Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Odzivi rastlinske celice na okoljske dejavnike**
Course title:	**Plant cell responses to environmental impacts**

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.	3. ali 4. ali 5. ali 6.
Undergraduate university programme Ecology with Nature Conservation, 1st degree		2nd or 3rd	3. or or 4. or 5. or 6.

Vrsta predmeta / Course type Izbirni/Elective

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	~~Laboratorijske~~Seminarske ~~V~~vaje Tutorial	Lab. vaje~~Klinične vaje~~ Lab. work~~work~~	~~Druge oblike študija~~Terenske vaje Field work	Samost. delo Individ. work	ECTS
30		~~15~~	15		135	6

Nosilec predmeta / Lecturer: Andreja URBANEK KRAJNC, Saška LIPOVŠEK

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski / slovene
	Vaje / Tutorial:	slovenski / slovene

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

Prerequisits:

/	/

Vsebina:	**Content (Syllabus outline):**
Uvodno predavanje (Zakaj proučujemo rastline, zgodovina in temelji mikroskopije) **Vpliv okoljskih dejavnikov na rastlinsko celico, celične tipe in celične kompartimente** Spremembe v strukturi celičnih organelov, spremembe v permeabilnosti membran, spremembe v vsebnosti snovi, spremembe v izražanju genov za proteine pomembne v rezistomu, programirana celična smrt. <u>Celična stena</u>: 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. <u>Vakuola</u>: Zgradba, funkcija, biogeneza, transport skozi tonoplast (membranski proteini, glutationska črpalka), vakuola kot založni in litični kompartiment, 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. <u>Plastidi</u>: Zgradba, tipi plastidov, biogeneza, evolucija plastidov, plastidno dedovanje, import	**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, changes in the gene expression of proteins involved in resistome , programmed cell death. <u>Cell wall:</u> 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. <u>Vacuole:</u> 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) <u>Plastids:</u>

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.

Mitohondriji:

Zgradba, evolucija mitohondrijev, mitohondrijsko dedovanje, vpliv biotskih in abiotskih dejavnikov na ultrastrukturo mitohondrijev (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 (ozadje PCS, kategorije celične smrti v rastlinah)

Povzetek stresnih dejavnikov na nivoju celice (sušni stres, foto-termični 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 glutationa v povezavi s toksičnostjo težkih kovin

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) plastifs as target og nenetic engineering principles for polimer synthesis.

Mitochondria:

Structure, evolution, mitochondrial inheritance, the impact of biotic and abiotic factors on mitochondria ultrastructure (heat shock proteins, radiation stress, drought stress, hipoxia)

The antioxidant synthesis and their significance in cell organelles, reactive oxigen 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, photo-thermal 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 in combination with heavy metal toxicity.

Temeljni literatura in viri / Readings:

OBVEZNA LITERATURA:
Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, Graham Johnson, 2022. Cell Biology. 4th Edition, Saunders Elsevier, Philadelphia. Print.

ALBERTS, BRUCE, 2019. ESSENTIAL CELL BIOLOGY ; EDITION: FIFTH EDITION; PUBLISHER: W.W. NORTON & COMPANY, NEW YORK, 2019.
Veranič, P., Romih, R., Pšeničnik, M., 2009: Praktični pouk celične biologije. TZS, Ljubljana.
Jezernik, K., Veranič, P., Sterle, M., 2012: Celična biologija. Učbenik za študente Medicinske fakultete. DZS, Ljubljana.
Dariš B., Lipovšek S.: Biologija celice: navodila za laboratorijske vaje. Maribor: Univerza v Mariboru, Univerzitetna založba, 2021

DODATNA LITERATURA:
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 in preko biomembran.

2. Pregled vpliva okoljskih dejavnikov na celične tipe in celične kompartimente.

3. Ponazoritev mehanizmov sprejemanja dražljajev ter mehanizmov medceličnega in celičnega sporočanja.

4. Predstavitev tolerančnih/rezistenčnih mehanizmov 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 within the cell and through biomembranes.

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 signalling.

4. Presentation of tolerance/resistance mechanisms of plant cell to stress factors at the cellular level and mechanisms of detoxification.

5. Application of methods in cell biology for environmental monitoring and ecotoxicology.

Predvideni študijski rezultati:

Intended learning outcomes:

Znanje in razumevanje:	**Knowledge and understanding:**
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.	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.
Prenesljive/ključne spretnosti in drugi atributi:	**Transferable/Key Skills and other attributes:**
1. Prepoznavanje vpliva okoljskih dejavnikov na strukturo in delovanje celic. 2. Sposobnost uporabe citoloških metod v okoljskem monitoringu in ekotoksikologiji.	1. Identification of the impacts of environmental factors on the plant cell structure and function. 2. Ability for using cytological methods in ecological monitoring and ecotoxicology.

Metode poučevanja in učenja:	**Learning and teaching methods:**
• predavanja • laboratorijske vaje • samostojno delo	• lectures • laboratory work • individual work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
laboratorijsko delo	30	laboratory work
pisni izpit	70	written exam

Reference nosilca / Lecturer's references:

1. Senekovič, J., Jelen, Š., & Urbanek Krajnc, A. (2025). Copper Sulfate Elicitation Effect on Biomass Production, Phenolic Compounds Accumulation, and Antioxidant Activity of *Morus nigra* L. Stem Node Culture. *Plants*, *14*(5), 766.
2. Laznik, Ž., Križman, M., Zekič, J., Roškarič, M., Trdan, S., & Urbanek Krajnc, A. (2024). Navigational Signals for Insect and Slug Parasitic Nematodes: The Role of Ascorbate–Glutathione System and Volatiles Released by Insect-Damaged Sweet Pepper Roots. *Insects*, *15*(10), 805.
3. Jelen, Š., & Krajnc, A. U. (2023). Composition of proteins and phenolics in the leaves of different mulberry species (*Morus alba* L., *M. alba*× *rubra*, *M. australis* Poir., *M. nigra* L.). *Agricultura Scientia*, *20*(1), 23-33.

4. Ambrožič-Dolinšek, J., Podgrajšek, A., Šabeder, N., Grudnik, Z. M., Urbanek Krajnc, A., Todorović, B., & Ciringer, T. (2023). The potential of *berula erecta in vitro* for As bioaccumulation and phytoremediation of water environments. *Environmental Pollutants and Bioavailability*, *35*(1), 2205010.

5. Urbanek Krajnc, A., Senekovič, J., Cappellozza, S., & Mikulic-Petkovsek, M. (2023). The Darker the Better: Identification of Chemotype Profile in Soroses of Local and Introduced Mulberry Varieties with Respect to the Colour Type. *Foods*, *12*(21), 3985.

6. Laznik, Ž., Križman, M., Zekič, J., Roškarič, M., Trdan, S., & Urbanek Krajnc, A. (2023). The Role of Ascorbate–Glutathione System and Volatiles Emitted by Insect-Damaged Lettuce Roots as Navigation Signals for Insect and Slug Parasitic Nematodes. *Insects*, *14*(6), 559.
7. Urbanek Krajnc, A., Bakonyi, T., Ando, I., Kurucz, E., Solymosi, N., Pongrac, P., & Berčič, R. L. (2022). 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*, *13*(9), 836.

LIPOVŠEK DELAKORDA, Saška, VAJS, Tanja, DARIŠ, Barbara, NOVAK, Tone, KOZEL, Peter. Autophagic activity in the midgut cells of three arachnids responds selectively to different modes of overwintering in caves. *Protoplasma*. 2024, 14 str., ilustr. ISSN 0033-183X. https://doi.org/10.1007/s00709-024-02009-x, DOI: 10.1007/s00709-024-02009-x.

LIPOVŠEK DELAKORDA, Saška, DOLENŠEK, Jurij, DARIŠ, Barbara, VALLADOLID-ACEBES, Ismael, VAJS, Tanja, LEITINGER, Gerd, STOŽER, Andraž, SKELIN, Maša. Western diet-induced ultrastructural changes in mouse pancreatic acinar cells. *Frontiers in cell and developmental biology*. 2024, vol. 12, [article no.] 1380564, 17 str. ISSN 2296-634X. https://www.frontiersin.org/articles/10.3389/fcell.2022.934684/full, DOI: 10.3389/fcell.2024.1380564. [COBISS.SI-ID 189348099]

KOZEL, Peter, NOVAK, Tone, JANŽEKOVIČ, Franc, LIPOVŠEK DELAKORDA, Saška. Starvation hardiness as preadaptation for life in subterranean habitats. *Scientific reports*. 2023, vol. 13, article no. 9643, 18 str., ilustr. ISSN 2045-2322. https://dk.um.si/IzpisGradiva.php?id=86400, DOI: 10.1038/s41598-023-36556-9, DOI: 20.500.12556/DKUM-86400. [COBISS.SI-ID 155869443].

LIPOVŠEK DELAKORDA, Saška, NOVAK, Tone, DARIŠ, Barbara, HOFER, Ferdinand, LEITINGER, Gerd, LETOFSKY-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. [COBISS.SI-ID 83684611]