UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika v biologiji
Course title:	Physics in Biology

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Nanoznanosti in nanotehnologije, 2. stopnja	/	1	2
Nanosciences and nanotechnologijes, 2nd cycle	/	1	2

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code: NANO2-268

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike Other	Samost. delo Individ. work	ECTS
30	30			30	210	**10**

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer: Prof. dr. Janez Štrancar

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

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

Zaključen študij prve stopnje s področja naravoslovja ali tehnike ali zaključen študij prve stopnje na drugih področjih z znanjem osnov s področja predmeta.

Prerequisits:

Completed first cycle studies in natural sciences or engineering or completed first cycle studies in other fields with knowledge of fundamentals in the field of this course.

Vsebina:

1. **Molekularna struktura in biološki sistemi**: molekularne vezi, atomske orbitale, molekularne orbitale, kovalenta vez, ionska vez, koordinativne vezi, kovino-organski kompleksi, Van der Waalsova sila, vodikova vez, vzbujanje in prenos energije, vzbujanje molekul in prenos energije, mehanizmi fotovzbujanja molekul, mehanizmi molekularnega prenosa energije, eksperimentalne tehnike: UV/Vis spektroskopija, fluorescenčna spektroskopija, fluorescenčni prenos resonančne energije (FRET)
2. **Molekulske in ionske interakcije kot osnova za oblikovanje bioloških struktur:** struktura vode, učinki hidracije, hidrofobne interakcije, amfifilne

Content (Syllabus outline):

1. **Molecular Structure and Biological Systems ,** Intramolecular Bonds , Atomic orbitals , Molecular orbitals, covalent bonds , Ionic bonds, Coordinative bonds, metallo-organic complexes , Van der Waals forces, Hydrogen bonds , Excitation and Energy Transfer , Molecular excitation and energy transfer , Mechanisms of photo-induced molecular excitation , Mechanisms of molecular energy transfer , Experimental techniques: UV/Vis spectroscopy , Fluorescence spectroscopy, Fluorescence resonance energy transfer (FRET)
2. **Molecular and Ionic Interactions as the Basis for the Formation of Biological Structures** , The water structure, effects of hydration,

molekule, Ioni v vodnih raztopinah, Debye-Huckleov radij, medmolekularne interakcije, oblikovanje strukture bioloških makromolekul

3. **Biološki polimeri**: nukleinske kisline, kemijska struktura nukleinskih kislin, struktura dvojne vijačnice DNA, dodatno zvitje DNA in nenavadne strukture DNA, struktura prenašalne RNA, proteini, aminokisline in primarna struktura proteinov, peptidna vez in sekundarna struktura proteinov, terciarna struktura – zvijanje proteinov, kvartarna struktura, struktura virusov, eksperimentalne tehnike: cirkularni dikroizem (CD) in optična rotacijska disperzija (ORD), infrardeča spektroskopija, Ramanova spektroskopija
4. **Dinamika proteinov**: časovne skale lokalne dinamike stranskih verig in globalne dinamike, rotacijski konformacijski prostori, dinamika kvartarne strukture, eksperimentalne tehnike: elektronska paramagnetna resonanca (EPR) s specifičnim spinskim označevanjem
5. **Supramolekularne strukture - Biološke membrane – dvodimenzionalne supramolekularne strukture:** lipidi - gradniki biomembran in enostavnih lipidnih vesiklov, tekoče kristalna narava in fazni diagrami, heterogenost in dinamika bioloških membran, lipidni dvosloj kot okolje za strukturiranje membranskih proteinov, eksperimentalne tehnike: elektronska paramagnetna resonanca (EPR) z nespecifičnim spinskim označevanjem
6. **Amfifilni transportni sistemi - Trodimenzionalne supramolekularne strukture:** lipoproteinski delci – struktura in funkcija, farmacevtski transportni sistemi na osnovi trdnih lipidnih nanodelcev, polisaharidne strukture na površini biomembran – primerjava strukture in funkcije med površinami evkariontske in prokariontske celice, eksperimentalne tehnike: rentgensko sipanje pri majhnih kotih (SAXS)
7. **Interakcije med biološkimi strukturami in bioaktivnimi molekulami:** primeri interakcij med bioaktivnimi molekulami in makromolekulami, protein / toksin - membranski proteinski receptor, nanodelci in reaktivne molekule – nenasičeni deli gradnikov bioloških struktur, primeri interakcij med bioaktivnimi molekulami in supramolekularnimi strukturami, toksin / virusni plaščni protein – membranske domene, eksperimentalne

hydrophobic interactions, amphiphilic molecules , Ions in aqueous solutions, the Debye-Huckle radius , Intermolecular interactions , Structure formation of macrobiomolecules

3. **Biological Polymers** , Nucleic Acids , The chemical structure of nucleic acids , The double-helical structure of DNA , DNA supercoiling and unusual DNA structures , The structure of transfer RNA , Proteins , Amino acids and the primary structure of proteins , The peptide bond and secondary structure of proteins , Tertiary structure – protein folding , Quaternary structure , Virus structure , Experimental techniques: Circular dichroism (CD) and optical rotary dispersion (ORD) , Infrared spectroscopy , Raman spectroscopy ,
4. **Dynamics of protein** , Time scales of local side-chain and global dynamics , Rotational conformational spaces , Quaternary structure dynamics , Experimental technique: Site-directed spin labeling EPR
5. **Supramolecular structures** - **Biological membranes – twodimenzional supramolecular structures** Lipids – constituent of biomembranes and simple lipid vesicles , Liquid crystal nature and phase diagrams , Heterogeneity and dynamics of biomembranes , Lipid bilayers as a constrained for membrane protein structuring , Experimental techniques: electron paramagnetic resonance (EPR) with non-specific spin labelling
6. **Amphiphilic transport systems – Threedimensional supramolecular structures** Lipoprotein particles – structure and function , Pharmaceutical transport systems based on lipid solid nanoparticles , Polysaccharide structures on membrane surfaces – comparison of structure and function of surfaces between eukaryotic and prokaryotic cells , Experimental techniques: small angle x-ray scattering (SAXS)
7. **Interaction between biological structures and bioactive substances** Examples of interactions between bioactive molecules and macromolecules , Protein /toxin – membrane protein receptor , Nanoparticles and reactive molecules – unsaturated parts of constituents of biological structures , Examples of interactions between bioactive molecules and supramolecular structures , Toxin / viral coat protein – membrane domains , Experimental

tehnike: konfokalna fluorescenčna (mikro)spektroskopija (CFMS), superločljive mikroskopije, kot je STED	techniques: confocal fluorescence (micro)spectroscopy (CFMS), superresolution microscopies such as STED

Temeljni literatura in viri / Readings:

- Rodney Cotterill: Biophysics: An Introduction, John Wiley & Sons, New York (2002).
- Roland Glaser: Biophysics, Springer, Heidelberg (1996).
- T.A.Waigh: Applied Biophysics: A Molecular Approach for Physical Scientists. Wiley & Sons. 2007.
- M.B.Jackson: Molecular and Cellular Biophysics. Cambridge press, 2006.
- J. Israelaschvili: Intermolecular and Surface Forces. Academic Press, London, 2011.
- I.N.Serdyuk, N.R.Zaccai, J.Zaccai: Methods in Molecular Biophysics. Cambridge press, 2007.
- J. Israelaschvili: Intermolecular interactions & surface forces. Academic press, London, 1992.
- R. Nossar, H. Lecar: Molecular and cell biophyics. Addison Wesley, NY, 1991.

Cilji in kompetence:

Učni cilji:

- Študentje so sposobni razumeti strukture v bioloških sistemih.
- Študentje so sposobni proučiti molekularne strukture, od nivoja molekul, supramolekularnih struktur in celičnih organel do makroskopskih struktur.
- Študentje so sposobni izbrati in ovrednotiti izbiro primernih eksperimentalnih metod za karakterizacijo bioloških struktur.
- Študentje so sposobni uporabiti temeljne fizikalne koncepte in fizikalni način razmišljanja za razumevanje molekularnih struktur.

Kompetence:

- Sposobnost ovrednotenja pogojev analiz vzorcev pri eksperimentalnem delu z biološkimi strukturami.
- Sposobnost interpretacije eksperimentalnih rezultatov na bioloških strukturah.
- Sposobnost informiranja o strukturni snovi na molekularni ravni.
- Sposobnost izvajanja varnega načina dela (preiskav).
- Sposobnost kontinuiranega profesionalnega razvoja in upravljanja lastne rasti.

Objectives and competences:

Objectives:

- Students can understand the structures in biologial systems.
- Students can analyze molecular structures at the level of molecules, supramolecular structures, cell organelles, and macroscopic systems.
- Students can select and evaluate the selection of experimental methods to characterize the molecular structures.
- Students can apply the basic physical concepts and physical way of thinking to understand the molecular structures.

Competences:

- Ability of evaluation the conditions of experimental work with biological structures.
- Ability of interpretation of the experimental results on biological structures.
- Ability of informing about the structure of matter on molecular level.
- Ability of performing safe work and analysis.
- Ability of continuous profesional development and personal growth.

Predvideni študijski rezultati:

Študenti se spoznajo z molekularno strukturo bioloških sistemov, načini njihovega vzbujanja ter vlogah, ki jih imajo molekulske in ionske interakcije pri njihovem oblikovanju. Podrobneje se seznanijo z biološkimi polimeri – nukleinskimi kislinami in proteini. Skozi praktično delo v laboratoriju

Intended learning outcomes:

Students become acquainted with molecular structure of biological systems, their excitations and roles which molecular and ionic interactions play in their formation. Particularly, they will study biological polymers – nucleic acids and proteins. Through practical work in a laboratory they will

pridobijo osnove nekaterih spektroskopskih metod, ki se uporabljajo v raziskavah bioloških makromolekul. Seznanijo se tudi z dinamiko bioloških molekul ter s tehnikami, ki omogočajo raziskovanje časovne komponente bioloških procesov na molekularni ravni. Nadalje spoznajo supramolekularne sisteme, kot so biološke membrane in tehnike, ki omogočajo nedestruktiven pogled v strukturiranost, in delovanje teh kompleksnih sistemov. Nazadnje pa spoznajo tipične interakcijske poti, preko katerih z molekularnimi, makromolekularnimi in supramolekularnimi biološkimi strukturami interagirajo različne bioaktivne snovi, od toksinov do nanomaterialov.	learn basics of selected spectroscopy techniques used in the research of biological macromolecules. Furthermore they will get basic knowledge about dynamics of biological molecules as well as the techniques which enable exploration of the time evolution of biological processes on molecular scale. The students also learn about structure and function of the supramolecular structures. Finally, they get familiar with the tipical interaction pathways of the several bioactive substances from toxins to nanoparticles interacting with molecular, macromolecular and supramolecular biological structures.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivna predavanja Seminar Konzultacije Individualno voden študij	Interactive lectures Seminar Consultations Individual guided studies

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminar	50 %	Seminar
Ustni izpit	50 %	Oral examination

Reference nosilca / Lecturer's references:

- ANDJELIĆ, Sofija, DRAŠLAR, Kazimir, HVALA, Anastazija, LOKAR, Nina, ŠTRANCAR, Janez, HAWLINA, Marko. Anterior lens epithelial cells attachment to the basal lamina. Acta ophthalmologica, ISSN 1755-375X, May 2016, vol. 94, iss. 3, str. e183-e188.
- 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.
- PODLIPEC, Rok, ŠTRANCAR, Janez. Cell-scaffold adhesion dynamics measured in first seconds predicts cell growth on days scale - optical tweezers study. ACS applied materials & interfaces, ISSN 1944-8244. [Print ed.], 2015, vol. 7, no. 12, str. 6782-6791
- 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
- 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