



Univerza v Mariboru

Fakulteta za naravoslovje  
in matematiko

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

<b>Predmet:</b>	<b>Odzivi rastlinske celice na okoljske dejavnike</b>
<b>Course title:</b>	<b>Plant cell responses to environmental impacts</b>

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Univerzitetni študijski program Ekologija z naravovarstvom, 1. stopnja		2. ali 3.; 2nd or 3rd	3. ali 4. ali 5. ali 6. / 3. or or 4. or 5. or 6.
Undergraduate university programme Ecology with Nature Conservation, 1st degree			

Vrsta predmeta / Course type

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje Field work	Samost. delo Individ. work	ECTS
30			15		135	6

Nosilec predmeta / Lecturer:

Jeziki / Languages:	Predavanja / Lectures:	<input type="text" value="slovenski / slovene"/>
	Vaje / Tutorial:	<input type="text" value="slovenski / slovene"/>

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

Prerequisites:

Vsebina:

Content (Syllabus outline):

**Uvodno predavanje** (Zakaj proučujemo rastline, zgodovina in temelji mikroskopije)

**Vpliv okoljskih dejavnikov na rastlinsko celico, celične tipe in celične kompartmente**

Spremembe v strukturi celičnih organelov, spremembe v permeabilnosti membran, spremembe v vsebnosti snovi, aktivnosti encimov, celična smrt.

Celična stena:

Kemijska zgradba, rast v dolžino in vloga citoskeletnih elementov, plazmodezme-zgradba in funkcija v patosistemih, mineralni vključki in njihov pomen v rastlinski fiziologiji, posebni tipi celične stene, obramba pred patogeni in škodljivci, primeri raziskav nekaterih patosistemov.

Vakuola:

Zgradba, funkcija, biogeneza, transport skozi tonoplast (membranski proteini, glutationska črpalka), vakuola kot založni in litični kompartment, strukturna vloga, turgorska gibanja, vektorska sinteza sladkorjev, vpliv nizkih temperatur («low temperature sweetening»), solni stres, težke kovine in privzem v vakuolo, vakuola v obrambi pred patogeni in škodljivci, vakuolarni sekundarni metaboliti, vakuolarni encimi, mehanizmi preprečevanja avtotoksicitete.

Plastidi:

Zgradba, tipi plastidov, biogeneza, evolucija plastidov, plastidno dedovanje, import proteinov, signalna transdukcija, vpliv biotskih in abiotskih dejavnikov na ultrastrukturo plastidov (sušni stres, abscizinska kislina-princip ionske kletke, radiacijski stres, biotski stres), plastidi kot tarča genskega inženiringa za pridobivanje polimerov.

Mitochondriji:

Zgradba, evolucija mitochondrijev, mitochondrijsko dedovanje, vpliv biotskih in abiotskih dejavnikov na ultrastrukturo

**Introduction** (Why study plants, history and the basic principles of microscopy)

**The environmental impacts on plant cell, cell types and cell compartments**

substructural changes of cell organelles, changes in membrane permeability, alterations in chemical compounds, enzyme activity and metabolism, cell death.

Cell wall:

Chemical structure and plant cell wall growth, the significance of cytoskeleton, plasmodesmata-structure and function in different patosystems, cell wall mineral inclusions and their role in plant physiology, the significance of cell wall in defense against pathogens and pests, case studies of selected pathosystems.

Vacuole:

Structure and function, biogenesis, transport through tonoplast (membrane proteins, glutathione pump), vacuole as a storage and lytic organelle, structural function, turgor movements, tonoplast sugar transport and vector synthesis, low temperature sweetening, salt stress, heavy metals detoxification, significance of vacuole in defense against pathogens and pests (vacuolar secondary metabolites, vacuolar enzymes, mechanisms of avoiding autotoxicity)

Plastids:

Structure, different types of plastids, biogenesis, evolution, plastid inheritance, protein import, signal transduction, the impact of biotic and abiotic factors on plastid ultrastructure (drought stress, abscisic acid-principle of ion cage, radiation stress, biotic stress) plastids as target of genetic engineering principles for polymer synthesis.

Mitochondria:

Structure, evolution, mitochondrial inheritance, the impact of biotic and abiotic factors on

mitochondrijev (vročinski stres in hsp-proteini, radiacijski stres, sušni stres, hipoxia)

**Sinteza in vloga antioksidantov v celičnih organelih in odpravljanje reaktivnih kisikovih vrst**(askorbatno-glutationska veriga, ksantofilni cikel, tokoferoli)

**Programirana celična smrt pri rastlinah** (kategorije celične smrti v rastlinah)

**Povzetek** stresnih dejavnikov na nivoju celice (sušni stres, radiacijski stres, vpliv visokih in nizkih temperatur, solni stres, hipoksija-anoksija, zračni polutanti, biotski stres)

**Laboratorijske vaje in mikroskopija**

določanje simptomov na nivoju celičnih organelov, celic in organov na podlagi TEM mikrografij,

določanje in lokaliziranje akumuliranih strupenih snovi v celicah,

standardizirani testi ugotavljanja genotoksičnosti (Allium-test, Tradescantia-test).

priprava vzorcev in fiksiranje preparatov, izolacija protoplastov

tehnike barvanja preparatov v svetlobni mikroskopiji, fluorescenčna barvila, imunohistokemijske in imunocitokemijske metode, histokemična lokalizacija glutaciona

mitochondria ultrastructure (heat shock proteins, radiation stress, drought stress, hipoxia)

**The antioxidant synthesis and their significance in cell organelles, reactive oxygen removal** (ascorbate-glutathione cycle, xanthophyll cycle, tocopherols)

**Programmed cell death in plants** (many ways to exit, cell death categories in plants)

Summary: abiotic and biotic stress factors at the cellular level (drought stress, radiation stress, high – low temperature stress, salt stress, hipoxia-anoxia, air pollutants, biotic stress)

**Laboratory work and microscopy**

symptom characterization of altered life functions within cell organelles (TEM micrographs)

determination and localization of accumulated toxic compounds in cells,

standardized genotoxicology tests (Allium-Test, Tradescantia-Test).

specimen preparation and fixation protocols

isolation of protoplasts

staining methods in light microscopy, fluorescent dyes, immunohistochemical and immunocytochemical methods, histochemical localization of glutathione

### Temeljni literatura in viri / Readings:

#### OBVEZNA LITERATURA:

ALBERTS B., JOHNSON A., LEWIS J., RAFF M., ROBERTS K., WALTER P., 2015. Molecular Biology of the Cell. 6<sup>th</sup>, edition, Garland Science, Taylor & Francis Group, New York.

Pollard T.D., Earnshaw W.C. 2016. Cell biology, Third edition, Saunders Elsevier, Philadelphia.

#### DODATNA LITERATURA:

KLEINIG H., SITTE P., 1999. Zellbiologie. 4. Aufl., Gustav Fischer Verlag, Stuttgart.

Batič F. in Košmrlj – Levačič B. 2023. Botanični terminološki slovar. ZRC SAZU, 2.izdaja.

Primeri raziskav so povzeti po člankih iz spodaj navedenih znanstvenih revij:

The Plant Cell  
Protoplasma  
Plant Cell and Environment  
Plant and Cell Physiology  
Journal of Plant Biotechnology  
Trends in Plant Science  
Insects  
Trees

**Cilji in kompetence:**

1. Predstavitev zgradbe rastlinske celice, kemične sestave in mehanizmi transporta snovi v celici.
2. Pregled vpliva okoljskih dejavnikov na celične tipe in celične kompartmente.
3. Ponazoritev mehanizmov sprejemanja dražljajev ter mehanizmov medceličnega in celičnega sporočanja.
4. Predstavitev nekaterih prilagoditev rastlinske celice na stresne dejavnike in predstavitev mehanizmov detoksifikacije.
5. Uporaba metod celične biologije na področju okoljskega monitoringa in ekotoksikologije.

**Objectives and competences:**

1. Introduction to the structure, chemical composition and transport mechanisms
2. Overview of the impacts of environmental factors on cell types and cell compartments.
3. Insights about the mechanisms of signal perception and mechanisms of inter- and intracellular sensing.
4. Presentation of some adaptations to stress factors at the cellular level and mechanisms of detoxification.
5. Application of methods in environmental monitoring and ecotoxicology.

**Predvideni študijski rezultati:**

**Znanje in razumevanje:**

1. Razumevanje in prepoznavanje celičnih sprememb zaradi vpliva stresnih dejavnikov.
2. Osvojitev principov mikroskopije in osnovnih metod v rastlinski celični biologiji.
3. Poznavanje pomena celične biologije v okoljskem monitoringu in ekotoksikologiji.

**Prenesljive/ključne spretnosti in drugi atributi:**

1. Prepoznavanje vpliva okoljskih dejavnikov na strukturo in delovanje celic.

**Intended learning outcomes:**

**Knowledge and understanding:**

1. Understanding and recognition of alterations within cells affected by stress factors.
2. Capturing principles of microscopy and basic methods in plant cell biology.
3. Throughout knowledge about the significance of cell biology in environmental monitoring and ecotoxicology.

**Transferable/Key Skills and other attributes:**

1. Identification of the impacts of environmental factors on the plant cell structure and function.

2. Sposobnost uporabe citoloških metod v okoljskem monitoringu in ekotoksikologiji.

2. Ability for using cytological methods in ecological monitoring and ecotoxicology.

**Metode poučevanja in učenja:**

- predavanja z aplikativnimi primeri principov in metod celične biologije ob uporabi različnih AV sredstev,
- eksperimentalne vaje, priprava laboratorijskega poročila

**Learning and teaching methods:**

- lectures with special attention to principles and methods in cell biology by using audiovisual equipment,
- experimental work, laboratory report

Delež (v %) /

Weight (in %)

**Assessment:**

**Načini ocenjevanja:**

pisni izpit

70

written examination

poročilo laboratorijskih vaj

30

laboratory report

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

AMBROŽIČ-DOLINŠEK, Jana, PODGRAJŠEK, Anja, ŠABEDER, Nik, MAZEJ, Zdenka, URBANEK KRAJNC, Andreja, TODORVIČ, Biljana, CIRINGER, Terezija. The potential of berula erecta in vitro for As bioaccumulation and phytoremediation of water environments. *Environmental pollutants & bioavailability*. 2023, vol. 35, no. 1, [article no.] 2205010, 12 str. ISSN 2639-5940. DOI: [10.1080/26395940.2023.2205010](https://doi.org/10.1080/26395940.2023.2205010). [COBISS.SI-ID [151163139](#)], [JCR, SNIP]

URBANEK KRAJNC, Andreja, BAKONYI, Tamás, ANDO, Istvan, KURUCZ, Eva, SOLYMOSI, Norbert, PONGRAC, Paula, BERČIČ, Rebeka Lucijana. The effect of feeding with Central European local mulberry genotypes on the development and health status of silkworms and quality parameters of raw silk. *Insects*. 2022, vol. 13, iss. 9, [article no.] 836, str. 1-29, graf. prikazi. ISSN 2075-4450. <https://www.mdpi.com/2075-4450/13/9/836>, DOI: [10.3390/insects13090836](https://doi.org/10.3390/insects13090836). financer: Hungarian Scientific Research Fund ARRS, OTKA SNN 116993, N1-0041, P-0164, P1-0212, J4-309

URBANEK KRAJNC, Andreja, LUTHAR, Zlata, LIPOVŠEK, Matej, IVANUŠ, Anja, MILJUŠ, Staš, BOHANEK, Borut, ŠIŠKO, Metka. Taxonomic analysis of certain taxa of Epipactis in Slovenia. *Perspectives in plant ecology, evolution and systematics*. September 2022, vol. 56, str. 1-33. ISSN 1433-8319. DOI: [10.1016/j.ppees.2022.125674](https://doi.org/10.1016/j.ppees.2022.125674). [COBISS.SI-ID [107451139](#)], [JCR, SNIP, WoS, Scopus] financer: ARRS, P1-0164, P4-0077

ŽEBELJAN, Aleksandra, VICO, Ivana, DUDUK, Nataša, ŽIBERNA, Bojana, URBANEK KRAJNC, Andreja. Profiling changes in primary metabolites and antioxidants during apple fruit decay caused by Penicillium crustosum. *Physiological and molecular plant pathology*. January 2021, vol. 113, 101586, str. 1-10, ilustr. ISSN 0885-5765. DOI: [10.1016/j.pmpp.2020.101586](https://doi.org/10.1016/j.pmpp.2020.101586).

TODORVIČ, Biljana, GRUJIĆ, Jaša Veno, URBANEK KRAJNC, Andreja, KRANVOGL, Roman, AMBROŽIČ-DOLINŠEK, Jana. Identification and content of astaxanthin and its esters from microalgae Haematococcus pluvialis by HPLC-DAD and LC-QTOF-MS after extraction with various solvents. *Plants*. 2021, vol. 10, iss. 11, str. 1-14. ISSN 2223-7747. DOI: [10.3390/plants10112413](https://doi.org/10.3390/plants10112413).

ŠELIH, Mateja, MIKULIČ PETKOVŠEK, Maja, KRAJNC, Damjan, BERČIČ, Rebeka Lucijana, URBANEK KRAJNC, Andreja. Screening of leaf metabolites in historical mulberry trees (*Morus alba* L.) from different eco-geographical regions of Slovenia. *Trees*. 2020, vol. 34, iss. 4, str. 971-986. ISSN 0931-1890. <https://link.springer.com.ezproxy.lib.ukm.si/content/pdf/10.1007%2Fs00468-020-01974-z.pdf>, DOI: [10.1007/s00468-020-01974-z](https://doi.org/10.1007/s00468-020-01974-z). [COBISS.SI-ID [4678188](#)].

SUNKARA, Sowmya, RADULOVIC, Snježana, LIPOVŠEK DELAKORDA, Saška, BIRKL, Christoph, EGGENREICH, Stefan, BIRKL-TOEGLHOFER, Anna Maria, SCHINAGL, Maximilian, FUNK, Daniel, STÖGER-POLLACH, Michael, HAYBAECK, Johannes, GÖSSLER, Walter, ROPELE, Stefan, LEITINGER, Gerd. Autolysis affects the iron cargo of

ferritins in neurons and glial cells at different rates in the human brain. *Applied biochemistry and biotechnology*. 2023, 15 str., ilustr. ISSN 0273-2289. DOI: [10.1007/s10571-023-01332-w](https://doi.org/10.1007/s10571-023-01332-w). [COBISS.SI-ID 145448963], [JCR, SNIP, WoS, Scopus]

LIPOVŠEK DELAKORDA, Saška, NOVAK, Tone, DARIŠ, Barbara, HOFER, Ferdinand, LEITINGER, Gerd, LETOFŠKY-PAPST, Ilse. Ultrastructure of spherites in the midgut diverticula and Malpighian tubules of the harvestman *Amilenus aurantiacus* during the winter diapause. *Histochemistry and cell biology*. Jan. 2022, vol. 157, iss. 1, str. 107-118, ilustr. ISSN 0948-6143. DOI: [10.1007/s00418-021-02046-0](https://doi.org/10.1007/s00418-021-02046-0).

MAROLT, Urška, PARADIŽ, Eva, POHOREC, Viljem, LIPOVŠEK DELAKORDA, Saška, VENGLOVECZ, Viktória, GÁL, Eleonóra, ÉBERT, Attila, MENYHÁRT, István, POTRČ, Stojan, GOSAK, Marko, DOLENŠEK, Jurij, STOŽER, Andraž. Calcium imaging in intact mouse acinar cells in acute pancreas tissue slices. *PloS one*. 2022, vol. 17, iss. 6, str. 1-26, ilustr. ISSN 1932-6203. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0268644>, DOI: [10.1371/journal.pone.0268644](https://doi.org/10.1371/journal.pone.0268644).

NOVAK, Tone, SLANA NOVAK, Ljuba, KOZEL, Peter, SCHAIDER, Miriam, KOMPOSCH, Christian, LIPOVŠEK DELAKORDA, Saška, PODLESNIK, Jan, PAUŠIČ, Igor, RASPOTNIG, Günther. Hidden diversity within the *Nemastoma bidentatum* Roewer, 1914 complex (Opiliones: Nemastomatidae). Part I, Morphological evidence. *European Journal of Taxonomy*. 2021, vol. 777, str. 1-67, ilustr. ISSN 2118-9773. DOI: [10.5852/ejt.2021.777.1561](https://doi.org/10.5852/ejt.2021.777.1561).

LIPOVŠEK DELAKORDA, Saška, KOZEL, Peter, LEITINGER, Gerd, NOVAK, Tone. Malpighian tubules in harvestmen. *Protoplasma*. 2021, vol. 258, iss. 5, str. 1145-1153, ilustr. ISSN 0033-183X. DOI: [10.1007/s00709-021-01634-0](https://doi.org/10.1007/s00709-021-01634-0).