



Univerza v Mariboru

Fakulteta za naravoslovje  
in matematiko

### UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	<b>Izbrana poglavja iz molekularne biofizike</b>
<b>Course title:</b>	<b>Selected topics in molecular biophysics</b>

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
FIZIKA, 3. stopnja		1. ali 2.	1., 2. ali 4.
PHYSICS, 3 <sup>rd</sup> cycle		1. ali 2.	1., 2. or 4.

Vrsta predmeta / Course type

Izbirni za vse module

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje Field work	Samost. delo Individ. work	ECTS
15					165	6

Nosilec predmeta / Lecturer:

Janez Štrancar

Jeziki /

Languages:

Predavanja /

Lectures:

slovenski/Slovenian

Vaje / Tutorial:

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Ni posebnih zahtev.

Prerequisites:

No special prerequisites.

Vsebina:

Strukturiranje vode:

- tekmovalne interakcije v različnih lokalnih okoljih
- pogled na različnih časovnih skalah

Kompleksne strukture na osnovi DNK molekul:

**Content (Syllabus outline):**

Water Structure:

- Interaction competition in various local environments
- View through different time scales

DNA-based complex structures:

- osnove kvadropleksov in drugih kompleksnih DNK struktur,
- energetski, kinetični in dinamični vidik,
- DNK kvadropleksi v biologiji in človeškem genomu
- G-kvartet v supramolekularni kemiji in nanotehnologiji.

#### Raziskovanje struktur proteinov:

- dinamika različnih strukturnih elementov proteinov
- vpliv okolja proteinov na njihove lastnosti
- moč in slabosti klasičnih visoko ločljivih eksperimentalnih metod za določanje proteinskih struktur
- alternativne metode in njihove kombinacije za določanje proteinskih struktur

#### Samoorganizacija proteinskih molekul v virusih:

- življenjski cikel virusa
- energetika virusov, urejenost proteinskih mrež

#### Molekularni stroji:

- ATPase, miozinski motorji
- funkcija mikrotubulov
- ionski kanali v delovanju

#### Pomen lateralne heterogenosti bioloških membran:

- fazni diagrami hidriranih lipidnih mešanic, koeksistenca faz in njihova dinamika, tekmovanje energije in entropije
- interakcija peptidov in toksinov z membranami

- Basics of quadruplex and other DNA structures
- Energy, kinetic, dynamic view
- DNA quadruplex in biology and human genome
- G-quartet in supramolecular chemistry and Nanotechnology

#### Protein structure exploration:

Dynamics of different protein structural elements

Environmental impact on protein structural properties

Advantages / disadvantages of classical high-resolution experimental methods for protein structure determination

Alternative methods and their combinations for protein structure determination

#### Self-organization of protein molecules in viruses:

- Virus life cycle
- Energetics of viruses, ordering in protein networks

#### Molecular machines:

- ATPase, myosin motors,
- Function of microtubule
- Ion channels in action

#### The importance of biomembrane lateral heterogeneity:

- Phase diagrams of hydrated lipid mixtures, phase coexistence and their dynamics, energy / entropy competition
- Peptide-membrane / toxin-membrane interaction

- membranske domene in rafti - pogled skozi različne eksperimentalne metode

#### Ekstracelularne polisaharidne mreže:

- samoorganizacija polisaharidnih mrež
- biološko/biofizikalno relevantne posledice strukturiranosti prostora in usmerjene difuzije

#### Samosestavljanje kompleksov nanomaterialov, proteinov in lipidov:

- pojav biokorone
- pojav lipidnega ovijanja
- membranska destabilizacija
- nove pojavnosti celične smrti

- Function role of membrane domains and rafts – an overview through different experimental methods

#### Extra-cellular polysaccharide networks:

- Self-assembly of polysaccharide networks
- Biologically / biophysically relevant consequences of spatial structure / rheology and constrained diffusion

#### Self-assembly of nanoparticles, proteins and lipids:

- Biocorona
- Lipid wrapping
- Membrane destabilization
- New phenomena of cell death

### **Temeljni literatura in viri / Readings:**

- 1) J. Israelaschvili: Intermolecular Interactions & Surface Forces. Academic Press, London, 1992.
- 2) R.J. Nossal in H. Lecar: Molecular and Cell Biophysics. Addison Wesley, NY, 1991.
- 3) S. Kauffman: At home in the universe: the search for laws of complexity. Penguin Science, London 1995.
- 4) Ahmed H. Zewail: Physical Biology: From Atoms to Medicine (Paperback), Imperial College Press, 2008
- 5) Tom Waigh: Applied Biophysics: A Molecular Approach for Physical Scientists, Willey-Interscience, 2007
- 6) Martin Beckerman: Molecular and Cellular Signaling, Springer, 2005

#### **Cilji in kompetence:**

Študenti so sposobni sestavljati obstoječa znanja in najnovejše raziskave z lastnim raziskovalnim delom na področju molekularnih znanosti s posebnim poudarkom na uporabi fizikalnih pristopov in načina reševanja molekularnih problemov

#### **Objectives and competences:**

Students can couple existing knowledge and the latest research with their own research work in fields of molecular sciences with special focus on implementation of physical approach and ways of solving molecular problems.

#### **Predvideni študijski rezultati:**

#### **Intended learning outcomes:**

<p><b>Znanje in razumevanje:</b></p> <p>Poglobljena analiza trenutnega znanja in glavnih tem na področju molekularne biofizike in mejnih področij molekularne biologije ter fizikalne biokemije.</p> <p>Vrednotenje lastnih rezultatov v luči najnovejših raziskav</p> <p>Zmožnost sinteze naprednih fizikalnih konceptov kot so samosestavljanje, dinamika in kompleksnost struktur in mrež s klasičnimi molekularno biološkimi in biokemijskimi koncepti</p> <p><b>Prenesljive/ključne spretnosti in drugi atributi:</b></p> <ul style="list-style-type: none"> <li>• sposobnost reševanja konkretnih interdisciplinarnih raziskovalnih problemov v molekularno bioloških vedah s fizikalnimi orodji, univerzalnosti v fiziki in celostnim pristopom k reševanju biofizikalnih problemov,</li> <li>• sposobnost oblikovanja in implementacije izvirnih znanstvenih rešitev v danih biofizikalnih in interdisciplinarnih problemov,</li> <li>• poglobljena analiza teoretskih in metodoloških molekularno biofizikalnih konceptov.</li> </ul>
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<p><b>Knowledge and understanding:</b></p> <p>Deep analysis of the current frontiers and expertise in the field of molecular biophysics, molecular biology and physical biochemistry. Evaluation of own results with respect to the state-of-the-art</p> <p>Ability of synthesis of advanced physical concepts such as selfassembly, dynamics and complexity of structures and networks with classical molecular biology and biochemical concepts</p> <p><b>Transferable/Key Skills and other attributes:</b></p> <ul style="list-style-type: none"> <li>• ability of solving interdisciplinary problems in molecular biology sciences with physical tools, universalities in physics and gained global approach on solving a biophysical problem,</li> <li>• ability of defining and implementing unique scientific solution within defined biophysical and interdisciplinary problems</li> <li>• deeper analysis of theoretical and methodological molecular biophysical concepts.</li> </ul>
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**Metode poučevanja in učenja:**

Predavanja, Problemsko učenje , seminar in izdelava seminarske naloge oz. članka iz področja molekularne biofizike.
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**Learning and teaching methods:**

Lectures, problem-based learning, seminar and work out of seminar work or paper from the field of molecular biophysics.
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**Načini ocenjevanja:**

Način (pisni izpit, ustno izpraševanje, naloge, projekt)
Ustni izpit

Delež (v %) /

Weight (in %)

**Assessment:**

Type (examination, oral, coursework, project):
Oral exam

**Reference nosilca / Lecturer's references:**

URBANČIČ, Iztok, GARVAS, Maja, KOKOT, Boštjan, MAJARON, Hana, UMEK, Polona, ŠKARABOT, Miha, ARSOV, Zoran, KOKLIČ, Tilen, ČEH, Miran, MUŠEVIČ, Igor, ŠTRANCAR, Janez, et al.
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Nanoparticles can wrap epithelial cell membranes ... *Nano letters*, 2018, vol. 18, no. 8, str. 5294-5305, doi: 10.1021/acs.nanolett.8b02291.

PODLIPEC, Rok, ŠTRANCAR, Janez. Cell-scaffold adhesion dynamics ... *ACS applied materials & interfaces*, 2015, vol. 7, no. 12, 6782-6791

ARSOV, Zoran, URBANČIČ, Iztok, GARVAS, Maja, BIGLINO, Daniele, LJUBETIČ, Ajasja, KOKLIČ, Tilen, ŠTRANCAR, Janez. Fluorescence microspectroscopy ... *Biomedical optics express*, 2011, vol. 2, no. 8, 2083-2095

KAVALENKA, Aleh A., URBANČIČ, Iztok, KURE, Sandra, ŠTRANCAR, Janez, et al. Conformational analysis ... *Biophysical journal*, 2010, vol. 98, no. 6, 1055-1064

BELLE, Valerie, ŠTRANCAR, Janez, et al. Mapping  $\alpha$ -helical induced folding ... *Proteins*, 2008, issue 4, vol. 73, 973-988

PODLIPEC, Rok, GORGIEVA, Selestina, JURAŠIN, Darija, URBANČIČ, Iztok, KOKOL, Vanja, ŠTRANCAR, Janez. Molecular mobility of scaffolds' biopolymers influences cell growth. *ACS applied materials & interfaces*, ISSN 1944-8244. [Print ed.], 2014, vol. 6, iss. 18, str. 15980-15990, doi: 10.1021/am5037719. [COBISS.SI-ID 18043926] 1. SEDMAK, Ivan, URBANČIČ, Iztok, PODLIPEC, Rok, ŠTRANCAR, Janez, MORTIER, Michel, GOLOBIČ, Iztok. Submicron thermal imaging of a nucleate boiling process using fluorescence microscopy. *Energy*, ISSN 0360-5442. [Print ed.], Aug. 2016, vol. 109, str. 436-445, ilustr., doi:10.1016/j.energy.2016.04.121. [COBISS.SI-ID 14672155]

LJUBETIČ, Ajasja, URBANČIČ, Iztok, ŠTRANCAR, Janez. Recovering position-dependent diffusion from biased molecular dynamics simulations. *The Journal of chemical physics*, ISSN 0021-9606, 2014, vol. 140, no. 8, str. 084109-1-084109 -11, doi: 10.1063/1.4866448. [COBISS.SI-ID28006951]

URBANČIČ, Iztok, LJUBETIČ, Ajasja, ŠTRANCAR, Janez. Resolving internal motional correlations to complete the conformational entropy meter. *The journal of physical chemistry letters*, ISSN 1948-7185, 2014, vol. 5, no. 20, str. 3593-3600, doi: 10.1021/jz5020828. [COBISS.SI-ID28004647]

KRIVEC, Matic, DILLERT, Ralph, BAHNEMANN, Detlef W., MEHLE, Alma, ŠTRANCAR, Janez, DRAŽIČ, Goran. The nature of chlorine-inhibition of photocatalytic degradation of dichloroacetic acid in a TiO<sub>2</sub>-based microreactor. *PCCP. Physical chemistry chemical physics*, ISSN 1463-9076, 2014, vol. 16, issue 28, str. 14867-14873, doi: 10.1039/C4CP01043D. [COBISS.SI-ID 27660327]

URBANČIČ, Iztok, LJUBETIČ, Ajasja, ARSOV, Zoran, ŠTRANCAR, Janez. Coexistence of probe conformations in lipid phases : a polarized fluorescence microspectroscopy study. *Biophysical journal*, ISSN 0006-3495, 2013, vol. 105, no. 4, str. 919-927, doi: 10.1016/j.bpj.2013.07.005. [COBISS.SI-ID 26970919]

URBANČIČ, Iztok, ARSOV, Zoran, LJUBETIČ, Ajasja, BIGLINO, Daniele, ŠTRANCAR, Janez. Bleaching-corrected fluorescence microspectroscopy with nanometer peak position resolution. *Optics express*, ISSN 1094-4087, 2013, vol. 21, no. 21, str. 25291-25306, doi: 10.1364/OE.21.025291. [COBISS.SI-ID 27156007]