MIKROBIOLOGIJA – INDIVIDUALNO RAZISKOVALNI PREDMETI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Mikrobiološke metode
Course title:	Methods in microbiology

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

Univerzitetna koda predmeta/University course code: 0566751

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
0	0	10	0	15	100	5

Nosilec predmeta/Lecturer:	Martina Turk
Izvajalci predavanj:	Tjaša Danevčič, Anja Klančnik, Sonja Smole Možina, Martina Turk, Polona Zalar
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	
Vrsta predmeta/Course type:	individualno raziskovalni /individual research
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 requirements for the enrolment in PhD program

Vsebina:	Content (Syllabus outline):
Pri predmetu Mikrobiološke metode se bodo študenti in študentke seznanili s tehnikami, ki se uporabljajo za preučevanje morfologije, fiziologije, biokemije, genetike in molekularne biologije mikroorganizmov, tako na ravni posamezne celice, čistih kultur kot tudi mikrobnih združb. V okviru predmeta bodo sodelujoči laboratoriji predstavili izbor metod, ki jih uporabljajo pri svojih raziskavah. Delo bo eksperimentalno in bo potekalo v izbranih laboratorijih. Študentke in študenti se bodo spoznali z: - osamitvijo mikroorganizmov in njihovo kvantifikacijo v kompleksnih vzorcih, kot so hrana in tla, - določanjem mikrobiološke kvalitete (neoporečnosti) in sledljivosti hrane,	Course Methods in microbiology is designed to familiarise students with the techniques used for the study of morphology, physiology, biochemistry, genetics, and molecular biology of microorganisms, from the single cell, pure cultures to the microbial communities. Within the framework of the course, the participating microbiology laboratories will introduce to students a selection of methods, which are used in their research. Experimental work will be carried out in the selected labs. Students will learn: - to isolate microorganisms and to quantify them in complex samples, such as food or soil,

- taksonomsko karakterizacijo mikroorganizmov z uporabo (a) klasičnih metod (temelječih na biokemijskih, fizioloških in morfoloških lastnostih) in (b) metod molekularne biologije (polimorfizem konformacije enojne verige (SSCP), polimorfizem dolžin pomnoženih fragmentov (AFLP), poliakrilamidna gelska elektroforeza v temperaturnem gradientu (TGGE), polimorfizem dolžin restrikcijskih fragmentov (RFLP), elektroforeza v pulzirajočem polju (PFGE), tipiziranje na osnovi multilokusnih sekvenc (MLST)…); študentke in študenti se bodo tudi naučili, kako izvesti filogenetske analize na teh podatkih, - identifikacijo sestave mikrobne združbe v nekem okolju z visokozmogljivim sekvenciranjem, - določitvijo odpornosti mikroorganizmov na fizikalne in kemijske dejavnike okolja, - določevanjem mikrobne aktivnosti čistih kultur in mikrobnih združb v tleh, aktivnem blatu in drugih habitatih z merjenjem emisij CO2, metana, N2O; merjenjem aktivnosti nitrifikacije in denitrifikacije; določevanjem aktivnosti pomembnih encimov, kot so na primer fenol oksidaze, celulaze, hemicelulaze in hitinaze, - uporabo metod molekularne biologije, kot je verižna reakcija s polimerazo (PCR, in RT-PCR) pri ugotavljanju avtentičnosti živil (mleko, meso), - uporabo podatkov s področij genomike, transkriptomike in proteomike, - ugotavljanjem občutljivosti mikroorganizmov proti protimikrobnim sredstvom in odkrivanjem mehanizmov odpornosti proti antibiotikom in drugim protimikrobnim snovem pri ocenjevanju potencialne nevarnosti mikroorganizmov za zdravje ljudi/živali/rastlin, - določevanjem toksičnosti in genotoksičnosti snovi z uporabo mikroorganizmov (kometni test), - uporabo različnih pristopov pri proučevanju nastanka mikrobnih biofilmov, sposobnosti pritrjevanja na površine in odpornosti na parametre okolja.	- to asses microbiological quality and the traceability of food products, - to taxonomically characterize microorganisms applying (i) classical (based on biochemical, physiological, and morphological traits) and (ii) molecular biology methods (single strand conformation polymorphism analysis (SSCP), amplified fragment length polymorphism (AFLP), temporal temperature and denaturing gradient electrophoresis (TTGE, DGGE), restriction fragment length polymorphism (RFLP), pulsed field gel electrophoresis (PFGE), multi locus sequence typing (MLST), etc.); students will also learn how to perform phylogenetic analyses on those data, - identification of the microbial community diversity with high-throughput sequencing, - to characterize the resistance of microorganisms to physical and chemical factors of the environment, - to determine the microbial activity of pure cultures and in microbial communities soil, active sludge and other habitats by measuring the emissions of CO2, methane, N2O; measuring the nitrification and denitrification activities; determination of the activities of important enzymes like phenol oxidase, cellullase, hemicellulase, and chitinase, - to use molecular biology methods, such as polymerase chain reactions (classical and real-time PCR) in food authenticity studies (milk, meat), - to use data from genomics, transcriptomics, and proteomics, - to test for antimicrobial susceptibility and discovering mechanisms of resistance to antibiotics and other antimicrobial substances in the evaluation of potential hazard of microorganisms for the human/animal/plant health, - to determine the toxicity and genotoxicity of substances with the use of microorganisms (comet assay), - to use different approaches for the investigation of microbial biofilm formation, their adhesive abilities and resistance in relation to surface characteristics and other environmental parameters.

Temeljna literatura in viri/Readings:

Revijalni in eksperimentalni članki s področja, tekoča periodika, druga učna gradiva, ki jih bo priskrbel izbrani raziskovalec/izvajalec.
Current scientific periodicals and literature from the field and text books, provided by the selected researcher.

Cilji in kompetence:	**Objectives and competences:**
• seznaniti študentko ali študenta z naborom metod, ki se uporabljajo v mikrobiologiji in ji/mu omogočiti izvedbo izbrane metode v laboratoriju. Izbrana metoda bo omogočila študentu rešitev specifičnega eksperimentalnega problema, ki se bo pojavil v okviru njenega/njegovega raziskovalnega dela, • posredovanje ključne znanstvene literature iz področja izbrane znanstvene metode , vključno s posredovanjem lastnega raziskovalčevega znanja,	• to provide the student with the range of methods used in microbiology and enable her/him to perform a selected method in a chosen laboratory. The selected method will enable the student to solve a specific experimental problem that will appear in the context of her/his research work, • to mediate key scientific literature from the field of the chosen method, including mediation of the lecturer's own experience,

• pomoč pri analizi podatkov pridobljenih z izbrano metodo, rešitev ali izboljšava rešitve specifičnega problema s pridobljenimi rezultati.	• to supply help with the analysis of data obtained with the chosen method, to enable or improve the solution of a specific problem with the obtained results.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Poznavanje izbrane mikrobiološke metode, sposobnost razlage principov na katerih izbrana metoda temelji in interpretacija pridobljenih rezultatov.	Knowledge and understanding: Familiarity with the chosen microbiological method, capability to explain the principles or laws on which the method is based and interpretation of the obtained results.

Metode poučevanja in učenja:	**Learning and teaching methods:**
V okviru eksperimentalnega laboratorijskega dela bodo udeleženi raziskovalci pomagali pri izvedbi izbrane metode kot tudi pri vpogledu v področje lastnih raziskav, pri katerih si pomagajo z izbrano metodo.	Within the framework of experimental lab work the participating researchers will provide help in realization of the chosen method as well as providing specific insight into their field of research in which they use the this method.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
- ocena kompetenc pri eksperimentalnem delu v laboratoriju	60,00 %	- evaluation of the competences at the experimental work in the lab
priprava pisnega poročila in ustna predstavitev projekta po zaključenem eksperimentalnem delu	40,00 %	- written report and oral presentation of the project after the completion of the experimental work

Reference nosilca/Lecturer's references:

Martina Turk

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Anja Klančnik

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biotic amoeba surfaces. *International journal of food science & technology*, ISSN 0950-5423. [Print ed.], 2018, vol. 53, str.1013-1020, doi: 10.1111/ijfs.13677. [COBISS.SI-ID 4856184]
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Sonja Smole Možina

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KOVAČ, Jasna, STESSL, Beatrix, ČADEŽ, Neža, GRUNTAR, Igor, CIMERMAN, Mojca, STINGL, Kerstin, LUŠICKY, Marija, OCEPEK, Matjaž, WAGNER, Martin, **SMOLE MOŽINA, Sonja**. Population structure and attribution of human clinical Campylobacter jejuni isolates from central Europe to livestock and environmental sources. *Zoonoses and public health*, ISSN 1863-2378. [Online ed.], 2018, vol. 65, no. 1, str. 51-58, ilustr. http://onlinelibrary.wiley.com/doi/10.1111/zph.12366/full, doi: 10.1111/zph.12366.
KLANČNIK, Anja, ŠIKIĆ POGAČAR, Maja, TROŠT, Kajetan, TUŠEK-ŽNIDARIČ, Magda, MOZETIČ VODOPIVEC, Branka, **SMOLE MOŽINA, Sonja**. Anti-Campylobacter activity of resveratrol and an extract from waste Pinot noir grape skins and seeds, and resistance of C. jejuni planktonic and biofilm cells, mediated via the CmeABC efflux pump. *Journal of applied microbiology*, ISSN 1364-5072, Jan. 2017, vol. 122, iss. 1, str. 65-77, ilustr., doi: 10.1111/jam.13315.
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Tjaša Danevčič

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Polona Zalar

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UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Mikrobne interakcije
Course title:	Microbial interactions

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

Univerzitetna koda predmeta/University course code: 0568365

Predavanja	**Seminar**	**Vaje**	**Klinične vaje**	**Druge oblike študija**	**Samostojno delo**	**ECTS**
0	20	30	0	0	200	10

Nosilec predmeta/Lecturer:	Ines Mandić Mulec
Izvajalci predavanj:	Ines Mandić Mulec
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	
Vrsta predmeta/Course type:	individualno raziskovalni/individual research

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 requirements for the enrolment in PhD program.

Vsebina:	**Content (Syllabus outline):**
Mikrobne interkacije in komunikacije so združuje novo, hitro se razvijajoče področje socialne mikrobiologije, ki obravnava mikrobne interakcije na nivoju molekularnih mehanizmov, ekologije in evolucije: V okviru *teoretičnega dela* predmeta študent spozna koncepte kot so • Mikrobno signaliziranje • Kooperativna vedenja mikroorganizmov • Večceličnost (biofilmi, rojenje) • Sorodstvena selekcija • Goljufi in mehanizmi, ki stabilizirajo kooperacijo • Sorodstveno razlikovanje pri mikrobih- mehanizmi • Kompeticija, antagonizem • Intra and interspecies interactions • Horizontalni prenos genov pri bakterijah v večceličnih skupnostih	Social microbiology is a new and rapidly developing field of microbiology which addresses microbial interactions at the level of molecular mechanisms of interactions and their ecology and evolution. Theoretical social microbiology: • Microbial cell- cell signaling • Cooperative /group behaviors • Phenotypic heterogeneity in genetically homogenous groups • Cheating and mechanisms that stabilize cooperation • Kin selection • Kin recognition/discrimination • Competition, antagonisms • Intra and interspecies interactions • Bacterial sex and adaptations • Ecology and evolution of social interactions

• Ekologija in evolucija zgoraj naštetih socialnih interakcij • Applications of social microbiology in industry, agriculture and medicine *Metodologija v socialni mikrobiologiji* Zasnova eksperimenta v sociomikrobiologiji Priprava rekombinantnih sevov. Zasnova kompeticijskih eksperimentov in kvantifikacija fitnesa mikroorganizmov, ki vstopajo v interakcije Fluoroescenčna mikroskopija Fluorometrija	• Applications of social microbiology in agriculture, industry, medicine *Methodology in social microbiology* Experimental design in social microbiology Competition experiments and methods to quantify fitness of interacting strains Preparation of recombinant strains Fluorescent microscopy Fluorometry

Temeljna literatura in viri/Readings:

Predmet je zasnovan na novejših revijalnih (Nature Review Microbiology, Current Biology, ISME journal, Molecular microbiology, Environemntal microbiology, eLide, mBio, Biofilms, etc) in eksperimentalnih člankih s področja in naštetih revij. The theoretical knwoledge is based on corent topics covered in major journals like Nature Review Microbiology, Current Biology, ISME journal, Molecular microbiology, Environemntal microbiology, eLife, mBio, Biofilms, etc)

Cilji in kompetence:	**Objectives and competences:**
Študent se skozi problemsko zasnovan seminar in eksperimentalno delo seznani s koncepti in naborom metod, ki se uporabljajo v sociomikrobiologiji in so predstavljene v okviru vsebine predmeta. Omogoči se mu izvedba in nudi pomoč pri reševanju eskperimentalne problematike vezane na področje sociomikrobiologije in prirejene individualnim potrebam študenta.	Student learns through seminar work fndamental concepts and methods (described above) used in sociomicrobiology. Student also provided an opportunty to work in the lecturer's laboratory and is supervized in solving the experimental problems in sociomicrobiology. These could alsobe part of student's thesis project.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent spozna in razume osnovne koncepte in teorijo v sociomikrobiologiji in uporabo teh konceptov v medicini, biotehnologiji in ekologiji. Študent se nauči zasnovati in izvesti eksperiment s področja sociomikrobiologije. Študent ima možnost izvajati del eksperimentov vezanih na doktorsko tezo v laboratoriju nosilke predmeta (v dogovoru z mentorjem).	Student gains an insight and understands the basic consepts in sociomicrobiology and application of this knowladge in medicine, biotechnology and ecology. Student learns how to design and execute an experiment in the field of sociomicrobiology. Student can perform part of the thesis project in the lecturer's laboratory (in agreement with the student's thesis supervisor)

Metode poučevanja in učenja:	**Learning and teaching methods:**
Konzultacije, pomoč pri zasnovi in izvedbi eksperimentalnega projekta. V okviru predmeta je možna uporaba raziskovalnih orodij, ki smo jih razvili v laboratoriju za proučevanje sociomikrobiologije, za potrebe raziskovalnega dela doktorskega študenta iz področja sociomikrobiologije v dogovoru z mentorjem.	Consulations and experimental project in the laboratory of the lecturer. Student may use research tools developed for the study of sociomicrobiology in our laboratory for his/her PhD project related to sociomicrobiology and with the thesis advisor agreement.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Seminar	30,00 %	Seminar
poročilo o rezultatih eksperimentalnega dela	70,00 %	written report of experimental work

Reference nosilca/Lecturer's references:

1. KALAMARA, Margarita, ŠPACAPAN, Mihael, **MANDIĆ-MULEC**, Ines, STANLEY-WALL, Nicola R. Social behaviours by Bacillus subtilis : quorum sensing, kin discrimination and beyond. Molecular microbiology. 2018, vol. 110, iss. 6, str. 863-878
2. ŠTEFANIČ, Polonca, KRAIGHER, Barbara, LYONS, Nicholas A., KOLTER, Roberto, **MANDIĆ-MULEC**, Ines. Kin discrimination between sympatric Bacillus subtilis isolates. Proceedings of the National Academy of Sciences of the United States of America. 2015, vol. 112, no. 45, str. 14042-14047.
3. LYONS, Nicholas A., KRAIGHER, Barbara, ŠTEFANIČ, Polonca, **MANDIĆ-MULEC**, Ines, KOLTER, Roberto. A combinatorial kin discrimination system in Bacillus subtilis. Current biology. [Print ed.]. 2016, vol. 26, iss. 6, str. 733-742.
4. **DRAGOŠ**, Anna, ŠTEFANIČ, Polonca, DOGŠA, Iztok, MANDIĆ-MULEC, Ines. Private link between signal and response in Bacillus subtilis quorum sensing. Proceedings of the National Academy of Sciences of the United States of America. 2014, vol. 111, no. 4, str. 1586-1591.
5. DOGŠA, Iztok, CHOUDHARY, Kumari Sonal, MARSETIČ, Živa, HUDAIBERDIEV, Sanjarbek, VERA, Roberto, PONGOR, Sándor, **MANDIĆ-MULEC**, Ines. ComQXPA quorum sensing systems may not be unique to Bacillus subtilis : a census in prokaryotic genomes. PloS one. 2014, vol. 9, iss. 5, str. 1-8, e96122.
6. **MANDIĆ-MULEC**, Ines, ŠTEFANIČ, Polonca, ELSAS, Jan D. Ecology of Bacillaceae. Microbiology spectrum, ISSN 2165-0497. [Spletna izd.], 2015, vol. 3, iss. 2, str. 1-24, ilustr. http://www.asmscience.org/docserver/fulltext/microbiolspec/3/2/TBS-0017-2013. [COBISS.SI-ID 4527224],
7. NESME, Joseph, ACHOUAK, Wafa, AGATHOS, Spiros N., BAILEY, Mark, BALDRIAN, Petr, BRUNEL, Dominique, FROSTEGÅRD, Åsa, HEULIN, Thierry, JANSSON, Janet K., JURKEVITCH, Edouard, KRUUS, Kristiina L., KOWALCHUK, George A., LAGARES, Antonio, LAPPIN-SCOTT, Hilary M., LEMANCEAU, Philippe, LE PASLIER, Denis, **MANDIĆ-MULEC**, Ines, MURRELL, J. Colin, MYROLD, David Douglas, NALIN, Renaud, et al. Back to the future of soil metagenomics. Frontiers in microbiology, ISSN 1664-302X, 2016, vol. 7, article 73, str. 1-5, ilustr., doi: 10.3389/fmicb.2016.00073. [COBISS.SI-ID 4619896],
8. JERMAN, Vesna, DANEVČIČ, Tjaša, **MANDIĆ-MULEC**, Ines. Methane cycling in a drained wetland soil profile. Journal of soils and sediments : protection, risk assessment and remediation, ISSN 1439-0108, 2017, vol. 17, iss. 7, str. 1874-1882, ilustr., doi: 10.1007/s11368-016-1648-2. [COBISS.SI-ID 4746616],
9. BERINI, Francesca, VERCE, Marko, AUSEC, Luka, ROSINI, Elena, TONIN, Fabio, POLLEGIONI, Loredano, **MANDIĆ-MULEC**, Ines. Isolation and characterization of a heterologously expressed bacterial laccase from the anaerobe Geobacter metallireducens. Applied microbiology and biotechnology. 2018, vol. 102, iss. 5, str. 2425-2439
10. **MANDIĆ-MULEC**, Ines, ŠTEFANIČ, Polonca, ELSAS, Jan D. Ecology of Bacillaceae. V: DRIKS, Adam (ur.). The bacterial spore : from molecules to systems. Washington: ASM Press. 2016, str. 59-85, ilustr., doi: 10.1128/microbiolspec.TBS-0017-2013. [COBISS.SI-ID 4495992],

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Praktična prokariontska genomika
Course title:	Practical prokaryotic genomics

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

Univerzitetna koda predmeta/University course code: 0568366

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
0	5	5	0	15	100	5

Nosilec predmeta/Lecturer:	Tomaž Accetto
Izvajalci predavanj:	Tomaž Accetto
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	
Vrsta predmeta/Course type:	individualno raziskovalni /individual research

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 prerequisites for enrolment into doctoral studies

Vsebina:	Content (Syllabus outline):
-strategije sekvenciranja NGS: primernost različnih tipov knjižnic in tehnologij sekvenciranja za različne cilje pri sekvenciranju bakteriofagov, genomov čistih kultur in metagenomov. -klasična in hibridna sestava genomov/filtracija kontaminacije -sestava metagenomov, klasifikacija odčitkov, metagenomske vrste -preverjanje biološke koherence in taksonomske pripadnosti dobljenih sestav -osnovna in napredna anotacija -filogenomika in analiza rekombinacije -poljubno iskanje različnih genetskih elementov po naboru genomov in strategije primerjav	-NGS sequencing strategies: choosing the right sequencing library preparation and sequencing technology for particular goals in bacteriophage, bacteria or metagenome sequencing -classic and hybrid genome assembly/contaminant removal -assembly of metagenomes, read classification, metagenome derived genomes -checking the biological coherence of obtained assemblies, taxonomy assignment -elementary and advanced annotation -phylogenomics and recombination analysis -custom searches for genetic elements in a panel of genomes

Temeljna literatura in viri/Readings:

Pregledni in primarni članki s področja.

Cilji in kompetence:	**Objectives and competences:**
- samostojna in pravilna zasnova projekta NGS za različne scenarije. - kritična analiza dobljenih podatkov - razumevanje delovanja združevalcev odčitkov in njihovih omejitev - taksonomsko ovrednotenje združenih odčitkov genomov in metagenomov - ustvarjanje in primerjava repertoarjev za študenta zanimivih genskih skupin iz nabora preučevanih genomov	- independent and correct design of a NGS project - critical assessment of the obtained data - understanding the workings and limitations of genome assemblers - taxonomy assignment of assembled genomes and metagenomes - ability to create and compare custom gene groups among genomes

Predvideni študijski rezultati:	**Intended learning outcomes:**
Uspešna obdelava problema, ki se dotika sekvenciranja NGS v sklopu doktorske naloge	An NGS-based solution to a problem encountered in the doctoral thesis.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Seminar, ki teoretično uvede študenta v orodja, primerna za reševanje problema. Postavitev primernega okolja za reševanje problema in rešitev lepe pozitivne kontrole. Konzultacije tekom samostojne izvedbe.	An introduction to the theory used in solving the problem (a seminar). Setting up of the computer environment suitable to solve the problem and a test run using a simple example. Consultations during the actual work

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Seminar	20,00 %	Seminar
Izvedba naloge	80,00 %	Project work

Reference nosilca/Lecturer's references:

Accetto, T., Avguštin, G. (2019) The diverse and extensive plant polysaccharide degradative apparatuses of the rumen and hindgut *Prevotella* species: A factor in their ubiquity? Syst. Appl. Microbiol. 42(2), 107–16, Doi: 10.1016/j.syapm.2018.10.001.

Accetto, T., Janež, N. (2018) The lytic *Myoviridae* of *Enterobacteriaceae* form tight recombining assemblages separated by discontinuities in genome average nucleotide identity and lateral gene flow. Microb. Genomics 4(3), Doi: 10.1099/mgen.0.000169.

Vidic, M., Smuc, T., Janez, N., Blank, M., Accetto, T., Mavri, J., Nascimento, I.C., Nery, A.A., Ulrich, H., Lah, T.T. (2018) In silico selection approach to develop DNA aptamers for a stem-like cell subpopulation of non-small lung cancer adenocarcinoma cell line A549. Radiol. Oncol. 52(2), 152–9, Doi: 10.2478/raon-2018-0014.

Janež, N., Peterka, M., Accetto, T. (2016) Complete Genome Sequences of Group III *Campylobacter* Bacteriophages PC5 and PC14. Genome Announc. 4(6), Doi: 10.1128/genomeA.01030-16.

Nograšek, B., Accetto, T., Fanedl, L., Avguštin, G. (2015) Description of a novel pectin-degrading bacterial species *Prevotella pectinovora* sp. nov., based on its phenotypic and genomic traits. J. Microbiol. Seoul Korea 53(8), 503–10, Doi: 10.1007/s12275-015-5142-0.

Accetto, T., Avguštin, G. (2015) Polysaccharide utilization locus and CAZYme genome repertoires reveal diverse ecological adaptation of *Prevotella* species. Syst. Appl. Microbiol. 38(7), 453–61, Doi: 10.1016/j.syapm.2015.07.007.

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Biofilmi
Course title:	Biofilms

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

Univerzitetna koda predmeta/University course code:	0568444

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
0	10	40	0	0	200	10

Nosilec predmeta/Lecturer:	David Stopar

Izvajalci predavanj:	Ines Mandić Mulec, David Stopar
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Individualno raziskovalni /individual research

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 prerequisites for enrolment into doctoral studies

Vsebina:	**Content (Syllabus outline):**
• Sestava biofilmov (biološka, kemijska). • Struktura, dinamika in razvoj biofilmov. • Vpliv okoljskih dejavnikov na razvoj biofilmov. • Transport in medcelične komunikacije v biofilmih. • Koristni in škodljivi biofilmi ter njihova perzistentnost v agroživilstvu. • Mehanska, kemijska in fizikalna kontrola rasti v biofilmih. • Napredne tehnike za določanje sestave, strukture in dinamike biofilmov (npr. konfokalna laserska vrstična mikroskopija, optična pinceta, interfazna reologija, mikrofluidika).	• Composition of biofilms (biological, chemical). • Structure, dynamics and development of biofilms. • The effect of environmental factors on biofilm development. • Transport and cell to cell communications in biofilms. • Good and bad biofilms in agro-food industry. • Mechanical, chmeical and physical control of biofilm growth. • Advanced techniques for evaluation of a biofilm composition, structure and dynamics (i.e. confocal laser scanning microscopy, optical tweezers, interphase rheology, microfluidics).

Temeljna literatura in viri/Readings:

- Microbial Biofilms, Second Edition; (ur.). Mahmoud Ghannoum, Matthew Parsek, Marvin Whiteley, Pranab K. Mukherjee, American Society for Microbiology, 2015
- Hans-Curt Flemming, Jost Wingender, Ulrich Szewzyk, Peter Steinberg, Scott A. Rice & Staffan Kjelleberg, Nature Reviews Microbiology, 2016, 14, 563–575.
- revijalni članki s področja

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je, da študent uporablja različne eksperimentalne pristope za gojenje in karakterizacijo rasti biofilmov. Uporablja različne mehanske in fizikalno-kemijske pristope za kontrolo rasti mikroorganizmov v biofilmih, spozna in razume vpliv biotskih/abiotskih dejavnikov okolja na razvoj biofilmov. Nauči se uporabe naprednih tehnik za določanje sestave, strukture in dinamike biofilmov.	Upon successful completion of the individual research training the student will learn how to use different techniques for the growth and characterization of biofilms. Will be familiar with various biotic and abiotic factors that influence biofilm development. The student will understand how to use different mechanical and physico-chemical tretaments to control microbial growth in biofilms. Uses the advanced techniques for the evaluation of a biofilm composition, structure and dynamics.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent skozi individualno raziskovalno delo v laboratoriju spozna glavne biološke in kemijske komponente biofilmov. Razume njihovo strukturno in dinamično obnašanje. Razume dinamiko nastanka in propada biofilma. Pozna spremembe v celični fiziologiji, ki omogočajo nastanek biofilma. Razume transportne pojave v biofilmu, vpliv signaliziranja in pozna glavne tehnike za proučevanje biofilmov. Pozna škodljive in koristne vplive biofilmov ter načine za preprečitev oziroma uporabo biofilmov.	Through individual research work in the laboratory student learns about the main biological and chemical components of biofilms. Understands structure – dynamic relationship in biofilms. Understands steps in biofilm formation, dispersal and disintegration. Understands physiological changes that allow biofilm formation. Understands transport phenomena in biofilms and role of signalling, knows the main techniques used for studies of biofilms. Student knows how to prevent or use biofilms.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Študent v dogovoru z nosilcem in izvajalci določi raziskovalni projekt in opravi praktično delo v laboratoriju, ki je vezano na rast in karakterizacijo biofilmov. V okviru predmeta je možna uporaba raziskovalnih orodij, ki smo jih razvili v laboratorijih, za potrebe raziskovalnega dela doktorskega študenta. V seminarskem delu študent pripravi poročilo o svojem raziskovalnem projektu.	In agreement with lecturers student determines the aims of the individual research project and performs the experiments related to growth and caracterization of biofilms in the laboratory. Student may use research tools developed in our laboratories for his/her PhD project related to microbial biofilms. In a seminar student produces a report about his/her individual research project.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Ocenjuje se izvedba problemsko orientiranega individualnega raziskovalnega dela in pripravljenega seminarja.	100,00 %	Assesment of problem oriented individual research work and written report.

Reference nosilca/Lecturer's references:

Prof. Dr. David Stopar

1. HORVAT, Maruša, PANNURI, Archana, ROMEO, Tony, DOGŠA, Iztok, STOPAR, David. Viscoelastic response of Escherichia coli biofilms to genetically altered expression of extracellular matrix components. Soft matter. 2019, vol. 15, str. 5042-5051, ilustr. ISSN 1744-683X. DOI: 10.1039/c9sm00297a. [COBISS.SI-ID 5060728]
2. BAŠ, Sara, KRAMER, Mateja, STOPAR, David. Biofilm surface density determines biocide effectiveness. Frontiers in microbiology. 2017, vol. 8, str. 1-9. ISSN 1664-302X. DOI: 10.3389/fmicb.2017.02443. [COBISS.SI-ID 1388638]
3. SRETENOVIĆ, Simon, STOJKOVIĆ, Biljana, DOGŠA, Iztok, KOSTANJŠEK, Rok, POBERAJ, Igor, STOPAR, David. An early mechanical coupling of planktonic bacteria in dilute suspensions. Nature communications. Aug. 2017, vol. 8, str. 1-10, ilustr. ISSN 2041-1723. https://www.nature.com/articles/s41467-017-00295-z, DOI: 10.1038/s41467-017-00295-z. [COBISS.SI-ID 33363673]

4. BENIGAR, Elizabeta, DOGŠA, Iztok, STOPAR, David, JAMNIK, Andrej, KRALJ CIGIĆ, Irena, TOMŠIČ, Matija. Structure and dynamics of a polysaccharide matrix : aqueous solutions of bacterial levan. Langmuir. 2014, vol. 30, issue 14, str. 4172-4182. ISSN 0743-7463. DOI: 10.1021/la500830j. [COBISS.SI-ID 4381304]
5. BENIGAR, Elizabeta, ZUPANČIČ-VALANT, Andreja, DOGŠA, Iztok, SRETENOVIĆ, Simon, STOPAR, David, JAMNIK, Andrej, TOMŠIČ, Matija. Structure and dynamics of a model polymer mixture mimicking a levan-based bacterial biofilm of Bacillus subtilis. Langmuir. 2016, vol. 32, iss. 32, str. 8182-8194, ilustr. ISSN 0743-7463. http://pubs.acs.org/doi/full/10.1021/acs.langmuir.6b02041, DOI: 10.1021/acs.langmuir.6b02041. [COBISS.SI-ID 1537177283]
6. LORENZETTI, Martina, DOGŠA, Iztok, STOŠICKI, Tjaša, STOPAR, David, KALIN, Mitjan, KOBE, Spomenka, NOVAK, Saša. The influence of surface modification on bacterial adhesion to titanium-based substrates. ACS applied materials & interfaces. [Print ed.]. 2015, vol. 7, str. 1644-1651, ilustr. ISSN 1944-8244. DOI: 10.1021/am507148n. [COBISS.SI-ID 4496504]
7. STOJKOVIĆ, Biljana, SRETENOVIĆ, Simon, DOGŠA, Iztok, POBERAJ, Igor, STOPAR, David. Viscoelastic properties of levan-DNA mixtures Important in microbial biofilm formation as determined by micro- and macrorheology. Biophysical journal. 2015, vol. 108, iss. 3, str. 758-765. ISSN 0006-3495. DOI: 10.1016/j.bpj.2014.10.072. [COBISS.SI-ID 4506744]
8. BORIĆ VEZJAK, Maja, DANEVČIČ, Tjaša, STOPAR, David. Viscosity dictates metabolic activity of Vibrio ruber. Frontiers in microbiology. July 2012, vol. 3, no. article 255, str. 1-12. ISSN 1664-302X. http://www.frontiersin.org/Microbial_Physiology_and_Metabolism/10.3389/fmicb.2012.00255/full, DOI: 10.3389/fmicb.2012.00255. [COBISS.SI-ID 4146552]
9. ŠARC, Andrej, KOSEL, Janez, STOPAR, David, ODER, Martina, DULAR, Matevž. Removal of bacteria Legionella pneumophila, Escherichia coli, and Bacillus subtilis by (super)cavitation. Ultrasonics Sonochemistry. Apr. 2018, vol. 42, str. 228-236, ilustr. ISSN 1350-4177. https://ac.els-cdn.com/S1350417717305072/1-s2.0-S1350417717305072-main.pdf?_tid=8731f192-db3f-11e7-96e6-00000aacb35d&acdnat=1512645336_7ae6f9b0762e2f47704d5873693ed3c0, DOI: 10.1016/j.ultsonch.2017.11.004. [COBISS.SI-ID 15787803]
10. SIMUNIČ, Urh, PIPP, Peter, DULAR, Matevž, STOPAR, David. The limitations of hydrodynamic removal of biofilms from the dead-ends in a model drinking water distribution system. Water research. [Print ed.]. 2020, vol. 178, str. 1-13, ilustr. ISSN 0043-1354. https://www.sciencedirect.com/science/article/pii/S0043135420303754?via%3Dihub, DOI: 10.1016/j.watres.2020.115838. [COBISS.SI-ID 12956163]

Prof. dr. Ines Mandić Mulec

1. XU, Zhihui, MANDIĆ-MULEC, Ines, ZHANG, Huihui, LIU, Yan, SUN, Xinli, FENG, Haichao, XUN, Weibing, ZHANG, Nan, SHEN, Qirong, ZHANG, Ruifu. Antibiotic bacillomycin D affects iron acquisition and biofilm formation in Bacillus velezensis through a Btr-mediated FeuABC-dependent pathway. Cell reports, ISSN 2211-1247, Oct. 2019, vol. 29, iss. 5, str. 1192-1202, e1-e5, ilustr., doi: 10.1016/j.celrep.2019.09.061. [COBISS.SI-ID 5118072]
2. ŠPACAPAN, Mihael, DANEVČIČ, Tjaša, MANDIĆ-MULEC, Ines. ComX-induced exoproteases degrade ComX in Bacillus subtilis PS-216. Frontiers in microbiology, ISSN 1664-302X, Feb. 2018, vol. 9, article 105, str. 1-11, ilustr., doi: 10.3389/fmicb.2018.00105. [COBISS.SI-ID 4876664]
3. GUBRY-RANGIN, Cecile, NOVOTNIK, Breda, MANDIĆ-MULEC, Ines, NICOL, Graeme, PROSSER, James Ivor. Temperature responses of soil ammonia-oxidising archaea depend on pH. Soil biology & biochemistry, ISSN 0038-0717. [Print ed.], 2017, vol. 106, str. 61-68, ilustr., doi: 10.1016/j.soilbio.2016.12.007. [COBISS.SI-ID 4743288]
4. DRAGOŠ, Anna, ŠTEFANIČ, Polonca, VATOVEC, Sabina, BEIGOT GLASER, Sara, RUPNIK, Maja, MANDIĆ-MULEC, Ines. Exploring ComQXPA quorum-sensing diversity and biocontrol potential of Bacillus spp. isolates from tomato rhizoplane. Microbial biotechnology, ISSN 1751-7915. [Online ed.], 2015, vol. 8, issue 3, str. 527-540, doi: 10.1111/1751-7915.12258. [COBISS.SI-ID 4494968]
5. AUSEC, Luka, ČRNIGOJ, Miha, ŠNAJDER, Marko, POKLAR ULRIH, Nataša, MANDIĆ-MULEC, Ines. Characterization of a novel high-pH tolerant laccase-like multicopper oxidase and its sequence diversity in Thioalkalivibrio sp. Applied microbiology and biotechnology, ISSN 0175-7598, 2015, vol. 99, str. 9987-9999, doi: 10.1007/s00253-015-6843-3. [COBISS.SI-ID 4548472]
6. DOGŠA, Iztok, DRAGOŠ, Anna, ŠTEFANIČ, Polonca, MANDIĆ-MULEC, Ines. Social interactions and biofilm formation in Bacillus subtilis. Food technology and biotechnology : journal of the Faculty of Food Technology and Biotechnology University of Zagreb, ISSN 1330-9862, 2014, vol. 52, no. 2, str. 149-157. [COBISS.SI-ID 4381816]

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Eksperimentalna evolucija mikroorganizmov
Course title:	Experimental evolution of microorganisms
Članica nosilka/UL Member:	UL BF

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

Univerzitetna koda predmeta/University course code:	0643143

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
0	2	0	0	23	100	5

Nosilec predmeta/Lecturer:	Anna Dragoš

Izvajalci predavanj:	
Izvajalci seminarjev:	Anna Dragoš
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	individualno raziskovalni /individual research course

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 prerequisites for doctoral study

Vsebina:	**Content (Syllabus outline):**
Eksperimentalna evolucija omogoča preučevanje evolucijskih sprememb znotraj eksperimentalnih populacij, ki nastanejo kot posledica selekcijskega pritisk, ki ga naloži raziskovalec. Že desetletja nam eksperimentalna evolucija omogoča manipuliranje z mikrobi in raziskovanje dolgoročne dinamike v mikrobnih populacijah. Metodo so uporabljali pri različnih modelnih mikroorganizmih, kot so kvasovke, glive, bakterije ali fagi. Omogoča preverjanje hipotez vezanih na temeljna biološka vprašanja: kako se razvija večceličnost? Kako se mikrobi prilagajajo	Experimental evolution allows to study evolutionary changes within experimental populations, that occur as a consequence of selection regime imposed by the experimenter. Since decades, experimental evolution has allowed us to manipulate microbes and to explore the long-term dynamics in microbial populations. It was used in variety of model microorganisms such as yeasts, fungi, bacteria or phages. It allows to test hypotheses linked to fundamental biological questions: how does multicellularity evolve? How microbes adapt to

abiotskemu ali biotskemu stresu, življenju v biofilmih ali nestabilnemu okolju? Kako se paraziti prilagajajo novemu gostitelju in obratno? V okviru predmeta se bo doktorski študent naučil osnovnih principov eksperimentalne evolucije mikrobov v teoriji in praksi. V teoretičnem delu se bo študent seznanil z temeljno literaturo ter dodatno izbrano znanstveno publicistiko, ki je lahko vezana na doktorsko temo. Kandidat se bo lahko pridružil tedenskim srečanjem katedre »Journal Club«, kjer bo predstavil eno izbrano publikacijo. Ta bo služila kot izhodna točka za praktični del predmeta. V praktičnem delu bo študent oblikoval evolucijski eksperiment, ki bo obravnaval raziskovalno vprašanje po lastni izbiri, lahko tudi vezano na tematiko doktorske disertacije. Končno temo bo izbral v dogovoru z nosilko predmeta in po potrebi tudi po dogovoru z mentorjem študenta. Med posvetovanjem bo predavatelj podal povratne informacije o eksperimentalnim načrtu: tip selekcijskega pritiska, število populacij, število prenosov in pogostost vzorčenja/arhiviranja ter fenotipske analize za primerjavo razvitih populacij/izolatov s prednikom. Študent izvaja eksperiment sam, možna pa so dodatna posvetovanja med in po eksperimentalnem delu, kjer predavatelj poda povratno informacijo o rezultatih. Eksperiment se lahko izvaja v laboratoriju mentorja in po potrebi in dogovoru tudi v laboratoriju nosilke predmeta. Ob koncu predmeta študent odda kratko pisno poročilo in predstavi rezultate na raziskovalnem seminarju. *predmet ne zajema genomske analize evolviranih izolatov in mehanizmov molekularne evolucije	abiotic or biotic stress, biofilm lifestyle, or changing environment? How parasites adapt to new host and vice versa? During the course, a PhD student will learn basic principles of microbial experimental evolution in theory and practice. In the theoretical part, the student will familiarize him/herself with recommended readings, and additional selected publication possibly connected to the students PhD topic. The candidate may participate in weekly meeting within the Chair »Journal Club« where he/she can present the selected publication. It will serve as a starting point for the practical part of the course. During the practical part the student will design an evolution experiment to address research question of his/her choice, which could be also relevant for their PhD thesis. Final topic will be selected in agreement with the lecturer, and if needed, also in agreement with the PhD supervisor. During the consultation the lecturer will provide feedback on experimental design: type of selection regime, nr of populations, nr of transfers and sampling/archiving frequency, and phenotypic assays to compare the evolved populations/isolates with the ancestor. The student conducts the experiment alone, but additional consultations are possible during and after the experimental part, where lecturer provides feedback on the results. The experiment can be conducted in the laboratory of the supervisor or if needed, and after mutual agreement, in the laboratory of the lecturer. At the end of the course, the student hands in a short, written report, and presents the data on research seminar. *the course does not cover genomic analysis of the evolved isolates and mechanisms of molecular evolution

Temeljna literatura in viri/Readings:

Kawecki et al., 2012, Trends in Ecology & Evolution doi: 10.1016/j.tree2012.06.001

Dragoš & Kovács, 2019, Journal of Molecular Biology doi: 10.1016/j.jmb.2019.02.005

Dodatna literatura izbrana v povezavi z izbranim eksperimentom /

Additional literature will be selected in connection to eksperimental design

Cilji in kompetence:	**Objectives and competences:**

Doktorski študent spozna možne aplikacije eksperimentalne evolucije in lahko postavi lasten eksperiment vezan na doktorsko nalogo. Študent se nauči načrtovati in izvesti eksperiment ter kritično analizirati podatke.	PhD candidate learns about possible applications of experimental evolution and he/she can set-up an evolution experiment (favorably in connection to PhD thesis). PhD candidate learns how to design and conduct the experiment and how to critically analyze the data.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Razumevanje osnovnih načel eksperimentalne evolucije. Sposobnost uporabe exp. evolucije kot metode za testiranje določenih raziskovalnih vprašanj/hipotez.	Understanding basic principles of experimental evolution. Ability to use exp. evolution as a tool to test specific research questions/hypotheses.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Analiza raziskovalnega članka po izboru študenta in nosilke predmeta, javno nastopanje v okviru raziskovalnih srečan, ki jih organizira nosilka predmeta. Eksperimentalni načrt (pripravi študent), komentarje (nosilka predmeta), prilagojen načrt (študent). Evolucijski eksperiment in analiza rezultatov (študent) in diskusija z nosilko predmeta.	Analysis of research manuscript selected by the student and lecturer, public presentation during research meetings organized by the lecturer. Experimental design (student) and feedback (lecturer), adjusted experimental plan (student). Evolution experiment and results interpretation (student) and discussion with lecturer.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Uvodni seminar	10,00 %	Presentation clarity assessed by lecturer.
Praktični del	60,00 %	Involvment in practical work assessed by lecturer.
Poročilo in končna predstavitev	30,00 %	Report and final presentation assessed by lecturer.

Reference nosilca/Lecturer's references:

Anna Dragoš

1. Gallegos-Monterrosa R, Nordgaard Christensen M, Barchewitz T, Koppenhöfer S, Priyadarshini B, Bálint B, Maróti G, Kempen PJ, Dragoš A, Kovács ÁT. 2021. Impact of Rap-Phr system abundance on adaptation of *Bacillus subtilis*. Communications biology 13;4(1):468 doi: 10.1038/s42003-021-01983-9

2. Dragoš A., Priyadarshini B., Hasan Z., Lenz-Strube M., Kempen PJ., Maróti G., Kaspar C., Bose B., Burton BM., Bischofs IB., Kovács AT. 2020. Pervasive prophage recombination occurs during evolution of spore-forming Bacilli. ISME J, doi: 10.1038/s41396-020-00854-1

3. Martin M, Dragoš A, Otto SB, Schäfer D, Brix S, Maróti G, Kovács ÁT. 2020. Cheaters shape the evolution of phenotypic heterogeneity in *Bacillus subtilis* biofilms. The ISME journal 14 (9), 2302-2312

4. Dragoš A., Kovács ÁT. 2019. Evolved biofilm: review on the experimental evolution studies of *Bacillus subtilis* pellicles. Journal of Molecular Biology, doi: 10.1016/j.jmb.2019.02.005

5. Dragoš A., Martin M., Falcón García C.,Kricks L., Pausch P., Heimerl T., Bálint B., Maróti G., Bange G., López D., Lieleg O., Kovács ÁT. 2018. Collapse of genetic division of labor and evolution of autonomy in pellicle biofilms. Nature Microbiology 3: 1451–1460

6. Dragoš A., Lakshmanan N., Martin M., Bálint B., Maróti G., Falcon Garcia C., Lieleg O., Kovács ÁT. 2018. Evolution of exploitative interactions during diversification in *Bacillus subtilis* biofilms. FEMS Microbiology Ecology, doi.org/10.1093/femsec/fix155

7. Martin M.*, Dragoš A.*, Hölscher T.*, Maróti G., Bálint B., Westermann M., Kovács ÁT. 2017. De novo evolved interference competition promotes the spread of biofilm defectors. Nature Communications, doi: 10.1038/ncomms15127