objectives and competences:

- To develop an understanding of how and why theoretical approaches can drive new experiments.
- To show students how theoretical results can deliver novel insight into the functioning of biosystems.
- To get an insight into the current theoretical research approaches in bio-sciences.
- To get an insight how to test the hypotheses resulting from molecular biology, physiology or biochemistry with mathematical modeling.

modeliranjem preizkušati hipoteze, ki izhajajo s področja molekularne biologije, fiziologije ali biokemije.	

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študent pridobi: - poznavanje in razumevanje fizikalnih, kemijskih, matematičnih in računalniških metod, ki se uporabljajo pri teoretičnem študiju bioloških sistemov; - zmožnost dela s predstavljenimi računalniškimi orodji in poznavanje drugih; - razumevanje obravnavanih teoretičnih primerov, poznavanje njihovih prednosti in slabosti ter seznanjenost z drugimi podobnimi primeri. Prenesljive/ključne spretnosti in drugi atributi: Zmožnost identificiranja pomembnih nerešenih problemov v bio-znanostih in zmožnost ocenitve, kako izbrati in rešiti probleme, pri katerih je teoretični in kvantitativni pristop smiseln in produktiven.	Knowledge and Understanding: Student gets: - knowledge and understanding of physical, chemical, mathematical and computational methods in theoretical approach to study biological systems; - ability of working with presented computational tools and having acquaintance with others; - understanding of presented theoretical examples, knowledge of their advantages and disadvantages, as well as having acquaintance with other similar examples. Transferable/Key Skills and other attributes: Ability to identify important unsolved problems in biology and ability to select and solve problems for which quantitative and theoretical approaches are productive.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• Predavanja • Seminar • Laboratorijske vaje	• Lectures • Seminar • Laboratory work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
• Ustno in pisno • Praktično delo v laboratoriju • Seminarska naloga	40 30 30	• Oral and written • Practical work in laboratory • Project

Reference nosilca / Lecturer's references:

Aleš Fajmut:

MBIKOU, Prisca, FAJMUT, Aleš, BRUMEN, Milan, ROUX, Etienne. Theoretical and experimental investigation of calcium-contraction coupling in airway smooth muscle. *Cell Biochem Biophys*, 2006, vol. 46, no. 3, str. 233-251. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list_uids=17272850&itool=iconabstr&query_hl=2&itool=pubmed_docsum. [COBISS.SI-ID 15168776]

FAJMUT, Aleš, BRUMEN, Milan. MLC-kinase/phosphatase control of Ca[sup]2+ signal transduction in airway smooth muscles. *J. theor. biol.*, 2008, vol. 252, no. 3, str. 474-481. http://dx.doi.org/10.1016/j.jtbi.2007.10.005, doi: 10.1016/j.jtbi.2007.10.005. [COBISS.SI-ID 15856392]

MBIKOU, Prisca, FAJMUT, Aleš, BRUMEN, Milan, ROUX, Etienne. Contribution of Rho kinase to the early phase of the calcium-contraction coupling in airway smooth muscle. *Exp. physiol. (Print)*, 2011, vol. 96,

issue 2, str. 240-258, ilustr., doi: 10.1113/expphysiol.2010.054635. [COBISS.SI-ID 18009864]

DOBOVIŠEK, Andrej, FAJMUT, Aleš, BRUMEN, Milan. Role of expression of prostaglandin synthases 1 and 2 and leukotriene C [sub] 4 synthase in aspirin-intolerant asthma: a theoretical study. *Journal of pharmacokinetics and pharmacodynamics*, 2011, vol. 38, no. 2, str. 261-278, doi: 10.1007/s10928-011-9192-6. [COBISS.SI-ID 18203144]

DOBOVIŠEK, Andrej, FAJMUT, Aleš, BRUMEN, Milan. Strategy for NSAID administration to aspirin-intolerant asthmatics in combination with PGE [sub] 2 analogue: a theoretical approach. *Med. biol. eng. comput.*. [Print ed.], 2012, vol. 50, no. 1, str. 33-42, doi: 10.1007/s11517-011-0844-x. [COBISS.SI-ID 18845192]

Milan Brumen:

DOBOVIŠEK, Andrej, ŽUPANOVIĆ, Paško, BRUMEN, Milan, BONAČIĆ LOŠIĆ, Željana, KUIĆ, Domagoj, JURETIĆ, Davor. Enzyme kinetics and the maximum entropy production principle. *Biophysical chemistry*. [Print ed.], 2011, vol. 154, iss. 2/3, str. 49-55, doi: 10.1016/j.bpc.2010.12.009. [COBISS.SI-ID 18206984]

MBIKOU, Prisca, FAJMUT, Aleš, BRUMEN, Milan, ROUX, Etienne. Contribution of Rho kinase to the early phase of the calcium-contraction coupling in airway smooth muscle. *Exp. physiol. (Print)*, 2011, vol. 96, issue 2, str. 240-258, ilustr., doi: 10.1113/expphysiol.2010.054635. [COBISS.SI-ID 18009864]

DOBOVIŠEK, Andrej, FAJMUT, Aleš, BRUMEN, Milan. Role of expression of prostaglandin synthases 1 and 2 and leukotriene C [sub] 4 synthase in aspirin-intolerant asthma: a theoretical study. *Journal of pharmacokinetics and pharmacodynamics*, 2011, vol. 38, no. 2, str. 261-278, doi: 10.1007/s10928-011-9192-6. [COBISS.SI-ID 18203144]

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BOHINC, Klemen, SHRESTHA, Ahis, BRUMEN, Milan, MAY, Sylvio. Poisson-Helmholtz-Boltzmann model of the electric double layer : analysis of monovalent ionic mixtures. *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, 2012, vol. 85, no. 3, str. 031130-1-031130-12, doi: 10.1103/PhysRevE.85.031130. [COBISS.SI-ID 4353131]