NANOZNANOSTI – TEORETIČNI PREDMETI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Biofizika membran in bioloških nanostruktur
Course title:	Biophysics of membranes and biological nanostructures

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Bioznanosti, tretja stopnja, doktorski	nanoznanosti		Celoletni

Univerzitetna koda predmeta/University course code:	3821

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
20	25	5	0	10	190	10

Nosilec predmeta/Lecturer:	Veronika Kralj Iglič

Izvajalci predavanj:	Aleš Iglič, Veronika Kralj Iglič
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	teoretični/theoretical

Jeziki/Languages:	Predavanja/Lectures:	Angleščina, Slovenščina
	Vaje/Tutorial:	Angleščina, Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
splošni pogoji za vpis na doktorski študij	General conditions for enrolment in doctoral studies

Vsebina:	Content (Syllabus outline):
Termodinamski opis sistemov z velikim številom delcev: fazna vsota, entropija, prosta energija, kemijski potencial, elektrokemijski potencial, osmotski tlak. *Sestava bioloških membran*: lipidne molekule, proteini, glikoproteini, membranski skelet,	*Thermodynamic description of systems with a large number of particles:* phase sums, entropy, free energy, chemical potential, electrochemical potential, osmotic pressure. *Composition of biological membranes:* lipid molecules, proteins, glycoproteins, membrane

oblika lipidov in proteinov, električne lastnosti lipidov in proteinov	skeletons, forms of lipids and proteins, electrical properties of lipids and proteins.
Samoorganizacija lipidov in proteinov: linearni agregati mebranskih sestavin, agregacija lipidnih molekul v micele in lipidne dvojne plasti, biološko pomembne nelamelarne lipidne faze, tvorba fleksibilnih membranskih nanodomen, lateralna fazna separacija membranskih sestavin, agregacija nanodomen, tvorba in stabilnost membranskih nanotub.	*Self-organisation of lipids and proteins:* linear aggregates of membranous components, aggregation of lipid molecules in mycelia and lipid double layers, biologically important non-lammelular lipid phases, formation of flexible membranous nano-domains, lateral phase separation of membranous components, aggregation of nanodomains, formation and stability of membranous nanotubes.
Električne lastnosti membran: deformacije v ravnini membrane, upogibna energija, vpliv oblike membranskih sestavin in direktnih interakcij med membranskimi sestavinami na elastične lastnosti membran, lateralna porazdelitev membranskih sestavin in elastične lastnosti membrane, elastičnih lastnosti membrane ter oblika celic in organel, vpliv citoskeleta na obliko celice.	*Elastic properties of membranes:* deformations in levels of a membrane, flexible energy, influence of forms of membrane components and direct interactions between membranous components in elastic properties of membranes, lateral distribution of membranous components and elastic properties of membranes, elastic properties of membranes and forms of cells and organelles, influence of cytoskeleton on forms of cells.
Električne lastnosti membran: električna dvojna plast, Poisson-Boltzmannova teorija električne dvojne plasti, Gouy-Chapmanov model električne dvojne plasti, prosta energija električne dvojne plasti, vpliv končne velikosti molekul in porazdelitve naboja znotraj posamezne molekule na lastnosti električne dvojne plasti, vpliv velikosti in porazdelitve električnega naboja membrane na transport naelektrenih molekul preko membrane, vezava in adhezija naelektrenih molekul na površino membrane.	*Electric properties of membranes:* electric double layer, Poisson-Boltzmann theory of electric double layer, Gouy-Chapman model of electric double layer, free energy of electric double layer, influence of final size of molecule and distribution of charge within individual molecules on the properties of an electrical double layer, influence of size and distribution of electrical charge of a membrane on transport of electrified molecules through a membrane, bonds and adhesion of electrified molecules on the surface of a membrane.
Elektrostatske Interakcije med membranskimi površinami: vpliv sestave raztopine na interakcije med membranami, vpliv električnih lastnosti molekul v raztopini na interakcije med membranami, adhezija membran.	*Electrostatic interaction between membrane surfaces:* influence of components of solvents on the interaction between membranes, influence of electrical properties of molecules in solvents on the interaction between membranes, adhesion of membranes.
Transport in komunikacije med celicami in organelami: mehanizmi miikro- in nano-vesikulacije, vpliv električnih lastnosti membran in raztopine na vesikulacijo membran, endocitoza, eksocitoza, fuzija vesiklov, enkapsulacija nanodelcev in DNA, vpliv detergentov in nanodelcev na vesikulacijo in obliko membrane, mehanizmi stabilnosti in tvorbe membranskih nanotub ter njihova vloga pri transportu snovi med celicami in med	*Transport and communication* ***between cells and organelles****:* mechanisms of micro- and nano-vesiculation, influence of electrical properties of membranes and solvens on the vesiculation of membranes, endocytosis, exocytosis, fusion of vesicles, encapsulation of nano-particles and DNA, influence of

celičnimi organelami. Mikrovesikulacija membran in njena vloga pri razširjanju tumorjev in nastajanju krvnih strdkov. Mehanizmi nastajanje in stabilnost membranskih por.	detergents and nano-particles on vesiculation and forms of membrane, mechanisms of stability and formations of membrane nanotubes and their role in the transport of substances between cells and between cell organelles. Microvesiculation of membranes and its role in spreading tumours and creation of blood clots. Mechanisms of creation and stability of membrane pores.

Temeljna literatura in viri/Readings:
- Iglič, D. Drobne, V. Kralj Iglič: Nanostructures in biological systems - theory and applications, Pan Stanford Publishing Pte. Ltd., Singapur, 2014 (in print). • J. Israelachvili: Intermolecular and Surface Forces, Academic Press ltd., London, vsakokratna nova izdaja. • T.L. Hill: An Introduction to Statistical Thermodynamics, Dover Publications, New York, USA, 1986. • aktualni znanstveni članki iz področja, ki jih sproti določijo izvajalci predmeta.

Cilji in kompetence:	Objectives and competences:
Študenti se seznanijo z biofizikalnim opisom bioloških membran s pomočjo uveljavljenih modelov elektrostatičnih in elastičnih lastnosti membran in membranskih mikro- ter nano-struktur. Prikazani bodo izbrani najnovejši rezultati s področja biofizike membranskih nanostruktur. Izobraževalni cilji: Temeljni izobraževalni cilj je poglobitev znanja za delo s celičnimi membranami, celicami in umetnimi lipidnimi sistemi ter pridobitev znanja na področju raziskav vpliva različnih snovi kot so maščobe, detergenti in nanodelci na stabilnost membrane, membransko vesikulacijo, medcelične komunikacije ter patološka stanja membrane in celice.	Students are familiarised with biophysical description of biological membranes with the aid of established models of electrostatic and elastic properties of membranes and membranous micro- and macro-nanostructures. Selected most recent results in the field of biophysics of membranous nanostructures will be presented. Educational aims: The basic educational aim is to deepen knowledge for work with cell membranes, cells and artificial lipid systems and to obtain knowledge in the field of research into the influence of various substances, such as fats, detergents and nanoparticles, on the stability of membranes, membrane vesicules, inter-cellular communication and pathological states of membranes and cells.

Predvideni študijski rezultati:	Intended learning outcomes:
Kandidata usposobiti za izvedbo omenjenih raziskav, katerih rezultati bodo predstavljali pomembne prispevke temeljni ali aplikativni znanosti na področju študija mebranskih lastnosti in membranske vesikulacije ter komunikacije med celicami v povezavi z študijem različnih bolezenskih stanj na nivoju membrane in celice, na primer razširjanje tumorjev ter nastajanje krvnih strdkov.	To qualify the candidate for carrying out the mentioned research, the results of which will make an important contribution to basic and applicative science in the field of studies of membrane properties and membrane vesiculation and communication between cells, in connection with the study of various disease states on the level of membranes and cells, such as the spread of tumours and the creation of blood clots.

Metode poučevanja in učenja:	Learning and teaching methods:
Predavanja, seminarji, konzultacije, projektno/ seminarsko delo.	Lectures, seminars, consultations, project/seminar work.

Načini ocenjevanja:	Delež/Weight	Assessment:
Seminar ali projekt.	100,00 %	Seminar or project.

Reference nosilca/Lecturer's references:

prof. dr. Veronika Kralj-Iglič (nosilka):

1. OGOREVC, Eva, ŠTUKELJ, Roman, BEDINA ZAVEC, Apolonija, ŠUŠTAR, Vid, ŠIMUNDIĆ, Metka, KRALJ-IGLIČ, Veronika, JANŠA, Rado. A 32-month follow-up study of nanovesicle concentrations in blood from 12 patients with gastrointestinal stromal tumour treated with imatinib. *Biochemical Society transactions*, ISSN 0300-5127, Feb. 2013, vol. 41, no. 1, str. 303-308, ilustr., doi: 10.1042/BST20120247. [COBISS.SI-ID 9629012], [JCR, SNIP, WoS up to 12. 3. 2013: no. of citations (TC): 0, without self-citations (CI): 0, weighted no. of citations (NC): 0, Scopus up to 14. 2. 2013: no. of citations (TC): 0, pure citations (CI): 0, normalized no. of pure citations (NC): 0]

2. JESENEK, Dalija, PERUTKOVÁ, Šárka, GÓŹDŹ, Wojciech, KRALJ-IGLIČ, Veronika, IGLIČ, Aleš, KRALJ, Samo. Vesiculation of biological membrane driven by curvature induced frustrations in membrane orientational ordering. *International journal of nanomedicine*, ISSN 1178-2013. [Online ed.], 2013, vol. 8, no. 1, str. 677-687, ilustr. http://www.dovepress.com/articles.php?article_id=12253. [COBISS.SI-ID 4516971], [JCR, SNIP, Scopus up to 8. 3. 2013: no. of citations (TC): 0, pure citations (CI): 0, normalized no. of pure citations (NC): 0]

3. OGOREVC, Eva, HUDOKLIN, Samo, VERANIČ, Peter, KRALJ-IGLIČ, Veronika. Extracellular vesicle-mediated transfer of membranous components from the highly malignant T24 urinary carcinoma cell line to the non-malignant RT4 urinary papilloma cell line. *Protoplasma*, ISSN 0033-183X, 2013, vol. , no. , str. 1-4, ilustr. http://link.springer.com/article/10.1007/s00709-013-0544-5/fulltext.html, doi: 10.1007/s00709-013-0544-5. [COBISS.SI-ID 10148948], [JCR, SNIP, Scopus up to 7. 10. 2013: no. of citations (TC): 0, pure citations (CI): 0, normalized no. of pure citations (NC): 0]

4. ZUPANC, Jernej, DROBNE, Damjana, DRAŠLER, Barbara, VALANT, Janez, IGLIČ, Aleš, KRALJ-IGLIČ, Veronika, MAKOVEC, Darko, RAPPOLT, Michael, SARTORI, Barbara, KOGEJ, Ksenija. Experimental evidence for the interaction of C-60 fullerene with lipid vesicle membranes. *Carbon*, ISSN 0008-6223. [Print ed.], 2012, vol. 50, no. 3, str. 1170-1178. http://dx.doi.org/10.1016/j.carbon.2011.10.030, doi: 10.1016/j.carbon.2011.10.030. [COBISS.SI-ID 2451279], [JCR, SNIP, WoS up to 1. 1. 2014: no. of citations (TC): 6, without self-citations (CI): 5, weighted no. of citations (NC): 2, Scopus up to 25. 12. 2013: no. of citations (TC): 7, pure citations (CI): 6, normalized no. of pure citations (NC): 2]

5. LOKAR, Maruša, KABASO, Doron, RESNIK, Nataša, SEPČIĆ, Kristina, KRALJ-IGLIČ, Veronika, VERANIČ, Peter, ZOREC, Robert, IGLIČ, Aleš. The role of cholesterol-sphingomyelin membrane nanodomains in the stability of intercellular membrane nanotubes. *International journal of nanomedicine*, ISSN 1178-2013. [Online ed.], 2012, vol. 7, str. 1891-1902, ilustr. http://dx.doi.org/10.2147/IJN.S28723, doi: 10.2147/IJN.S28723. [COBISS.SI-ID 2548559], [JCR, SNIP, WoS up to 17. 9. 2013: no. of citations (TC): 2, without self-citations (CI): 1, weighted no. of citations (NC): 0, Scopus up to 10. 7. 2013: no. of citations (TC): 3, pure citations (CI): 1, normalized no. of pure citations (NC): 0]

6. ŠUŠTAR, Vid, ZELKO, Jasna, LOPALCO, Patrizia, LOBASSO, Simona, OTA, Ajda, POKLAR ULRIH, Nataša, CORCELLI, Angela, KRALJ-IGLIČ, Veronika. Morphology, biophysical properties and protein-

mediated fusion of archaeosomes. *PloS one*, ISSN 1932-6203, 2012, vol. 7, no. 7, str. 1-15, e39401, doi: 10.1371/journal.pone.0039401. [COBISS.SI-ID 4113016], [JCR, SNIP, WoS up to 10. 7. 2013: no. of citations (TC): 3, without self-citations (CI): 3, weighted no. of citations (NC): 1, Scopus up to 15. 5. 2013: no. of citations (TC): 2, pure citations (CI): 2, normalized no. of pure citations (NC): 1]
7. ŠUŠTAR, Vid, BEDINA ZAVEC, Apolonija, ŠTUKELJ, Roman, FRANK, Mojca, BOBOJEVIĆ, Goran, JANŠA, Rado, OGOREVC, Eva, KRULJC, Peter, MAM, Keriya, ŠIMUNIČ, Boštjan, MANČEK KEBER, Mateja, JERALA, Roman, ROZMAN, Blaž, VERANIČ, Peter, HÄGERSTRAND, Henry, KRALJ-IGLIČ, Veronika. Nanoparticles isolated from blood : a reflection of vesiculability of blood cells during the isolation process. *International journal of nanomedicine*, ISSN 1178-2013. [Online ed.], 2011, vol. 6, str. 2737-2748. http://www.dovepress.com/nanoparticles-isolated-from-blood-a-reflection-of-vesiculability-of-bl-peer-reviewed-article-IJN, doi: org/10.2147/IJN.S24537. [COBISS.SI-ID 29065433], [JCR, SNIP, WoS up to 21. 1. 2014: no. of citations (TC): 13, without self-citations (CI): 8, weighted no. of citations (NC): 3, Scopus up to 29. 1. 2014: no. of citations (TC): 15, pure citations (CI): 9, normalized no. of pure citations (NC): 3]
8. ŠUŠTAR, Vid, BEDINA ZAVEC, Apolonija, ŠTUKELJ, Roman, FRANK, Mojca, OGOREVC, Eva, JANŠA, Rado, KERIYA, Mam, VERANIČ, Peter, KRALJ-IGLIČ, Veronika. Post-prandial rise of microvesicles in peripheral blood of healthy human donors. *Lipids in health and disease*, ISSN 1476-511X, 2011, no. 47, vol. 10, 11 str. http://www.lipidworld.com/content/10/1/47, doi: 10.1186/1476-511X-10-47. [COBISS.SI-ID 4640794], [JCR, SNIP, WoS up to 10. 7. 2013: no. of citations (TC): 4, without self-citations (CI): 3, weighted no. of citations (NC): 1, Scopus up to 7. 6. 2011: no. of citations (TC): 0, pure citations (CI): 0, normalized no. of pure citations (NC): 0]
9. MRVAR BREČKO, Anita, ŠUŠTAR, Vid, JANŠA, Vid, ŠTUKELJ, Roman, JANŠA, Rado, MUJAGIĆ, Emir, KRULJC, Peter, IGLIČ, Aleš, HÄGERSTRAND, Henry, KRALJ-IGLIČ, Veronika. Isolated microvesicles from peripheral blood and body fluids as observed by scanning electron microscope. *Blood cells, molecules & diseases*, ISSN 1079-9796, 2010, vol. 44, no. 4, str. 307-312. [COBISS.SI-ID 3176826], [JCR, SNIP, WoS up to 3. 12. 2013: no. of citations (TC): 12, without self-citations (CI): 7, weighted no. of citations (NC): 2, Scopus up to 28. 1. 2014: no. of citations (TC): 15, pure citations (CI): 11, normalized no. of pure citations (NC): 3]
10. ZUPANC, Jernej, VALANT, Janez, DROBNE, Damjana, KRALJ-IGLIČ, Veronika, IGLIČ, Aleš. A new approach to analyse effects of nanoparticles on lipid vesicles. *International journal of biomedical nanoscience and nanotechnology*. [Print ed.], 2010, vol. 1, no. 1, str. 34-51, ilustr. http://www.inderscience.com/storage/f106312181192754.pdf. [COBISS.SI-ID 7837524]

prof. ddr. Aleš Iglič (izvajalec):
1. 2. GONGADZE, Ekaterina, VELIKONJA, Aljaž, SLIVNIK, Tomaž, KRALJ-IGLIČ, Veronika, IGLIČ, Aleš. The quadrupole moment of water molecules and the permittivity of water near a charged surface. *Electrochimica Acta*, ISSN 0013-4686. [Print ed.], 2013, vol. 109, str. 656-662, ilustr. http://dx.doi.org/10.1016/j.electacta.2013.07.126. [COBISS.SI-ID 10049876], [JCR, SNIP, WoS up to 22. 1. 2014: no. of citations (TC): 1, without self-citations (CI): 1, weighted no. of citations (NC): 0, Scopus up to 1. 1. 2014: no. of citations (TC): 1, pure citations (CI): 1, normalized no. of pure citations (NC): 0]
2. VELIKONJA, Aljaž, BUDIME SANTHOSH, Poornima, GONGADZE, Ekaterina, KULKARNI, Mukta Vishwanath, ELERŠIČ, Kristina, PERUTKOVÁ, Šárka, KRALJ-IGLIČ, Veronika, POKLAR ULRIH, Nataša, IGLIČ, Aleš. Interaction between dipolar lipid headgroups and charged nanoparticles mediated by water dipoles and ions. *International journal of molecular sciences*, ISSN 1422-0067, 2013, vol. 14, no. 8, str. 15312-15329. http://www.mdpi.com/1422-0067/14/8/15312. [COBISS.SI-ID 4257144], [JCR, SNIP, Scopus up to 13. 8. 2013: no. of citations (TC): 0, pure citations (CI): 0, normalized no. of pure citations (NC): 0]
3. JESENEK, Dalija, PERUTKOVÁ, Šárka, GÓŹDŹ, Wojciech, KRALJ-IGLIČ, Veronika, IGLIČ, Aleš, KRALJ, Samo. Vesiculation of biological membrane driven by curvature induced frustrations in membrane orientational ordering. *International journal of nanomedicine*, ISSN 1178-2013. [Online

ed.], 2013, vol. 8, no. 1, str. 677-687, ilustr. http://www.dovepress.com/articles.php?article_id=12253. [COBISS.SI-ID 4516971], [JCR, SNIP, Scopus up to 8. 3. 2013: no. of citations (TC): 0, pure citations (CI): 0, normalized no. of pure citations (NC): 0]

4. GONGADZE, Ekaterina, KABASO, Doron, BAUER, Sebastian, PARK, Jung, SCHMUKI, Patrik, IGLIČ, Aleš. Adhesion of osteoblasts to a vertically aligned TiO[sub]2 nanotube surface. *Mini reviews in medicinal chemistry*, ISSN 1389-5575, Feb. 2013, vol. 13, no. 2, str. 194-200, ilustr. [COBISS.SI-ID 9947476], [JCR, SNIP, Scopus up to 12. 2. 2014: no. of citations (TC): 2, pure citations (CI): 2, normalized no. of pure citations (NC): 1]

5. FOŠNARIČ, Miha, IGLIČ, Aleš, KROLL, Daniel M., MAY, Sylvio. Monte Carlo simulations of a polymer confined within a fluid vesicle. *Soft matter*, ISSN 1744-683X, 2013, vol. 9, issue 15, str. 3976-3984, ilustr. http://pubs.rsc.org/en/content/articlepdf/2013/sm/c3sm27938c, doi: 10.1039/C3SM27938C. [COBISS.SI-ID 9692756], [JCR, SNIP, WoS up to 8. 5. 2013: no. of citations (TC): 0, without self-citations (CI): 0, weighted no. of citations (NC): 0, Scopus up to 8. 1. 2014: no. of citations (TC): 1, pure citations (CI): 1, normalized no. of pure citations (NC): 0]

6. ELERŠIČ, Kristina, PAVLIČ, Janez Ivan, IGLIČ, Aleš, VESEL, Alenka, MOZETIČ, Miran. Electric-field controlled liposome formation with embedded superparamagnetic iron oxide nanoparticles. *Chemistry and physics of lipids*, ISSN 0009-3084. [Print ed.], 2012, vol. 165, issue 1, str. 120-124, doi: 10.1016/j.chemphyslip.2011.11.006. [COBISS.SI-ID 25304103], [JCR, SNIP, WoS up to 22. 1. 2014: no. of citations (TC): 3, without self-citations (CI): 3, weighted no. of citations (NC): 1, Scopus up to 15. 8. 2013: no. of citations (TC): 4, pure citations (CI): 2, normalized no. of pure citations (NC): 1]

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Koloidi
Course title:	Colloids

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Bioznanosti, tretja stopnja, doktorski	nanoznanosti		Celoletni

Univerzitetna koda predmeta/University course code:	3822

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
10	15	0	0	15	85	5

Nosilec predmeta/Lecturer:	Ksenija Kogej

Izvajalci predavanj:	Ksenija Kogej
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	teoretični/theoretical

Jeziki/Languages:	Predavanja/Lectures:	Angleščina, Slovenščina
	Vaje/Tutorial:	Angleščina, Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
splošni pogoji za vpis na doktorski študij	general conditions for enrolment in doctoral studies

Vsebina:	Content (Syllabus outline):
Klasifikacija koloidnih sistemov. Vrste medfaznih površin in pojavi na njih. Medmolekulske interakcije in tvorba urejenih struktur. Dinamika v koloidnih sistemih. Fazne spremembe. **Polimeri**. Konformacija verig, karakterizacija, polidisperznost. Polimeri v raztopinah. Amorfni in kristalinični polimeri. Polimerne zmesi in blok-kopolimeri. Polielektroliti.	**Classification of colloid systems.** Types of interfaces and interfacial phenomena. Intermolecular interactions and formation of ordered structures. Dynamics in colloid systems. Phase changes. **Polymers**. Chain conformation, characterisation, polydispersity. Polymer solutions. Amorphous and crystalline polymers.

Koloidi. Vrste koloidov. Sile med koloidnimi delci. Vpliv polimerov na stabilnost koloidov. Sterična in elektrostatska stabilizacija koloidov. Kinetične lastnosti. Obravnava nekaj praktičnih primerov koloidnih sistemov (glina, barve, farmacevtske oblike, biološke membrane, itd.). Koncentrirane koloidne raztopine. **Amfifili**. Vrste amfifilov. Površinska aktivnost. Monomolekularne plasti. Adsorpcija na površinah. Micelizacija in kritična micelna koncentracija. Delovanje detergentov. Solubilizacija v micelah. Ukrivljenost površin in njena povezava s strukturo. **Izbrani primeri urejenih micelnih struktur**. Mikro in makro emulzije. Tekoči kristali. Biološki koloidi (lipidne membrane, DNA, proteini, polisaharidi in glikoproteini). Združevanje makromolekul (mikrotubule in nitaste strukture).	Polymer mixtures and block-copolymers. Polyelectrolytes. **Colloids**. Types of colloids. Forces between colloidal particles. Influence of polymers on the stability of colloids. Steric and electrostatic stabilisation of colloids. Kinetic properties. Discussion of some practical examples of colloid systems (clays, colours, pharmaceutical forms, biological membranes, etc.). Concentrated colloid solutions. **Amphiphiles**. Types of amphiphiles. Surface activity. Monomolecular layers. Adsorption at surfaces. Micellization and critical micelle concentration. Detergency. Solubilisation in micelles. Surfaces curvature and its connection to structure. **Selected examples of ordered micellar structures**. Micro- and macro-emulsions. Liquid crystals. Biological colloids (lipid membranes, DNA, proteins, polysaccharides and glycoproteins). Association of macromolecules (microtubules and thread-like structures).

Temeljna literatura in viri/Readings:
• Ksenija Kogej: Površinska in koloidna kemija, 1. izd. Ljubljana: Fakulteta za kemijo in kemijsko tehnologijo, 2010 . IX, 185 str., ilustr. ISBN 978-961-6756-15-0. [COBISS.SI-ID 251129600] • Ian W. Fleming: *Introduction to Soft Matter. Synthetic and Biological Self-Assembling Materials*, Revised Edition, John Wiley & Sons, Ltd., Chichester, 2007. • Bo Jönsson, Björn Lindman, Krister Holmberg, Bengt Kronberg: *Surfactants and Polymers in Aqueous Solution*, John Wiley & Sons, Chichester, 1998. • D. Fennell Evans, H. Wenerstrom: *The Colloidal Domain: Where Physics, Chemistry and Biology Meet*, 2nd Edition, Wiley-VCH, New York, 1999. • Revijalni članki s področja, tekoča periodika, druga učna gradiva.

Cilji in kompetence:	Objectives and competences:
Cilj predmeta je študenta seznaniti s sistemi, ki vsebujejo delce koloidnih dimenzij (npr. amfifile, koloide, polimere) in z zakonitostmi, ki določajo njihove lastnosti. Študent se seznani z velikim pomenom površine (medfazne meje) v koloidnih sistemih in pribobi znanje za prepoznavanje in razumevanje značilnih pojavov, ki so s tem povezani.	The aim of the subject is to acquaint the student with systems containing particles of colloid dimensions (e.g., amphiphiles, colloids, polymers) and with basic principles that define their properties. The subject presents to students the importance of surfaces (interfaces) in colloidal systems and helps them to recognise and understand the related phenomena.

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje: S pridobljenim znanjem bo študent razumel pojave v kompleksnih koloidnih sistemih, ki jih bo srečeval pri svojem strokovnem in	*Knowledge and understanding*: The acquired knowledge enables the student to understand complex phenomena in colloid systems encountered in her/his research work.

raziskovalnem delu. Naučil se bo vrednotiti stabilnost in uporabiti ustrezne metode za proučevanje lastnosti koloidnih sistemov. *Uporaba:* Študent bo sposoben reševati zelo različne probleme s področja nanotehnologije in nanobiologije, eksperimentalna opažanja in rezultate svojega raziskovalnega dela bo zmožen interpretirati na molekularnem nivoju. Hkrati mu bo znanje koristilo pri načrtovanju razvoja novih materialov, pri razumevanju bioloških procesov, pa pri razvoju novih farmacevtskih oblik in pri podobnih nalogah. *Refleksija*: Študent se zave tesne povezave med strukturo in sestavo polimerov, amfifilov ter koloidov in njihovimi lastnostmi v praktičnih sistemih. *Prenosljive spretnosti:* Način reševanje problemov povezanih s koloidi in predstavljene eksperimentalne metode so uporabne na raznih naravoslovnih področjih, od kemije in fizike do biologije in medicine, in tudi na mnogih tehnoloških področjih.	The student learns to appreciate stability of colloidal systems and the appropriate methods for studying their properties. *Application:* The course provides students with a good basis for solving various problems in the field of nanotechnology and nanobiology and for the interpretation of experimental results on molecular level. The acquired knowledge helps the student in designing new materials, in understanding biological processes, in developing novel pharmaceutical formulations and in similar tasks. *Reflection*: The student becomes aware of the close relation between structure and composition of polymers, amphiphiles, and colloids and their properties in practical systems. *Transferable skills:* Principle of solving problems in related colloids and the introduced experimental techniques can be profitabely used in various fields of natural sciences, from chemistry and physics to biology and medicine, and also in technological fields.

Metode poučevanja in učenja:	Learning and teaching methods:
-predavanja v računalniških učilnicah; -izdelava projekta, ki se navezuje na raziskovalno delo študenta. Projekt študenti izdelujejo sproti v obliki obveznih domačih nalog in ga dokončajo po izteku predavanj. Pri izpeljavi jim je zagotovljeno individualno spremljanje in pomoč; -predstavitev projekta v pisni obliki in ustno pred skupino študentov	-lectures held in computer classrooms -within the framework of the subject, students will carry out a project related to their research work. The project will be carried out simultaneously with lectures in the form of compulsory homework and completed after the completion of lectures. Students can discuss the development of the project with the lecturer; -presentation of the project in written and oral form (to colleague students).

Načini ocenjevanja:	Delež/Weight	Assessment:
Dokončanje in predstavitev projekta	50,00 %	Completion and presentation of the project
Ustni izpit	50,00 %	Oral exam

Reference nosilca/Lecturer's references:
1. **KOGEJ, Ksenija**, FONSECA, Sofia M., ROVISCO, J., AZENHA, M. E., LUÍSA RAMOS, M., SEIXAS DE MELO, J., BURROWS, Hugh. Understanding the interaction between trivalent lanthanide ions and stereoregular polymethacrylates through luminescence, binding isotherms, NMR, and interaction with

cetylpyridinium chloride. *Langmuir*, ISSN 0743-7463, 2013, vol. 29, no. 47, str. 14429-14437, [COBISS.SI-ID 1656879].

2. ANŽLOVAR, Alojz, CRNJAK OREL, Zorica, **KOGEJ, Ksenija**, ŽIGON, Majda. Polyol-mediated synthesis of zinc oxide nanorods and nanocomposites with poly(methyl methacrylate). *Journal of nanomaterials*, ISSN 1687-4110, 2012, vol. 2012, art. no. 760872 (9 str.), [COBISS.SI-ID 36033029].
3. **KOGEJ, Ksenija**. Association and structure formation in oppositely charged polyelectrolyte-surfactant mixtures. *Advances in colloid and interface science*, ISSN 0001-8686. [Print ed.], 2010, vol. 158, no. 1/2, str. 68-83, [COBISS.SI-ID 34100741].
4. PETERLIN, Primož, ARRIGLER, Vesna, **KOGEJ, Ksenija**, SVETINA, Saša, WALDE, Peter. Growth and shape transformations of giant phospholipid vesicles upon interaction with an aqueous oleic acid suspension. *Chemistry and physics of lipids*, ISSN 0009-3084. [Print ed.], 2009, letn. 159, str. 67-76, [COBISS.SI-ID 25598681].
5. PELJHAN, Sebastijan, ŽAGAR, Ema, CERKOVNIK, Janez, **KOGEJ, Ksenija**. Strong intermolecular association between short poly(ethacrylic acid) chains in aqueous solutions. *The journal of physical chemistry. B, Condensed matter, materials, surfaces, interfaces & biophysical*, ISSN 1520-6106, 2009, vol. 113, no. 8, str. 2300-2309. [COBISS.SI-ID 22456103].
6. VLACHY, N.; TOURAUD, D.; **KOGEJ, K.**; KUNZ, W. Solubilization of methacrylic acid based polymers by surfactants in acidic solutions. *J. colloid interface sci.*, 2007, vol. 315, no. 2, p. 445-455. [COBISS.SI-ID 28920325].

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Mikro/nano tehnologije in strukture
Course title:	Micro/nano technologies and structures

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Bioznanosti, tretja stopnja, doktorski	Ni členitve (študijski program)		Celoletni

Univerzitetna koda predmeta/University course code:	3823

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
10	25	0	0	0	90	5

Nosilec predmeta/Lecturer:	Samo Penič

Izvajalci predavanj:	Samo Penič
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	teoretični/theoretical

Jeziki/Languages:	Predavanja/Lectures:	Angleščina, Slovenščina
	Vaje/Tutorial:	Angleščina, Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
Splošni pogoji za vpis na doktorski študij	General conditions for enrollment in doctoral study

Vsebina:	Content (Syllabus outline):
Osnove mikro/nano tehnologij in struktur – definicije, principi, klasifikacije. Osnovne mikro/nano strukture: senzorji, aktuatorji, mikroreaktorji, mikrofluidni čipi, »lab-on-chip« sistemi, mikro/nano pozicionerji in druge podobne strukture. Pregled mikro/nano tehnologij: mikroobdelava, mikroelektronske tehnologije, depozicije, jedkanje, LIGA, žrtvovani film, laserske	Fundamentals of micro/nano technologies and structures – definitions, principles, classifications. Basic micro/nano structures: sensors, actuators, microreactors, microfluidic chips, lab-on-chip systems, micro/nano positioners and other similar structures.

aplikacije, zatesnitev odprtin, bondiranje substratov, zapiranje v ohišja, izdelava 3D struktur, nanocevke itd. Analogna obdelava signalov: osnove vezij, vezja z operacijskimi ojačevalniki (instrumentacijski ojačevalnik, seštevalni ojačevalnik, nabojni ojačevalnik), izvori (tok, napetost, band gap reference), filtri, komparatorji in Schmittov prožilnik, analogni pretvorniki (tok/napetost /naboj/frekvenca) itd. Digitalna obdelava signalov: osnovni sklopi, diskretizacija signala, vzorčno-zadrževalna vezje, digitalno-analogni in analogno-digitalni pretvorniki in drugo. Pregled mikro/nano struktur in aplikacij: Senzorji (bio/kemični senzorji, piezoresistivni senzorji, piezoelektrični senzorji, piroelektrični senzorji, kapacitivni senzorji, resonančni senzorji, termoelektrični senzorji, radiacijski senzorji, magnetni senzorji, senzorji z optičnimi vlakni, itd.), aktuatorji (termični, kapacitivni, piezoelectrični, itd.), mikrofluidični čipi, mikroreaktorji, lab-on-chip, Mikro/Nano pozicionerji itd. Napredne mikro/nano tehnologije in strukture. Simulacijska orodja za analizo in načrtovanje (SPICE simulacije, metoda končnih elementov in večfizikalne simulacije, metoda Monte Carlo)	Review of micro/nano technologies: micromachining, microelectronic technologies, deposition, etching, LIGA, sacrified film, laser application, opening sealing, substrate bonding, sensor chip encapsulation/packaging, 3D structures fabrication, nanotubes etc. Analog signal conditioning: basic circuits, operational amplifier circuits (instrumentation amplifier, summing amplifier, charge amplifier), sources (current, voltage, band gap references), filters, comparators and Schmitt trigger, analog converters (current/voltage/charge/frequency) etc. Digital signal conditioning: basic building blocks, signal discretisation, sample&hold circuits, digital-to-analog and analog-to-digital converters etc. Review of micro/nano structures and applications: Sensors (Bio/Chemical sensors. Piezoresistive sensors. Piezoelectric sensors. Pyroelectric sensors. Capacitive sensors. Resonant sensors. Thermoelectric sensors. Radiation sensors. Magnetic sensors. Optical fiber sensors, etc.), Actuators (thermal, capacitive, piezoelectric etc.), Microfluidic chips, Microreactors, Lab-on-chip, Micro/Nano positioners etc. Advanced micro/nano technologies and structures. Simulation tools for analysis and design (SPICE simulacije, finite element method and multiphysics simulations, Monte Carlo method)

Temeljna literatura in viri/Readings:
• S.Amon, **SENZORJI IN AKTUATORJI 1. del: Osnove senzorike** , Založba UL FE, 2013 (knjiga na spletu) • S.Amon, **SENZORJI IN AKTUATORJI 2. del: Pregled senzorjev in aktuatorjev** Založba UL FE, 2013 (knjiga na spletu) • S.E.Lyshevsky, Nano- and Micro- Electromechanical Systems, CRC Press, 2005. • J. Fraden, Handbook of Modern Sensors, AIP Press, 1997. • P. Horowitz, W. Hill, The Art of Electronics 3rd. ed., Cambridge University Press, 2015. - E. Gusev, E. Garfunkel, A. Dideikin, Advanced Materials and Technologies for Micro Nano-Devices, Sensors and Actuators, Springer, 2010.

Cilji in kompetence:	Objectives and competences:
Osnovni namen predmeta je posredovati udeležencem pregled novih pristopov, principov, tehnologij, struktur in aplikacij na področju mikro/nano tehnologij in struktur.	The aim of the course is to give participants a comprehensive overview of new approaches, principles, technologies, structures and applications in the field of micro/nano technologies and structures.

Predvideni študijski rezultati:	Intended learning outcomes:
Predvideni študijski rezultati predmeta vključujejo obvladovanje osnovnih pojavov, dizajnov, realizacij in aplikacij ter osnovnih elektronskih vezij na področju mikro/nano tehnologij in struktur.	Learning outcomes of the course include a comprehensive overview of basic effects, designs, realizations and applications, together with basic electronic circuits, in the field of micro/nano technologies and structures.

Metode poučevanja in učenja:	Learning and teaching methods:
Osnovna teoretska znanja so podana v obliki predavanj, medtem ko so praktična znanja podana v obliki laboratorijskega dela, seminarjev in projektov.	Basic theory and subject overview is addressed by lectures, while practical knowledge and experience are gained through laboratory work, seminars and projects.

Načini ocenjevanja:	Delež/Weight	Assessment:
Projekt/seminar	30,00 %	Project/Seminar
pisni izpit	30,00 %	written exam
ustni izpit	40,00 %	oral exam

Reference nosilca/Lecturer's references:

doc. dr. Samo Penič

- S. Penič, L. Mesarec, M. Fošnarič, L. Mrówczyńska, H. Hägerstrand, V. Kralj-Iglič, A. Iglič. Budding and fission of membrane vesicles: a mini review. Frontiers in Physics, ISSN. 2020, doi: 10.3389/fphy.2020.00342
- GRAZIANO, Brian R., TOWN, Jason P., SITARSKA, Ewa, NAGY, Tamas L., FOŠNARIČ, Miha, PENIČ, Samo, IGLIČ, Aleš, KRALJ-IGLIČ, Veronika, GOV, Nir S., DIZ-MUÑOZ, Alba, WEINER, Orion D. Cell confinement reveals a branched-actin independent circuit for neutrophil polarity. *PLoS biology*, ISSN 1545-7885. [Online ed.], 2019, vol. 17, iss. 10, str. 1-34, ilustr. https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3000457, doi: 10.1371/journal. pbio.3000457. [COBISS.SI-ID 5728875], [JCR, SNIP]
- FOŠNARIČ, Miha, **PENIČ, Samo**, IGLIČ, Aleš, KRALJ-IGLIČ, Veronika, DRAB, Mitja, GOV, Nir S. Theoretical study of vesicle shapes driven by coupling curved proteins and active cytoskeletal forces. *Soft matter*, ISSN 1744-6848, 2019, vol. 15, 26, str. 5319-5330, doi: 10.1039/c8sm02356e. [COBISS.SI-ID 5646187],
- **PENIČ, Samo**, IGLIČ, Aleš, BIVAS, Isak, FOŠNARIČ, Miha. Bending elasticity of vesicle membranes studied by Monte Carlo simulations of vesicle thermal shape fluctuations. *Soft matter*, ISSN 1744-683X, 7 Jul. 2015, vol. 11, no. 25, str. 5004-5009, ilustr. http://pubs.rsc.org/en/content/articlepdf/2015/sm/c5sm00431d?page=search, doi: 10.1039/C5SM00431D. [COBISS.SI-ID 11044180]
- RESNIK, Drago, VRTAČNIK, Danilo, ALJANČIČ, Uroš, MOŽEK, Matej, **PENIČ, Samo**, AMON, Slavko. Influence of mechanical stress on adhesion properties of DC magnetron sputtered Ti/NiV/Ag layers on n+Si substrate. *Microelectronic engineering*, ISSN 0167-9317. [Print ed.], Jul. 2008, vol. 85, no. 7, str. 1603-1607, ilustr. [COBISS.SI-ID 6523476]
- RESNIK, Drago, VRTAČNIK, Danilo, ALJANČIČ, Uroš, MOŽEK, Matej, **PENIČ, Samo**, AMON, Slavko. Influence of mechanical stress on adhesion properties of DC magnetron sputtered Ti/NiV/Ag layers on n+Si substrate. *Microelectronic engineering*, ISSN 0167-9317. [Print ed.], Jul. 2008, vol. 85, no. 7, str. 1603-1607, ilustr. [COBISS.SI-ID 6523476]
- MESAREC, Luka, GÓŹDŹ, Wojciech, KRALJ, Samo, FOŠNARIČ, Miha, **PENIČ, Samo**, KRALJ-IGLIČ, Veronika, IGLIČ, Aleš. On the role of external force of actin filaments in the formation of tubular protrusions of closed membrane shapes with anisotropic membrane components. *European*

biophysics journal, ISSN 0175-7571, 2017, vol. 46, iss. 8, str. 705-718, ilustr. http://link.springer.com/article/10.1007/s00249-017-1212-z, doi: 10.1007/s00249-017-1212-z. [COBISS.SI-ID 11740500]
- **PENIČ, Samo**, FOŠNARIČ, Miha, MESAREC, Luka, IGLIČ, Aleš, KRALJ-IGLIČ, Veronika. Active forces of myosin motors may control endovesiculation of red blood cells. *Acta chimica slovenica*, ISSN 1580-3155. [Spletna izd.], 2020, vol. 67, no. , str. 1-8, ilustr. https://journals.matheo.si/index.php/ACSi/article/view/5863/2503, doi: 10.17344/acsi.2020.5863. [COBISS.SI-ID 12869460]
- MESAREC, Luka, FOŠNARIČ, Miha, **PENIČ, Samo**, KRALJ-IGLIČ, Veronika, KRALJ, Samo, GÓŹDŹ, Wojciech, IGLIČ, Aleš. Numerical study of membrane configurations. *Advances in condensed matter physics*, ISSN 1687-8108, 2014, vol. 2014, art. ID 373674, str. 1-7, ilustr. http://dx.doi.org/10.1155/2014/373674, doi: 10.1155/2014/373674. [COBISS.SI-ID 10880596]
- PEČAR, Borut, MOŽEK, Matej, RESNIK, Drago, VRTAČNIK, Danilo, ALJANČIČ, Uroš, **PENIČ, Samo**, AMON, Slavko. Microflow generator for fuel cell methanol hydrogen microreactor = Dozirni sistem za mikroprocesor goriva. *Informacije MIDEM : časopis za mikroelektroniko, elektronske sestavne dele in materiale*, ISSN 0352-9045. [Tiskana izd.], sep. 2010, letn. 40, št. 3, str. 208-217, ilustr. [COBISS.SI-ID 8169044]
- **PENIČ, Samo**, ALJANČIČ, Uroš, RESNIK, Drago, VRTAČNIK, Danilo, MOŽEK, Matej, AMON, Slavko. Cantilever method for determination of D31 coefficient in thin piezoelectric films = Metoda za določanje koeficienta d31 tankih piezoelektričnih filmov. *Informacije MIDEM : časopis za mikroelektroniko, elektronske sestavne dele in materiale*, ISSN 0352-9045. [Tiskana izd.], mar. 2009, letn. 39, št. 2, str. 85-92, ilustr. [COBISS.SI-ID 7570516]
- MOŽEK, Matej, VRTAČNIK, Danilo, RESNIK, Drago, ALJANČIČ, Uroš, **PENIČ, Samo**, AMON, Slavko. Calibration system for smart pressure sensors = Sistem za umerjanje tlačnih senzorjev. *Informacije MIDEM : časopis za mikroelektroniko, elektronske sestavne dele in materiale*, ISSN 0352-9045. [Tiskana izd.], sep. 2006, letn. 36, št. 3, str. 161-165, ilustr. [COBISS.SI-ID 5672788]
- **PENIČ, Samo**, MESAREC, Luka, FOŠNARIČ, Miha, KRALJ-IGLIČ, Veronika, KRALJ, Samo, GÓŹDŹ, Wojciech, IGLIČ, Aleš. Modeling of closed membrane shapes. V: DIMOVA-MALINOVSKA, Doriana (ur.). *Challenges of nanoscale science : theory, materials, applications*, 18th International School on Condensed Matter Physics (ISCMP), 1-6 September 2014, Varna, Bulgari, (Journal of physics, ISSN 1742-6596, vol. 558). Bristol: IOP. 2014, str. 1-9, ilustr. http://iopscience.iop.org/1742-6596/558/1/012010/pdf/1742-6596_558_1_012010.pdf, doi: 10.1088/1742-6596/558/1/012010. [COBISS.SI-ID 10889300]
- BUDIME SANTHOSH, Poornima, **PENIČ, Samo**, GENOVA, Julia, IGLIČ, Aleš, KRALJ-IGLIČ, Veronika, POKLAR ULRIH, Nataša. A study on the interaction of nanoparticles with lipid membranes and their influence on membrane fluidity. V: DIMOVA-MALINOVSKA, Doriana (ur.). *Open problems in condensed matter physics, biomedical physics and their applications*, 17th International School on Condensed Matter Physics (ISCMP), 2-7 September 2012, Varna, Bulgari, (Journal of physics, ISSN 1742-6596, Vol. 398). Bristol: Institute of Physics Publishing. 2012, vol. 398, str. 012034-1-012034-6. http://iopscience.iop.org/1742-6596/398/1/012034/, doi: 10.1088/1742-6596/398/1/012034. [COBISS.SI-ID 4188536]

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Nanotehnologije in bio-nano interakcije
Course title:	Nanotechnology and bio-nano interactions

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Bioznanosti, tretja stopnja, doktorski	Ni členitve (študijski program)		Celoletni

Univerzitetna koda predmeta/University course code:	3824

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
20	0	0	0	40	190	10

Nosilec predmeta/Lecturer:	Damjana Drobne

Izvajalci predavanj:	Damjana Drobne, Anita Jemec Kokalj, Ksenija Kogej, Veronika Kralj Iglič, Julijana Kristl, Maja Remškar
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	teoretični/theoretical

Jeziki/Languages:	Predavanja/Lectures:	Angleščina, Slovenščina
	Vaje/Tutorial:	Angleščina, Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
Splošni pogoji za vpis na doktorski študij	General conditions for enrollment in doctoral study

Vsebina:	Content (Syllabus outline):
1. Uvod: Uporaba nanomaterialov in nanostrukturiranih površin v sodobnih tehnoloških procesih (živilska industrija, farmacija, avtomobilska industrija, medicinska uporaba) 2. Specifične fizikalne in kemijske lastnosti nanodelcev	1. Introduction: The use of nanomaterials and nanostructured areas in modern technological processes (food industry, pharmacy, automotive industry, medicine) 2. Specific physico-chemical properties of nanoparticles 3. Detection methods for nanoparticles in air and liquid media

3. Metode za detekcijo nanodelcev v zraku in tekočem mediju 4. Interakcije med nanodelci in celico, tkivom in organizmom: *in vivo* ter *in vitro* študije; Interakcije med nanodelci in mikroorganizmi 5. Korelacija med lastnostmi nanodelcev (odmerek, površina, oblika, velikost,… in odgovorom biološkega sistema. 6. Zagotavljanje kvalitete podatkov fizikalno-kemijske karakterizacije nanomaterialov ter nanotoksikoloških podatkov 7. Primerjava med učinki nanodelcev in drugimi kemikalijami (kovinskimi ioni in pesticidi) 8. Polimeri, koloidi in amfifili v vodnih raztopinah: lastnosti in karakterizacija; sile v koloidnih sistemih; interakcije in strukture v mešanih sistemih, ki vsebujejo polimere in površinsko aktivne snovi; eksperimentalne metode za študij interakcij; primeri kompleksnih asociirajočih sistemov v tehniki in naravi.	4. Interactions between nanoparticles and cells, tissues and organisms: *in vivo* studies, *in vitro* studies, tissue methods to determine nanoparticles, cellular internalization of nanoparticles, bioaccumulation of nanoparticles. Interactions between nanoparticles and microorganisms 5. The relation between the physico-chemical properties of nanoparticles (dose, surface area, shape, size) and observed response of biological system. 6. Quality assurance of physico-chemical characterization of nanomaterials and nanotoxicity data 7. Comparison of toxicity data for nanomaterials with other »conventional« chemicals, such as metals and pesticides 8. Polymers, amphiphiles, and colloids in aqueous solutions: properties and characterization; forces in colloidal systems; interactions and structures in mixed polymer-surfactant systems; experimental techniques for studying mixed systems; examples of complex colloid systems in nature and technology.

Temeljna literatura in viri/Readings:
Aktualni znanstveni članki iz področja, ki jih sproti določijo izvajalci predmeta. Scientific papers.

Cilji in kompetence:	Objectives and competences:
Izobraževalni cilji: Študent bo sposoben razumeti različna področja nanotehnologij in nanobiologije. Glede na osnovna študentova predznanja, bo ta poglobil in nadgradil s spoznanji drugih naravoslovnih disciplin. Če bo študentova doktorska naloga iz področja nanoznanosti, bo pri predmetu pridobil vrhunsko znanje za razumevanje problemov in dogajanj na tem področju in jih bo sposoben reševati z vrhunskimi znanstvenimi pristopi. Študijski rezultati: Študentje bodo zmožni razumeti in rešiti znanstvena vprašanja iz področja nanoznanosti ter , prenesti rezultate raziskav v prakso. Pridobili bodo osnovne veščine pisana znanstvenih publikacij. Sposobni bodo komunicirati z javnostjo na področju interpretacije problemov in rešitev, ki se nanašajo na področje nanoznanosti in bio-nanointerakcij.	Objectives: Students will gain specific knowledge regarding different areas of nanotechnology and nanobiology. This background will be complementary to those of other natural sciences. The course will provide an indespensible background for those students whose doctoral thesis will be done in this area od research. Results: Students will be able to comprehend and resolve nano-related scientific problems and transfer the solutions to the industry sector. They will gain basic knowledge and skills in the preparation of scientific publications. They will be able to communicate nanoscience and bionanointeraction related content to the interested public.

Predvideni študijski rezultati:	Intended learning outcomes:

Znanje in razumevanje:	Knowledge and understanding:

Metode poučevanja in učenja:	Learning and teaching methods:
Predavanja, diskusijske, delavnice, predstavitve v laboratorijih.	Lectures, discussions, workshops, laboratory demonstrations.

Načini ocenjevanja:	Delež/Weight	Assessment:
Diskusija, ustni izpit	50,00 %	Discussion, oral exam
Predstavitev individualnega projekta	50,00 %	Project presentation

Reference nosilca/Lecturer's references:

prof. dr. Damjana Drobne

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prof. dr. Veronika Kralj Iglič

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Ksenija Kogej

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Julijana Kristl

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prof. dr. Maja Remškar

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Doc. dr. Anita Jemec

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UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Elektrostatika in statistična termodinamika površin in nanostruktur
Course title:	Electrostatics and statistical thermodynamics of surfaces and nanostructures

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Bioznanosti, tretja stopnja, doktorski	nanoznanosti		Celoletni

Univerzitetna koda predmeta/University course code:	0566691

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
10	20	0	0	0	95	5

Nosilec predmeta/Lecturer:	Aleš Iglič

Izvajalci predavanj:	Aleš Iglič, Veronika Kralj Iglič
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	teoretični /theoretical

Jeziki/Languages:	Predavanja/Lectures:	Angleščina, Slovenščina
	Vaje/Tutorial:	Angleščina, Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
splošni pogoji za vpis na doktorski študij	General conditions for enrolment in doctoral studies

Vsebina:	Content (Syllabus outline):
Osnove statistične termodinamike, teoretični opis naelektrene površine v stiku z elektrolitsko raztopino (teorija električne dvojne plasti), dielektrične lastnosti električne dvojne plasti, elektrostatika nanostruktur, vpliv nanodelcev na interakcije med naelektrenimi površinami, adsorpcija naelektrenih nanodelcev na naelektrene površine, interakcija naelektrenih nanodelcev z naelektrenimi nanostrukturiranimi kovinskimi in polprevodniškimi površinami	Thermodynamic description of systems with a large number of particles, theoretical description of electrolyte solution in contact with charged surface (electric double layer theory), dielectric properties of electric double layer, electrostatics of nanostructures, adsorption of charged nanoparticles on charged surfaces, influence of charged nanoparticles on mediated interactions between charged surfaces, interaction of charged nanoparticles with nanostructured metallic and/or semiconductor surfaces

Temeljna literatura in viri/Readings:
1.Iglič A., Drobne D., Kralj Iglič V. Nanostructures in biological systems - theory and applications, Pan Stanford Publishing , Singapore; CRC Press, Boca Raton, 2015.

2.Israelachvili J. Intermolecular and Surface Forces, Academic Press, London, zadnja izdaja.
3.Dill K.A., Bromberg S. Molecular Driving Forces – Statistical Thermodynamics in Chemistry and Biology, Garland Science, New York and London, zadnja izdaja.
4.Safran S.A. Statistical Thermodynamics of Surfaces, Interfaces, and membranes, Addison-Wesley, Reading, New York, zadnja izdaja.
5.Butt H.-J., Graf K., Kappč M., Physics ad Chemistry of Interfaces, Wiley, Weinheim, zadnja izdaja.
6.Aktualni znanstveni članki iz področja, ki jih sproti določijo izvajalci predmeta.

Cilji in kompetence:	Objectives and competences:
Poznavanje teoretičnih eksperimentalnih osnov elektrostatskih interakcij v sistemih naelektrenih površin in nanodelcev.	Students are familiarised with physical description of electrostatic interactions in the systems of charged surfaces and charged nanoparticles.

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje za izvedbo raziskav elektrostatskih interakcij v različnih sistemih naelektrenih površin in nanodelcev.	Knowledge and understanding which will qualify the candidate for carrying out the research in the field of electrostatic interactions in the systems of charged surfaces and charged nanoparticles

Metode poučevanja in učenja:	Learning and teaching methods:
Predavanja, konzultacije, projektno/seminarsko delo.	Lectures, consultations, project/seminar work

Načini ocenjevanja:	Delež/Weight	Assessment:
Seminar ali projekt.	100,00 %	Seminar or project.

Reference nosilca/Lecturer's references:

prof. dr. Aleš Iglič :

A.V. Dubtsov, S.V. Pasechnik, D.V. Shmeliova, A.Sh. Saidgaziev, E. Gongadze, A. Iglič, S. Kralj: **Liquid Crystalline Droplets in Aqueous Environment: Electrostatic Effects,** Soft Matter, 14(47): 9619-9630, 2018.
J. Gimsa, P. Wysotzki, Š. Perutkova, T. Weihe, P. Elter, P.E. Marszalek, V. Kralj-Iglič, A. Iglič: **The spermidine-induced attraction of like-charged surfaces is correlated with the pH-dependent spermidine charge: force spectroscopy characterization,** Langmuir, 34: 2725-2733, 2018.
A. Dubtsov, S.V. Pasechnik, D. V. Shmeliova, A. Iglič, S. Kralj: **Influence of polar dopant on internal configuration of azoxybenzene nematic-in-water droplets,** Liquid crystals, 45: 388-400, 2018.
S. Mohajernia, A. Mazare, E. Gongadze, V. Kralj-Iglič, A. Iglič, P. Schmuki: **Self-organized, free-standing TiO2 nanotube membranes: Effect of surface electrokinetic properties on flow-through membranes**, Electrochimica Acta, 245: 25-31, 2017.
M. Kulkarni, A. Mazare, J. Park, E. Gongadze, M.S. Killian, S. Kralj, K. von der Marke, A. Iglič, P. Schmuki: Protein interactions with layers of TiO2 nanotube and nanopore arrays: morphology and surface charge influence, Acta Biomaterialia, 45: 357–366, 2016.
Alenka Maček Lebar, Aljaž Velikonja, Peter Kramar, Aleš Iglič: Internal configuration and electric potential in planar negatively charged lipid head group region in contact with ionic solution, Bioelectrochemistry, 111: 49–56, 2016

prof. dr. Veronika Kralj-Iglič :

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