Department of Biology
Josip Juraj Strossmayer University of Osijek

Programme of study in Biology

Master level study programme

accredited by the Ministry of Science, Education and Sports of the Republic of Croatia on 16 June 2005

Osijek, October 2020

3. STUDY PROGRAMME DESCRIPTION

3.1. The list of obligatory and elective courses and modules with corresponding number of teaching hours and ECTS credits

OBLIGATORY COURSES

I semester		**L**	**S**	**P**	**ECTS**	**CODE**
Biochemistry 3		30		30	5	BM754
Animal Physiology 2		30		15	4	BM755
Plant Physiology 2		30		30	4	BM756
Virology		15		15	3	BM757
Quantitative Biology 2		30		15	4	BM972
Marine Ecology		30	15	15	4	BM759
Elective courses	**90**				6	
	285	**165**	**15**	**105**	**30**	
II semester		**L**	**S**	**P**	**ECTS**	**CODE**
Basics of Horticulture		15		15	2	BM861
Plant nutrients		30		15	4	BM860
Embryology and Evolution of Organic Systems		30		30	4	BM862
Ecology of Inland Waters		45		45	8	BM863
Molecular Ecotoxicology		30		15	4	BM864
Scientific Research Practice 1				30	2	BM865
Elective courses	**90**				6	
	315	**150**	**15**	**150**	**30**	
III semester		**L**	**S**	**P**	**ECTS**	**CODE**
Immunology		15		15	3	BM966
Developmental Biology of Plants		30		15	3	BM967
Plant Molecular Ecophysiology		15		15	3	BM968
Animal Behaviour		30	15		3	BM969
Ecology of Terrestrial Habitats		45		45	8	BM970
Scientific Research Practice 2				60	2	BM971
Elective Courses	**90**				8	
	300	**135**	**15**	**150**	**30**	

IV semester	**ECTS**
Acceptance of MS theses	5
Research work with scientific contibution	15
MS theses defence and final exam	10
	30

ELECTIVE COURSES	L	S	P	ECTS	CODE
Modelling of Biological Processes	15	15		2	BMZ72
Plant Toxicity Tests	15		15	2	BMZ73
Biochemical Mechanisms of Toxicity	15		15	2	BMZ74
Molecular Mechanism of Oxidative Stress	15		15	2	BMZ75
Enzyme Kinetics	15		15	2	BMZ76
Biomolecules in Food	15	15		2	BMZ77
Plant Cell and Tissue Culture	15		15	2	BMZ78
Genome Evolution	15	15		2	BMZ79
Plant Pathoanatomy	15		15	2	BMZ80
Supramolecular Structures	15	15		2	BMZ81
Plant Microtechnique and Microscopy	30		15	2	BMZ82
Plant Stress Physiology	15	15	15	2	BMZ83
Immunocompetence and Transplantation	15		15	2	BMZ84
Ecotoxicology	15		15	2	BMZ87
Entomology	15	15	15	2	BMZ88
Ornithology	15	15		2	BMZ89
Biogeographic Inventory	15		15	2	BBZ54
Underwater Biological Research			30	2	BMZ93
Geoinformation Science in Biological Research	15		15	2	BMZ94
Molecular Genetics	30		15	4	BM758
Dendrology	15	30		2	BMZ95
Geology and Paleontology	30	15		2	BMZ96
Protection and Revitalisation of Aquatic Ecosystems	15	15		2	BMZ97
Avian Metabolism	15	15		2	BMZ98
Biochemical Basis of Drug Action	15	15		2	BMZ99

Course teachers and associates are assigned to courses as of the academic year 2020/2021.

Obligatory courses

Course title	**Animal Physiology 2**
Code	BM755
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Assoc. Prof. Dr. Davorka Hackenberger Kutuzović
Associate teachers	Prof. Dr. Branimir Hackenberger Kutuzović
Course entry requirements (Preceding courses)	
Course objective	To enable students to understand the basic concepts of physiological adaptation of animals to environmental changes, and the principles of homeostasis regulation and energy balance at lower and higher levels of the biological system. To explain the necessary connection between different levels of the biological system and the integration of physiological processes under the influence of environmental factors. To enable students to analyse the principles of adaptation to different environmental conditions based on case studies and relevant scientific literature.
Learning outcomes	1. Ability to define physiological responses of animal organisms in different environmental conditions. 2. Ability to explain adaptive mechanisms of animal organisms to environmental changes. 3. Ability to analyse the principles of adaptation to different environmental conditions in the terrestrial and aquatic environment, as well as in extreme environmental conditions. 4. Ability to determine the adaptive mechanisms of animals to environmental changes on the examples of case studies. 5. Skills in assessing scientific papers dealing with animal physiology by writing of a scientific essay.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	1	Lecture	Lecture attendance and active participation	Records related to attendance and activity	5	10
3-5	1	Practices	Interpretation of a case study and critical discussion, preparation of a seminar paper	Monitoring of students' performance at interpretations and active participation	10	20

	1-4	1	Written exam	Preparation for written exam	Written exam	15	30
	1-4	1	Oral exam	Preparation for oral exam	Oral exam	20	40
	Total	**4**				**50**	**100**

Final grade:
50.1-62.5 points: grade 2 (sufficient)
62.6-75 points: grade 3 (good)
75.1-87.5 points: grade 4 (very good)
87.6-100 points: grade 5 (excellent)

Consultation hours	By appointment.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	15

Course content / teaching units

Lectures:

- Introduction and repetition of basic physiological concepts
- Limits of adaptation
- Restrictive and expansive adaptation
- Physical interactions between the organism and the environment
- Radiation, conduction, convection and evaporation
- Scaling of metabolism and thermal interactions
- Adaptation to temperature
- Poikilothermia and ectothermia
- Homeothermy and endothermy
- Exchange of matter with the environment
- Osmotic exchange in aquatic and transitional animals
- Water and sodium chloride exchange in terrestrial animals
- Gas exchange adaptations
- Movement energy
- Physiological energy balance
- Periodicity in the environment and physiological changes
- Physiology of hibernation
- Exophysiology and physiology of extraterrestrial biological systems
- Physiology of high and low air and water pressure

Seminar: case studies related to ecophysiology

Recommended reading

Willmer P., Stone G., Johnston I. (2004) Environmental Physiology of Animals. Wiley-Blackwell.

Optional reading

Bradshaw D. (2003) Vertebrate Ecophysiology. Cambridge University Press, Cambridge.
McNab B.K. (2002) The Physiological Ecology of Vertebrates, Cornell University Press, London.
Moyes C.D., Schulte P.M. (2016) Principles of animal physiology. San Francisco, CA: Pearson/Benjamin Cummings.
Paul J.R. (2001) Physiologie der Tiere. Thieme, Stuttgart.

Conditions for obtaining teacher's signature

Students are obliged to participate in lectures actively and to fulfil all assignments within the course.

Exam passing procedure

Before taking oral exam, students are obliged to pass written exam, te predati znanstveni Essay. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.

Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.

Course title	**Biochemistry 3**
Code	BM754
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	5
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Rosemary Vuković Assist. Prof. Dr. Senka Blažetić
Associate teachers	Ana Vuković, assistant
Course entry requirements (Preceding courses)	
Course objective	To enable students to understand the basic principles of biochemical processes in the organism and their connection with physiological functions, as well as the biochemical basis of a living organism response to environmental changes. To develop students' skills for experimental work, for selection and application of biochemical methods and techniques, for sampling, analysis and interpretation of results by using scientific literature.
Learning outcomes	1. Knowledge about mechanisms that allow a living organism to respond successfully and quickly to environmental changes. 2. Ability to predict and compare the mechanism of ions and molecules transfer through the membrane, and to understand the importance of ionic balance maintenance. 3. Ability to compare different pathways of signal transmission in cells, and to review cell responses that result from the activation of individual signalling pathways. 4. Skills in performing research work in the field of biochemistry, which includes literature analysis, experiment design, selection and implementation of methods and techniques for testing of hypotheses, data collection and analysis, and their interpretation by using relevant scientific literature. 5. Knowledge about parts of the immune system and their function in the body. 6. Ability to determine the links between genetic and external factors and disease development.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-6	1	Lecture	Critical conversation and discussion	Records related to student performance during lectures	5	10
4	1.5	Practices	Independent performance of experimental tasks, data collection and analysis; presentation and interpretation of obtained results	Monitoring of experimental work progress; Work diary; Assessment of presentation and interpretation of obtained results with provision of feedback	25	40

	1-6	1.5	Written exam	Preparation for written exam	Written exam	10	20
	1-6	1	Oral exam	Preparation for oral exam	Oral exam	20	30
	Total	**5**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	30

Course content / teaching units

- Membrane channels and pumps: active and passive transport, ATP in the function of membrane transport, P-type ATPase, concentration gradients, lactose permease, ion channels (sodium, potassium and acetylcholine channel), action potential, gap junction, water channels
- Signal conduction pathways: heterotrimeric G-proteins, cAMP, Ca^{2+}, inositol-triphosphate and diacyl-glycerol as secondary messengers, insulin signalling, epidermal growth factor (EGF) signalling, common features and participants in signalling pathways, diseases caused by signalling pathway disorders
- Immune system: specificity and diversity of antibody molecule structure, genetic basis of high antibody variability, synthesis of antibody classes as part of the immune response, major histocompatibility complex (MHC I and MHC II), immune system cells and receptors (T-cell receptors, T-cell killers, selection of T-cells in the thymus), autoimmune diseases, the role of the immune system in cancer prevention
- Sensory systems: sense of smell, taste, sight, hearing and touch
- Molecular motors: motor proteins, myosin and actin, muscle contraction, kinesin and dynein in interaction with microtubules, bacterial movement, bacterial flagellar motor, chemotaxis

Recommended reading

Berg J.M., Tymoczko J.L., Gatto G.J., Stryer L. (2019) Biochemistry (9th edition). Macmillian International Higher Education, New York.
Stryer L., Berg J., Tymoczko J. (2013) Biokemija (6th edition, 1st Croatian edition). Školska knjiga, Zagreb.

Optional reading

Alberts A.J., Lewis J., Raff M., Roberts K., Walter P. (2008) Molecular Biology of the Cell (5th edition). Garland Science, New York.
Harperova ilustrirana biokemija (28th edition). (2011) Medicinska naklada.
Nelson D.L., Cox M.M. (2013) Lehninger Principles of Biochemistry (6th edition). W. H. Freeman & Co, New York.
Purves D., Augustine G.J., Fitzpatrick D., Hall W.C., LaMantia A.S., White L.E. (2012) Neuroscience (5th edition). Sinauer Associates, INC, Sunderland, Massachusetts, USA.
Voet D., Voet J.G. (2011) Biochemistry (4th edition). Wiley, New York.
Original scientific papers and review papers.

Conditions for obtaining teacher's signature

Students are obliged to participate in lectures actively and to fulfil all assignments within the course.

Exam passing procedure

During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After the course, students take a written exam and then oral exam. During the semester, students can take preliminary exams and

	substitute them for the written exam if passing each preliminary exam with more than 60% of the total number of points.
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	During the course, the teacher continuously evaluates student achievement, and gives students the opportunity to make oral or written comments. After the course, students are given a survey in which they give their subjective opinion about quality and organisation of teaching, all with the aim to improve future teaching.

Course title	**Ecology of Terrestrial Habitats**
Code	BM970
Study programme	Graduate University Study Programme in Biology
Semester	III winter semester
Workload/ECTS credits	8
Course status	Obligatory
Course teacher	Prof. Dr. Oleg Antonić Assoc. Prof. Dr. Davorka Hackenberger Kutuzović
Associate teachers	Assist. Prof. Dr. Goran Palijan Assist. Prof. Dr. Olga Jovanović Glavaš
Course entry requirements (Preceding courses)	
Course objective	To enable students to understand the spatial variability of terrestrial habitats on Earth and in Croatia, their biological diversity and connection with environmental processes and factors that influence the emergence, survival and extinction of these habitats. Students will be given synthetic approach to terrestrial ecology by linking relevant information on climate, soil, relief, flora and vegetation, fauna and other components of terrestrial ecosystems.
Learning outcomes	1. Knowledge about parallel development of soil and vegetation in different ecological conditions. 2. Ability to connect the spatial distribution of macroclimatic factors on a global level with the spatial distribution of bioclimatic zones. 3. Ability to identify typical life strategies and adaptations of organisms in terrestrial habitats. 4. Ability to distinguish between the types of terrestrial habitats in Croatia and to assess their characteristic ecological conditions. 5. Ability to analyse the structure and dynamics of selected habitat types by applying appropriate methods.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	2	Lecture	Participation in discussions during lectures	Records related to attendance and participation in discussions	15	20
3-5	2	Practices	Performance at solving of tasks	Assessment of performance during practices	15	20
1-5	3	Written exam	Preparation for written exam	Written exam	20	40
1-5	1	Oral exam	Preparation for oral exam	Oral exam	10	20
Total	**8**				**60**	**100**

<table>
<tr><td></td><td colspan="3">Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)</td></tr>
<tr><td>Consultation hours</td><td colspan="3">By appointment</td></tr>
<tr><td>Teaching</td><td>Lectures</td><td>Seminars</td><td>Practices</td></tr>
<tr><td>Hours - total</td><td>45</td><td>0</td><td>45</td></tr>
<tr><td>Course content / teaching units</td><td colspan="3">Lectures:
What is a terrestrial habitat and what kind of organisms live there
The ecological factors that influence life of the organisms in a terrestrial habitat
Solar energy on the Earth surface
Global atmospheric circulation
Macroclimate – parameters, their spatial and temporal variability
Water cycle
Lithology and relief as the environmental factors
Topoclimate
Soil as a precondition for the terrestrial habitat formation and maintenance
Pedosphere, pedogenesis, pedosystematics – basic terms
Biotic factors
Life strategies of the terrestrial organisms
Matter and energy cycles in a terrestrial habitat
Basic types of the terrestrial habitats (biomes) and their correlation with the macroclimate
Spatial distribution of the biomes on the Earth and their dynamics in time (global paleoecological aspect)
Bioclimatic zones of Europe and Croatia
Edaphic factors and biogeocoenosis differentiation within the bioclimatic zones
Spatial and temporal relation between the soil and vegetation
Classification of the terrestrial habitats
Overview of the particular habitat types (on the global, regional and local level): 1) dominant abiotic factors, 2) soil and vegetation, 3) typical organism representatives and their adaptations to the habitat and interactions with the habitat, 4) genesis and ecological stability, 5) anthropogenic influence
Terrestrial habitat boundaries
Environmental gradients and gradual transition between the terrestrial habitats and between the terrestrial and marine/freshwater habitats
Anthropogenic terrestrial habitats
Levels of bioecological details in the terrestrial habitat research
Overview of the research themes and methods
Practical examples
Practices:
Recognition of the major types of the terrestrial habitats on the global level (biomes)
Recognition of the terrestrial habitats in Croatia
Determination of the expected habitat type for the set environmental factors (and vice versa)
Overview of the different sampling methods for the particular organism groups in different habitats, qualitative and quantitative field data analysis</td></tr>
<tr><td>Recommended reading</td><td colspan="3">Chapin F.S. III, Matson P., Mooney H.A., Chapin M.C. (2002) Principles of Terrestrial Ecosystem Ecology. Springer-Verlag, New York.</td></tr>
</table>

Optional reading	Archibold O.W. (1995) Ecology of World Vegetation. Chapman & Hall, London, New York. Bailey R.G. (2009) Ecosystem Geography: From Ecoregions to Sites. Springer-Verlag, New York, Dordrecht, Heidelberg, London. Ćirić M. (1986) Pedologija. Svjetlost, Sarajevo. Gobat J.-M., Aragno M., Matthey W. (2004) The Living Soil – Fundamentals of Soil Science and Soil Biology. Science Publishers Inc., Endfield USA, Plymouth UK. Herak M. (1990) Geologija. Školska knjiga, Zagreb. Oldeman R.A.A. (1990) Forests: Elements of Silvology. Springer-Verlag, Berlin. Penzar I., Penzar B. (1989) Agroklimatologija. Školska knjiga, Zagreb. Topić J., Vukelić J. (2009) Priručnik za određivanje kopnenih staništa u Hrvatskoj prema Direktivi o staništima EU. Državni zavod za zaštitu prirode, Zagreb. Vukelić J., Mikac S., Baričević D., Bakšić D., Rosavec R. (2009) Šumska staništa i šumske zajednice u Hrvatskoj. Državni zavod za zaštitu prirode, Zagreb.
Conditions for obtaining teacher's signature	Attendance at lectures and practices by obtaining a minimum of 30 points.
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of each student. After the course, students pass the written exam with a minimum of 20 points. After having passed the written exam, students take the oral exam and pass it with a minimum of 10 points.
Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Evaluation form

Course title	**Ecology of Inland Waters**
Code	BM863
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	8
Course status	Obligatory
Course teacher	Assoc. Prof. Dr. Melita Mihaljević
Associate teachers	Assist. Prof. Dr. Filip Stević Assist. Prof. Dr. Dubravka Špoljarić Maronić
Course entry requirements (Preceding courses)	
Course objective	To teach students about the structure and function of freshwater ecosystems and enable them to use the acquired knowledge and skills for critical interpretation of research results and for development of attitudes about the ecological status and protection of inland waters.
Learning outcomes	1. Ability to determine the relation between hydrological, ecological and biological characteristics of water systems. 2. Development of natural science literacy by learning through field research, sampling and processing of biological material of lake and river ecosystems. 3. Ability to review research referring to biological and ecological characteristics of waters by learning how to handle equipment and devices and by using professional literature and keys for the determination of plant and animal species. 4. Ability to critically review pressures on aquatic ecosystems and revitalisation measures.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	2	Lecture	Lecture attendance and active participation	Records, evaluation	10	15
1-4	2	Practices	Practical classes attendance, written report containing results and conclusions of performed analyses	Records, evaluation of written report	15	20
1-4	2	Written exam	Preparation for written preliminary exam	Written exam	15	20
1-4	2	Oral exam	Exam preparation	Oral exam	20	45
Total	**8**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)

	81-90 points: grade 4 (very good) **91-100 points: grade 5 (excellent)**		
Consultation hours	Two hours a week according to determined schedule.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	45	0	45
Course content / teaching units	Lectures: • Distribution and types of freshwater systems • Water as a living medium - molecular structure, physical and chemical properties of water, nutrient cycles, vertical gradient • Composition and distribution of biotic communities - plankton, nekton, benthos • Adaptations of organisms to different living conditions in lotic and lentic systems • Energy flow and trophic system - primary production, secondary production, detrital food chain • Eutrophication • Water usage • Water pollution • Water protection - protection of habitats and biodiversity Practices: • Sampling of water, sediment and biocenosis - field work at selected sites • Determination of physical and chemical properties of water (flow rate, temperature, colour, transparency, pH, dissolved oxygen, chlorophyll) • Sediment analysis • Determination of qualitative and quantitative composition of phytoplankton, zooplankton, macrofauna and meiofauna • Qualitative and quantitative analysis of biofilm • Saprobiological analysis of phytoplankton • Aquatic water toxicity tests • Statistical data processing		
Recommended reading	Wetzel R.G. (2001) Limnology – Lake and River Ecosystems. 3rd ed. Academic Press, San Diego.		
Optional reading	APHA (2001) Standard methods for examination of water and wastewater. Amer. Public Health Assoc. 20th ed. Washington. Engelhardt W. (2003) Was lebt in Tümpel, Bach und Weiher? Kosmos, Stuttgart. Streble H., Krauter D. (2002) Das Leben im Wassertropfen. Kosmos, Stuttgart.		
Conditions for obtaining teacher's signature	Attendance at lectures and practices by collecting of minimum 25 points, and achieving of at least 40% of the total number of points within the preliminary exam.		
Exam passing procedure	During the course, the teacher monitors and evaluates the work of each student, which makes up to 25% of the final grade. During the course, students will be taking written preliminary exams, which can be considered as a substitute for the written final exam if they achieve at least 90% of total points. Preliminary exam or final written exam contribute with 25% to the final grade, while oral exam makes up 45% of the final grade.		
Main language of instruction; other languages	Croatian language		

Method of monitoring the quality and efficiency of teaching	Periodic evaluation of students and teachers is planned to be carried out in order to assure and continuously improve the quality of teaching and of the study programme. During the last week of lectures, an anonymous student survey will be carried out to evaluate the overall quality of the course. The analysis of students' success at exams will be carried out.

Course title	**Marine Ecology**
Code	BM759
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Anita Galir Balkić
Associate teachers	Assist. Prof. Dr. Filip Stević
Course entry requirements (Preceding courses)	
Course objective	To learn about the ecology of marine ecosystems by examining characteristics of habitats, organisms and their dependence.
Learning outcomes	1. Knowledge about different marine ecosystems. 2. Ability to examine the relations between marine organisms and their habitats. 3. Ability to assess the regulation effects of marine population. 4. Ability to analyse the causes of changes in marine ecosystems. 5. Ability to critically evaluate the content of similar subjects and relevant scientific literature.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	1	Lecture	Attendance of lectures and active participation	Records	10	20
1-4	0.5	Seminars	Independent research into selected topics and active participation in discussions; preparation of a seminar paper	Records, seminar paper, evaluation	10	10
1-3	0.5	Practices	Laboratory work and independent analysis of results	Records, Work diary	10	10
1-5	1	Written exam	Preparation for written exam	Written exam	15	30
1-5	1	Oral exam	Preparation for oral exam	Oral exam	15	30
Total	**4**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	15	15
Course content / teaching units	Lectures: • Properties of the ocean as a three-dimensional habitat • Primary production • Epipelagic zone • Tide zone • Estuaries, salt marshes and mangrove forests • Coral reefs • Deep-sea habitats • The polar sea • Functioning of marine ecosystems • Fishery and human influence on marine ecosystems Seminars: • Ocean pollution and causes • Hydrothermal springs • El Niño and La Niña Practices: • Waves • Thermohaline circulation and albedo • Marine protected areas • Food chain in different marine habitats		
Recommended reading	Kaiser M.J., Attrill M.J., Jennings S., Thomas D.N., et al. (2005) Marine Ecology: processes, systems, and impacts. Oxford University Press, Oxford.		
Optional reading	Arias A.H., Menendez M.C. (2013) Marine Ecology in a Changing World. Taylor & Francis Inc., Bosa Roca, United States. Bailey J. (2019) Marine Ecology and Biodiversity. Callisto Reference, United States. Valiela I. (2016) Marine Ecological Processes. Springer-Verlag New York Inc., NY, United States.		
Conditions for obtaining teacher's signature:	Students are obliged to participate in lectures actively and to complete all course assignments.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of each student by awarding points according to determined criteria, which contributes with 30% to the final grade. Passing of written exam refers to 30% of the final grade, and passing of oral exam refers to the remaining 40% of the final grade.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Students will have opportunity to make written or oral remarks during or after lectures; monitoring of students' success at exams.		

Course title	**Embryology and Evolution of Organic Systems**
Code	BB862
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Assoc. Prof. Dr. Dubravka Čerba
Associate teachers	Barbara Vlaičević, Ph.D.
Course entry requirements (Preceding courses)	
Course objective	To teach students about the process of development of the organism from fertilization of ovum to formation of all organic systems. To develop skills for observation and linking of changes and adaptations of organic systems that occur during embryonic development, the life of adult organisms and organisms that undergo a process of metamorphosis.
Learning outcomes	1. Ability to analyse the processes at the genetic level and changes in embryonic cells that lead to the development of the adult organism from fertilisation to the end of early development, and to understand the changes of different stages of early embryonic development from the first furrow to the gastrula. Ability to determine the importance of epigenetic mechanisms in the regulation of gene expression. 2. Ability to understand similarities and differences in the embryonic development of invertebrates and vertebrates, with special reference to the embryonic development of humans. 3. Ability to understand anatomical, morphological and physiological adaptations, as well as behavioural adaptations, that enable the survival and evolution of different groups of organisms - specialization and the emergence of new structures. 4. Ability to critically determine why environmental protection is important for normal embryonic development. 5. Ability to assess the importance and to develop an attitude about cloning, artificial insemination and stem cell use.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	1	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	15	25
1-5	1	Practices	Individual and group work	Monitoring of student performance	15	25
1-5	1	Written exam	Preparation for written exam	Written exam	20	30

	1-5	1	Oral exam	Preparation for oral exam	Oral exam	10	20
	Total	**4**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	30
Course content / teaching units	• History of embryology. Evolution and embryology • size and types of cells and their communication during early development • Genes and development. Genetic sex determination • Early development of plants • Gametogenesis. Characteristics and role of ova and sperm • From fertilization to gastrula. Neurulation • Embryonic development of different groups of invertebrates • Embryonic development of different groups of vertebrates and humans • Stem cells. Cloning • Regeneration in animals and humans • Evolution of organic systems of invertebrates and vertebrates and their adaptations		
Recommended reading	Gilbert S.F. (2003) Developmental Biology. 7th ed. Sinauer Associates, Inc. Sadler T.W. (2008) Langmanova medicinska embriologija. Školska knjiga, Zagreb.		
Optional reading	Kardong K.V. (1994) Vertebrates: Comparative Anatomy, Function, Evolution. Brown Co., U.S. Ruppert E.E., Fox R.S., Barnes R.D. (2004) Invertebrate Zoology. A functional evolutionary approach. 7th ed. Thomson Brooks/Cole.		
Conditions for obtaining teacher's signature	Students are obliged to attend practices, to actively participate in lectures and to fulfil all course assignments.		
Exam passing procedure	During the course, the teacher monitors the work of each student. Students' knowledge is assessed within written and oral exam. Before taking oral exam, students are obliged to pass written exam.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.		

Course title	**Plant Physiology 2**
Code	BM756
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Prof. Dr. Janja Horvatić
Associate teachers	Assist. Prof. Dr. Vesna Peršić Martina Varga, Ph.D. Vera Tikas, expert advisor
Course entry requirements (Preceding courses)	Cell Biology, Biochemistry 1, Plant Physiology 1
Course objective	To enable students to understand the interaction of physiological processes and their regulatory mechanisms in plant organisms. To enable students to interpret the results of scientific research.
Learning outcomes	1. Knowledge about connection between metabolic processes in the plant - photosynthesis and respiration, distribution and transport of metabolites in the plant. 2. Ability to compare biosynthesis, transfer, physiological effects and mechanisms of plant growth regulators. 3. Ability to analyse the causes and levels of plant tissue differentiation and the aging process of the plant. 4. Ability to examine the physiological processes of plant movements. 5. Development of professional knowledge and skills by applying laboratory techniques and methods in monitoring of physiological processes in the plant and ability to critically interpret results of scientific research.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	1	Lecture	Lecture attendance and active participation	Records related to student performance with provision of feedback	6	10
1,2,5	1	Practices	Practical classes attendance and active participation	Records related to student activity during practices and provision of feedback	12	20
1-5	1.5	Written exam	Preparation for written exam	Written exam	24	40
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	18	30
Total	**4**				**60**	**100**

	Final grade: **60-69.9 points: grade 2 (sufficient)** **70-79.9 points: grade 3 (good)** **80-89.9 points: grade 4 (very good)** **90-100 points: grade 5 (excellent)**		
Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	30
Course content / teaching units	Lectures: • Photosynthesis (C3, C4 and CAM plants) • Photosynthesis and respiration • Regulations in cellular metabolism: intracellular regulation (regulation of genetic and enzymatic activity) • Intercellular regulation: plant growth regulators - auxins, gibberellins, cytokinins, ethylene and abscisic acid (chemical composition, biosynthesis, transfer, physiological effects and mechanism of action) • Growth, differentiation and development: levels of differentiation, cause of cell differentiation, plant aging • Regulation by environmental factors: the effect of air temperature and day length on plant growth and development • Physiology of movement of plant organelles and/or organs Practices: • Starch phosphorylase • Enzymatic degradation of glycosides • Enzymatic degradation of sucrose by the action of the enzyme sucrose • Amylase • Influence of GA3 on starch hydrolysis during barley seed germination • Influence of kinetin on leaf senescence • Influence of auxin on elongation of etiolated bean seedling stems		
Recommended reading	Pevalek-Kozlina B. (2003) Fiziologija bilja. Profil, Zagreb. Taiz L., Zeiger E., Moller I.M., Murphy A. (2015) Plant Physiology and Development. 6th ed. Sinauer Associates, Inc.		
Optional reading	Berg J.M., Tymoczko J.L., Stryer L. (2013) Biokemija. Školska knjiga, Zagreb.		
Conditions for obtaining teacher's signature	Regular attendance and active participation in lectures.		
Exam passing procedure	Before taking oral exam, students are obliged to pass written exam. The final grade is determined according to the number of points for student's performance and the points achieved in written and oral exams.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.		

Course title	**Immunology**
Code	BM966
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	3
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Senka Blažetić
Associate teachers	
Course entry requirements (Preceding courses)	Biochemistry 3 (attended)
Course objective	To enable students to understand the role of the immune system, principles and mechanisms of immune responses, and to be able to determine the connection of the immune system with other functional and organic systems while distinguishing between classical and modern research methods used in immunology.
Learning outcomes	1. Ability to compare the complexity and relations of the immune system components in the immune response. 2. Ability to assess the genetic basis of the body's defence reactions against pathogens. 3. Ability to link the consequences of synthesis disorders and interaction of components of the immune system with the development of specific diseases (immunodeficiency, hypersensitivity, autoimmune diseases). 4. Ability to select appropriate immunochemical tests in the process of proving and treating certain diseases. 5. Skills in performing basic laboratory analyses based on the immune system function.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	0.75	Lecture	Critical conversation and discussion	Records related to student performance during lectures	10	20
4-5	0.75	Practices	Independent performance of experimental tasks, data collection and analysis; presentation and interpretation of obtained results	Monitoring of experimental work progress; Work diary; Assessment of interpretations of obtained results and provision of feedback	10	20
1-5	0.5	Written exam	Preparation for written exam	Written exam	5	20
1-5	1	Oral exam	Preparation for oral exam	Oral exam	25	40

	Total	**3**				**50**	**100**
	Final grade: **50-62 points: grade 2 (sufficient)** **63-75 points: grade 3 (good)** **76-88 points: grade 4 (very good)** **89-100 points: grade 5 (excellent)**						
Consultation hours	By appointment						
Teaching	**Lectures**		**Seminars**		**Practices**		
Hours - total	15		0		15		
Course content / teaching units	• Cells, tissues and organs of the immune system • Hematopoiesis, lymphocytes and macrophages • Complement system • Development of B and T cells • Organisation and expression of immunoglobulin genes • Cytokines • Major tissue histocompatibility complexes and transplantation • Immune responses • Diseases of the immune system						
Recommended reading	Abbas A.K., Lichtman A.H., Pillai S. (2012) Cellular and Molecular Immunology, Elsevier, Saunders, USA. Andreis I., Batinić D., Čulo F., Grčević D., Marušić M., Taradi M., Višnjić D. (2004) Imunologija. Medicinska naklada, Zagreb.						
Optional reading	Delves P.J., Martin S.J., Burton D.R., Roitt I.M. (2011) Roitt's Essential Immunology. Wiley Blackwell, United Kingdom. Janeway A.C. (editor) (2001) Immunobiology. Garland Publishing, New York.						
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.						
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After the course, students take a written exam and then oral exam. During the semester, students can take preliminary exams and substitute them for the written exam if passing each preliminary exam with more than 60% of the total number of points.						
Main language of instruction; other languages	Croatian language, English language						
Method of monitoring the quality and efficiency of teaching	During the course, the teacher continuously evaluates student achievement, and gives students the opportunity to make oral or written comments. After the course, students are given a survey in which they give their subjective opinion about quality and organisation of teaching, all with the aim to improve future teaching.						

Course title	**Quantitative Biology 2**
Code	BM972
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Prof. Dr. Branimir K. Hackenberger
Associate teachers	Assist. Prof. Dr. Željka Lončarić
Course entry requirements (Preceding courses)	
Course objective	Acquisition of theoretical and practical knowledge in data processing, their interpretation and selection of appropriate mathematical and/or statistical methods.
Learning outcomes	1. Knowledge about basic scientific methods, including the logic of experimental design and hypothesis testing. 2. Ability to apply basic statistical and computational methods for biology-related problem solving. 3. Ability to critically evaluate the advantages and limitations of different statistical methods. 4. Ability to interpret and evaluate the results of statistical analyses. 5. Skills in using the R programming language. 6. Skills needed for critical analysis of literature dealing with environmental and statistical issues.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-6	1	Lectures	Critical conversation and discussion	Records related to active participation in conversations and discussions	5	10
1-6	1	Practices	Analysis of experimental data	Monitoring of student performance at solving of tasks	10	20
1-6	1	Written exam	Preparation for written exam	Written exam	20	30
1-6	1	Oral exam	Preparation for oral exam	Oral exam	25	40
Total	**4**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	15
Course content / teaching units	Lectures: • Design of a laboratory experiment • Design of an experiment in the environment • Sampling principles • Supervision and monitoring • Census methods • Indexes • Parametric data processing • Non-parametric data processing • Multivariate methods • Classification analyses • Interpretations of results • Methods of repetitions • Monte Carlo simulation • Basics of Bayesian statistics • Statistical modelling • Spatial statistics • Methods of quantification of biological data • Methods of quantification of biological relationships and changes in the time function Practices: • Creating of experiments in laboratory and on field • Primary data processing • Data processing by statistical methods • Making simulations • Quantification of biological data • Development of statistical and mathematical models • Application of spatial statistics • Census		
Recommended reading	Britton F.N. (2004) Essential Mathematical Biology (2nd ed.). Springer Verlag, London. Šošić I. (2004) Primijenjena statistika. Školska knjiga, Zagreb. Zar J.H. (2009) Biostatistical Analysis (5th ed.). Prentice Hall.		
Optional reading	Babak S. (2012) Biostatistics with R: An Introduction to Statistics Through Biological Data. Springer, New York. Dalgaard P. (2008) Introductory Statistics with R (2nd ed). Springer, New York. Sutherland W.J. (2006) Ecological Census Techniques: A Handbook (2nd ed.). Cambridge University Press, Cambridge. Quinn P.G. (2002) Experimental Design and Data Analysis for Biologists. Cambridge University Press, Cambridge.		
Conditions for obtaining teacher's signature	Regular attendance at lectures, successfully completed practices.		
Exam passing procedure	During lectures, the teacher monitors and evaluates performance of each student, which refers to 30% of the final grade. Passing of written exam refers to 30% of the final grade, and passing of oral exam refers to the remaining 40% of the final grade.		
Main language of instruction; other languages	Croatian language, English language		

Method of monitoring the quality and efficiency of teaching	Student survey to evaluate the overall quality of the course. Analysis of student success at the exams.

Course title	**Plant Molecular Ecophysiology**
Code	BM968
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	3
Course status	Obligatory
Course teacher	Prof. Dr. Janja Horvatić
Associate teachers	Martina Varga, Ph.D. Vera Tikas, expert advisor
Course entry requirements (Preceding courses)	Plant Ecology, Plant Physiology 1, Biochemistry 2, Molecular biology
Course objective	To teach students about interactions of the environment and plants at the cellular and molecular level, and to train students for experimental work by using some cell and molecular biology methods and by reviewing scientific literature.
Learning outcomes	1. Ability to analyse molecular mechanisms of signal perception and physiological response in the plant cell. 2. Ability to determine how environmental factors affect changes in gene expression. 3. Ability to determine the connection of abiotic and biotic environmental factors with the molecular organisation of the photosynthetic apparatus. 4. Ability to analyse molecular mechanisms of adaptation to changing environmental conditions. 5. Development of expert knowledge by critical interpretation of scientific research results.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Critical conversation and discussion	Records on attendance and student activities	6	10
5	0.5	Practices	Work on the experimental task	Monitoring of student performance	12	20
1-5	1.5	Written exam	Preparation for written exam	Written exam	24	40
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	18	30
Total	**3**				**60**	**100**

Final grade:
60-69.9 points: grade 2 (sufficient)
70-79.9 points: grade 3 (good)
80-89.9 points: grade 4 (very good)
90-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**

Hours - total	15	0	15
Course content / teaching units	Lectures: • Review of the biotic and abiotic ecological factors • Molecular mechanisms of the signal perception in the plant cell and physiological response • Changes of gene expression caused by changes of temperature, light or by drought and anoxia • Effect of air pollutants on the plant physiological status • Plant tolerance to heavy metals • Molecular biology of the oxidative stress in plants • Effect of the abiotic factors (light, temperature, herbicides, heavy metals) on molecular organisation and function of the photosynthetic apparatus Practices: • Within the practices, students will choose a course-related topic for independent studying		
Recommended reading	Buchanan B., Gruissem W., Jones R. (2002) Biochemistry & Molecular Biology of Plants. American Society of Plant Physiologists Rockville, Maryland. Taiz L., Zeiger E., Moller I.M., Murphy A. (2015) Plant Physiology and Development. 6th ed. Sinauer Associates, Inc.		
Optional reading	Aducci P. (1997) Signal Transduction in Plants. Birkhäuser Verlag, Switzerland. Basra A.S. (1993) Stress-Induced Gene Expression in Plants. Harwood Academic Publishers, Switzerland. Scandalios J.G. (1997) Oxidative Stress and the Molecular Biology of Antioxidant Defenses. Cold Spring Harbor Laboratory Press, New York.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	Before taking oral exam, students are obliged to pass written exam. The final grade is determined according to the number of points for student's performance and the points achieved in written and oral exams.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.		

Course title	**Molecular Ecotoxicology**
Code	BM864
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Prof. Dr. Branimir Hackenberger Kutuzović
Associate teachers	Assoc. Prof. Dr. Davorka Hackenberger Kutuzović Assoc. Prof. Dr. Sandra Ečimović
Course entry requirements (Preceding courses)	
Course objective	To teach students about the basic principles of ecotoxicology, and modern approaches to the issue of pollutant effects on various structural parts of the ecological system, as well as on the entire biosphere. To enable students to acquire knowledge about pollutants in the environment, their mechanisms of action at different levels of the ecological system, and methods for monitoring of pollutant effects at lower levels of biological organisation (molecular, biochemical).
Learning outcomes	1. Knowledge about basic concepts of ecotoxicology. 2. Ability to understand interactions between pollutants and different components of the environment. 3. Ability to analyse pollutants in the environment. 4. Ability to review and analyse the mechanisms of action and the impact of pollutants on environmental components. 5. Ability to critically review the relevant scientific literature 6. Knowledge and skills in application of basic methods for assessment of pollutant action at lower levels of biological organisation, and skills to independently measure selected biomarkers.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	1	Lecture	Lecture attendance and active participation	Records related to student attendance and activity	10	15
4-6	1	Practices	Solving of experimental tasks	Monitoring of students' performance at solving of tasks	10	15
1-5	1	Written exam	Preparation for written exam	Written exam	20	40
1-5	1	Oral exam	Preparation for oral exam	Oral exam	20	30
Total	**4**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)

	71-80 points: grade 3 (good) **81-90 points: grade 4 (very good)** **91-100 points: grade 5 (excellent)**		
Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	15
Course content / teaching units	Lectures: • Pollution and contamination • Xenobiotics • Mechanisms of the xenobiotics entering the biological systems • The effect of the first pass • Defence mechanisms • Biotransformation reactions • The first phase of xenobiotics transformation • The second phase of xenobiotics transformation • The third phase of xenobiotics transformation • Elimination of xenobiotics • Xenobiotic induction and inhibition • Hormonal disruptors • Xenoandrogens • Xenoestrogens • Vitelogenin • Oxidative stress as a consequence of physical factors, exposure and action of xenobiotics • Effect of xenobiotics on metabolic pathways • Molecular biomarkers • P-glycoprotein and MXR • Biomarkers of exposure and effect • Influence of xenobiotics on markers of metabolic activity and health condition Practices: • Methods of exposure to xenobiotics • Test with artificial soil and contact filter paper test • Preparation of postmitochondrial fraction • Inhibition of cholinesterases as an indicator of the effect of organophosphates, carbamates and detergents • Measurement of catalase activity and the amount of thiobarbituric acid reactive substances as indicators of oxidative stress • Measurement of efflux pump activity modulation by rhodamine B accumulation. • Metabolic markers		
Recommended reading	Hoffman D.J., Rattner B.A., Burton G.A., Cairns J. (2003) Handbook of ecotoxicology. CRC Press LLC. Newman M.C., Clements W.H. (2008) Ecotoxicology. A comprehensive treatment. CRC Press, Taylor & Francis Group. Newman M.C. (2009) Fundamentals of Ecotoxicology. CRC Press.		
Optional reading	Mumtaz M. (2010) Principles and practice of mixtures toxicology. WILEY-VHC. Robinson L., Thorn I. (2005) Toxicology and Ecotoxicology in Chemical Safety Assessment. Blackwell Publishing Ltd.		
Conditions for obtaining teacher's signature	Regular attendance at lectures, successfully completed practices, preparation and presentation of seminar paper.		

Exam passing procedure	Before taking oral exam, students are obliged to pass written exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.
Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.

Course title	**Plant nutrients**
Code	BM860
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	4
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Vesna Peršić
Associate teachers	Vera Tikas, expert advisor
Course entry requirements (Preceding courses)	Plant Physiology
Course objective	To teach students about the role and dynamics of mineral nutrients in the proper growth and development of plants.
Learning outcomes	1. Ability to evaluate the influence of chemical processes in the soil on the availability of nutrients to plants. 2. Ability to explain the uptake, transfer and assimilation of mineral nutrients in plants. 3. Ability to critically compare the interaction of mineral nutrients and abiotic and biotic stress on plants. 4. Ability to design an experimental plan with specific research goal. 5. Skills in implementation of experiments, analysis and interpretation of the obtained data.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1 -5	2	Lecture	Active learning; critical discussion and pair work; Presentation of an experimental plan	Records related to active participation in discussions and in pair work; student portfolio	18	30
1, 2, 5	1	Practices	Laboratory work; supervised research; analysis and interpretation of results	Records related to student performance in laboratory; written report about the research	24	40
1 - 5	0.5	Written exam	Writing of an academic essay	Essay	12	20
1 - 5	0.5	Oral exam	Preparation for oral exam	Oral exam	6	10
Total	**4**				**60**	**100**

Final grade:

<table>
<tr><td></td><td colspan="3">60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)</td></tr>
<tr><td>Consultation hours</td><td colspan="3">By appointment</td></tr>
<tr><td>Teaching</td><td>Lectures</td><td>Seminars</td><td>Practices</td></tr>
<tr><td>Hours - total</td><td>30</td><td>0</td><td>15</td></tr>
<tr><td>Course content / teaching units</td><td colspan="3">Lectures:
Physiological, ecological and agroecological aspects of studying nutrients in plants
Concentrations and content of mineral elements in plants
Soil as a source of mineral elements for plant growth
Soil structure
Water in the soil
Chemical properties of soil
Soil adsorption complex
Availability of mineral elements in the soil
Ion exchange capacity of roots
Mycorrhiza
Essential mineral elements - the role and circulation of elements in nature
Nitrogen uptake and assimilation
Adoption and assimilation of phosphorus and potassium
Secondary elements - sulphur, calcium and magnesium - intake and assimilation
Trace elements: iron, manganese, boron, zinc, molybdenum - intake and their role in plants
Beneficial elements
Biofortification
Mulder diagram - antagonism and synergism
Consequences of mineral deficiency for plant growth and the influence of abiotic and biotic stress
Theoretical preparation of an experiment and solving of tasks
Practices:
Determination of symptoms of deficiency and/or excess of certain elements in plant nutrition within hydroponic growing conditions</td></tr>
<tr><td>Recommended reading</td><td colspan="3">Marschner H. (2012) Marschner’s Mineral Nutrition of Higher Plants (3rd ed). Academic Press, London.
Taiz L., Zeiger E, Møller I.M., Murphy A. (2015) Plant Physiology and Development. 6th ed. Sinauer Associates, Inc., U.S.A.
Vukadinović V., Vukadinović V. (2011) Ishrana bilja. Poljoprivredni fakultet, Osijek.</td></tr>
<tr><td>Optional reading</td><td colspan="3">Benton J.J. Jr. (2005) Hydroponics. A Practical Guide for the Soilless Grower. Second Edition. CRC Press.
Maathius, F.J.M. (2013) Plant Mineral Nutrients. Methods and Protocol. Springer, London.</td></tr>
<tr><td>Conditions for obtaining teacher’s signature</td><td colspan="3">Attendance of classes is mandatory in accordance with the Regulations on Studies and Studying at Josip Juraj Strossmayer University of Osijek. If a student misses more than 30% of the teaching hours, he/she is not entitled to obtain a teacher's signature for the course attendance.</td></tr>
<tr><td>Exam passing procedure</td><td colspan="3">During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After lectures and practices, students shall pass the written exam, as well as oral exam. The final grade is determined according to the number of points gained during lectures and practices and the number of points achieved at written and oral exam.</td></tr>
</table>

Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	During the course, the teacher continuously monitors the learning process and student achievement, thus determining and adapting his/her teaching. After each lecture, students have the opportunity to make oral or written remarks. During the last week of lectures, students are given an anonymous survey to evaluate the overall quality of the course. The teacher monitors the success of students at the exams.

Course title	**Basics of Horticulture**
Code	BM861
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Obligatory
Course teacher	Assoc. Prof. Dr. Ivna Štolfa Čamagajevac
Associate teachers	Ksenija Doboš, laboratory technician
Course entry requirements (Preceding courses)	Cormophyte (passed exam)
Course objective	To develop students' knowledge in botany through practical application of planned plant breeding.
Learning outcomes	1. Knowledge about basic concepts of botany and horticulture. 2. Ability to select appropriate methods of plant propagation depending on plant species and to assess the importance of pedological and climatic conditions in plant breeding. 3. Ability to evaluate the advantages of *in vitro* plant cultivation compared to classical cultivation. 4. Skills in using software in design of horticultural areas.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	0.5	Lecture	Critical conversation and discussion; collaborative learning and reciprocal teaching; knowledge-based tasks	Records related to active and independent participation in lecture activities	5	10
3,4	0.5	Practices	Independent performance of laboratory exercises	Records related to student activity during practices	10	20
1-4	0.5	Written exam	Exam preparation	Exam	20	30
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	25	40
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15
Course content / teaching units	Lecture: • Classification and characteristics of the flower types (annual, biennia, perennials, water plants, creepers) • Basics of growing vegetables and the most important vegetable representatives • Reproduction of vegetable and flower cultures • *In vitro* propagation methods • Woody plant species and park architecture Practices: • Basic methods of the reproduction in plants • *In vitro* breeding methods • Creation of a themed garden • Architecture of gardens and parks		
Recommended reading	Parađiković N., Tkalec M., Zeljković S., Kraljičak J., Vinković T. (2018) Osnove florikulture. Poljoprivredni fakultet, Osijek. Parađiković N. (2009) Opće i specijalno povrćarstvo. Poljoprivredni fakultet, Osijek. Parađiković N. (1994) Plastenici i staklenici. Nova zemlja, Osijek. Idžojtić M. (2009) Dendrologija-list. Sveučilište u Zagrebu, Šumarski fakultet, Zagreb. Idžojtić M. (2013) Dendrologija-cvijet, češer, plod, sjeme. Sveučilište u Zagrebu, Šumarski fakultet, Zagreb.		
Optional reading	Hartmann T.H., Kester D.E., Davies Jr. F.T., Geneve R.L. (2011) Hartmann and Kester's plant propagation: principles and practice. 8th ed. Prentice Hall, USA. Pittenger D.R. (2002) California Master Gardener Handbook. University of California, USA. Zdravi vrt - organski, prirodan i bez kemikalija (2010) Mozaik knjiga, Zagreb. Selected scientific papers		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. The teacher thus provides continuous feedback, which students use to assess their learning progress and to create a portfolio to improve the learning process and their own professional development. At the end of the course, students shall pass the written exam, after which they take oral exam. During the oral exam, the teacher asks questions that are related to learning outcomes. The final grade is determined according to the number of points achieved at written and oral exam and the number of points gained during lectures.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	During the course, the teacher performs evaluation for learning by continuous monitoring of the learning process and student achievement, thus determining and adapting his/her teaching. After the course, the teacher conducts a survey among students to evaluate their subjective impression about the teaching quality, all with the aim to improve future teaching.		

Course title	**Animal Behaviour**
Code	BM969
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	3
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Mirta Sudarić Bogojević
Associate teachers	
Course entry requirements (Preceding courses)	
Course objective	To teach students about animal behaviour patterns in extreme and normal circumstances, and about the influence of environment on behaviour of an individual animal. To enable students to understand animal behaviour through an interdisciplinary approach to the study of evolutionary, functional, developmental and physiological-anatomical characteristics of animals.
Learning outcomes	1. Knowledge about development of animal behaviour and about physiological mechanisms that generate and control animal behaviour. 2. Ability to determine adaptive value of specific behaviour and the role of natural selection in the evolution of animal behaviour. 3. Ability to determine the influence of environmental conditions on the development of behavioural adaptations in different species of animals. 4. Ability to make comparison between behaviour of animals and humans. 5. Widening of knowledge about animal behaviour by critical interpretation of behaviour of live animals, and of those recorded in video material or described in scientific and professional papers.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	1	Lectures	Lecture attendance and active participation	Records related to student activity during lectures	5	10
1-5	1	Seminars	Attendance of lectures, Independent preparation of seminar paper	Records, evaluation of presented seminar paper	20	30
1-5	0.5	Written exam	Preparation for written exam	Written exam	15	30
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	20	30
Total	**3**				**60**	**100**

	Final grade: **60-70 points: grade 2 (sufficient)** **71-80 points: grade 3 (good)** **81-90 points: grade 4 (very good)** **91-100 points: grade 5 (excellent)**		
Consultation hours	By appointment.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	15	0
Course content / teaching units	• Introduction to the animal behaviour (What is animal behaviour?; The history of the study of animal behaviour; Proximate and ultimate causes of behaviour) • Mechanisms of behaviour: the role of the nervous system (Innate vs. learned behaviour; Imprinting) • Motivation and organisation of behaviour (Physiology and behaviour in a changing environment) • Development of behaviour (Natural selection; Learning) • Communication (Living in groups. Social communities. Ritualization) • Foraging behaviour (Optimal foraging theory; Decision-making) • Avoiding of predators (Primary and secondary strategies) • Reproductive behaviour (Sexual selection; Conflicts; Mating systems; Parental care; Altruism) • Human behaviour • Analysis of video materials and papers related to course topics • Presentation of one form of animal behaviour		
Recommended reading	Alcock J. (2009) Animal Behavior: An Evolutionary Approach. 9th ed, Sinauer Associates, Sunderland. Goodenough J., McGuire B., Wallace R.A. (2001) Perspectives of Animal Behavior. John Wiley and sons, Inc. New York, Brisbane, Toronto. McFarland D. (1996) Animal behaviour. Addison Wesley Longman Limited, Edinbourgh.		
Optional reading	Halliday T. (1994) Animal Behavior. A Blanford book, London. Miller S., Harley J.P. (1996). Zoology. WCB Mc. Graw – Hill Companiec Inc. Boston. Wilson E.O. (2000) Sociobiology, The new synthesis. 25th ed. The President and Fellows of Harvard College. Scientific journals, popular articles and videos		
Conditions for obtaining teacher's signature	Attendance of lectures and seminars, and completion of all course assignments.		
Exam passing procedure	Performance of students is assessed during lectures, as well as within the written and oral exam. Preparation and presentation of seminar paper is awarded by certain number of points according to determined criteria.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	During the course, the teacher continuously monitors the learning process and student achievements, thus determining and adapting his/her teaching. After the course, the teacher conducts an anonymous survey among students to evaluate their subjective impression about the teaching quality.		

Course title	**Developmental Biology of Plants**
Code	BM967
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	3
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Jasenka Antunović Dunić
Associate teachers	
Course entry requirements (Preceding courses)	Physical Foundations of Instrumental Methods in Biology, Cell Biology, Genetics, Plant Anatomy, Plant Physiology 1
Course objective	To present to students the processes and mechanisms of differentiation during the development of a plant organism.
Learning outcomes	1. Ability to review the basic scientific findings about the processes and mechanisms of differentiation during the development of a plant organism. 2. Ability to explain the principle of dynamic connection between plant structures and their functioning during development. 3. Ability to analyse the continuity of development processes. 4. Ability to critically review relevant scientific literature. 5. Ability to evaluate the suitability of methods and techniques for solving the selected experimental problem.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1 - 4	1.2	Lecture	Lecture attendance and active participation; Flipped classroom	Records on students' activity during lectures; portfolio	21	35
3, 5	0.5	Practices	Laboratory work; independent completion of an experimental task	Records on students' performance at tasks; portfolio	12	20
1 - 5	0.8	Written exam	Preparation for written exam	Written exam	18	30
1 - 5	0.5	Oral exam	Preparation for oral exam	Oral exam	9	15
Total	**3**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	Wednesdays, from 12.00 – 14.00 p.m.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	15
Course content / teaching units	Lectures: • Life cycle of the seed plants and gametogenesis: microsporogenesis and megasporogenesis • Fertilisation • Embryogenesis • Postembryonic development • Germination. Cell and tissue differentiation during the development of the vegetative and generative organs • Molecular mechanisms of the plant growth regulators action: auxins, cytokinins, abscisic acid, jasmonic acid, brassinolides, oligosaccharides, gibberellins, ethylene • Research methods and approach to plant development process: cytological, anatomical and physiological methods • Molecular analyses: gene transcripts and proteins Practices: • Within practices, students will study some of the course topics by using appropriate methods in molecular biology (protein isolation, SDS electrophoresis, Western blotting, immunodetection - chemiluminescence)		
Recommended reading	Nikolić T. (2017) Morfologija biljaka: razvoj, građa i uloga biljnih tkiva, organa i organskih sustava. Alfa d.d., Zagreb. Raghavan V. (2000) Developmental Biology of Flowering Plants. Springer-Verlag, New York, Berlin, Heidelberg. Taiz L., Zeiger E., Møller I.M., Murphy A. (2015) Plant Physiology and Development, 6th ed. Sinauer Associates, Inc., Sunderland, Massachusetts U.S.A.		
Optional reading	Ambriović Ristov A. (2007) Metode u molekularnoj biologiji. Institut Ruđer Bošković, Zagreb. Relevant scientific papers referring to the subject area.		
Conditions for obtaining teacher's signature	Students are obliged to attend lectures and practices, to actively participate in the teaching process and to fulfil all course assignments.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. The final grade is determined according to the number of points collected during the lectures and the points achieved in written and oral exams.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	Survey carried out during the course, opportunity given to students to make written remarks and/or suggestions after the lectures. Monitoring of students' success at exams. Carrying out a uniform University Student Survey.		

Course title	**Virology**
Code	BM757
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	3
Course status	Obligatory
Course teacher	Assist. Prof. Dr. Zorana Katanić
Associate teachers	
Course entry requirements (Preceding courses)	Cell Biology, Microbiology
Course objective	To enable students to understand the characteristics and significance of viruses and the basic concepts and research methods in virology.
Learning outcomes	1. Ability to compare characteristics, structure and function of different viruses. 2. Ability to examine the harmful and positive characteristics of the viruses on living organisms. 3. Ability to assess the importance of viruses as ecological and evolutionary factors. 4. Skills in planning and using of basic methods in virus research.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	10	20
4	1	Practices	Work on the experimental task	Monitoring of student performance	20	30
1-4	1	Written exam	Preparation for written exam	Written exam	20	30
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	10	20
Total	**3**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15
Course content / teaching units	Lectures: • Structure, function and classification of viruses		

	• Virus replication strategies • Epidemiology of viral diseases • Evolution and ecology of viruses • Research methods in virology and laboratory diagnostics of viral diseases • Viruses and biotechnology • Vaccines and antiviral drugs • Application of the virus in gene therapy • Biological disease control Practices: • Laboratory diagnostics of some viruses
Recommended reading	Carter J., Saunders V. (2013) Virology: Principles and Applications, 2nd ed. John Wiley and Sons Ltd. Juretić N. (2002) Osnove biljne virologije. Školska knjiga, Zagreb. Kalenić S. et al. (2019) Medicinska mikrobiologija. Medicinska naklada, Zagreb.
Optional reading	Flint J., Racaniello V., Rall G., Skalka A.M., Enquist L.W. (2015) Principles of Virology, 4th ed. ASM Press, Washington, DC. Scientific papers referring to the subject area.
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After having attended lectures and practices, students proceed with the written and oral exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	After the course, an anonymous survey will be carried out among students to evaluate their subjective impression about the teaching quality; during the course or after the exams, students will be given an opportunity to make oral or written remarks; the teacher will monitor students' success at exams.

<table>
<tr><td>Course title</td><td colspan="5">Scientific Research Practice 1</td></tr>
<tr><td>Code</td><td colspan="5">BM865</td></tr>
<tr><td>Study programme</td><td colspan="5">Graduate University Study Programme in Biology</td></tr>
<tr><td>Semester</td><td colspan="5">II semester</td></tr>
<tr><td>Workload/ECTS credits</td><td colspan="5">2</td></tr>
<tr><td>Course status</td><td colspan="5">Obligatory</td></tr>
<tr><td>Course teacher</td><td colspan="5">Assigned mentor</td></tr>
<tr><td>Associate teachers</td><td colspan="5"></td></tr>
<tr><td>Course entry requirements (Preceding courses)</td><td colspan="5"></td></tr>
<tr><td>Course objective</td><td colspan="5">To introduce students to modern principles and methods of research work by enabling them to actively work in research teams while being supervised by a mentor.</td></tr>
<tr><td>Learning outcomes</td><td colspan="5">1. Skills in using previously acquired theoretical knowledge in research work and in applying research methods in the selected laboratory.
2. Skills in applying scientific methodology in an independent and responsible manner.</td></tr>
<tr><td>Link between learning outcomes, teaching and students' activities</td><td colspan="5">
<table>
<tr><th rowspan="2">Learning outcome</th><th rowspan="2">Share of ECTS</th><th rowspan="2">Form of teaching</th><th rowspan="2">Activities of learning and teaching</th><th colspan="3">Assessment</th></tr>
<tr><th>Methods of monitoring and evaluation</th><th>Grading Points min</th><th>max</th></tr>
<tr><td>1-2</td><td>2</td><td>Research work</td><td>Critical conversation and discussion; collaborative learning within analysis of different types of information sources</td><td>Records evaluation, diary on the scientific and research practice</td><td></td><td></td></tr>
<tr><td>Total</td><td>2</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Consultation hours</td><td colspan="5">By appointment.</td></tr>
<tr><td>Teaching</td><td>Lectures</td><td colspan="2">Seminars</td><td colspan="2">Practices</td></tr>
<tr><td>Hours - total</td><td>0</td><td colspan="2">0</td><td colspan="2">30</td></tr>
<tr><td>Course content / teaching units</td><td colspan="5">Field work:
• Preparation for field work (appropriate clothing and footwear, security measures and safety, keeping a field work diary)
• Field work: learning about the methods of sampling, making of collections, conservation and labelling of samples
• Measurements performed on field
Laboratory work:
• Introduction to laboratory routines
• Keeping of a laboratory diary
• Introduction to and learning about the laboratory techniques
• Participation in the laboratory work
• Independent work on the selected tasks</td></tr>
</table>

Recommended reading	
Optional reading	
Conditions for obtaining teacher's signature	Successful completion of scientific research practice and approved diary on scientific research practice.
Exam passing procedure	
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	Student survey to evaluate the overall quality of the course. Analysis of student success at the exams.

Course title	**Scientific Research Practice 2**
Code	BM971
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Obligatory
Course teacher	Assigned mentor
Associate teachers	
Course entry requirements (Preceding courses)	
Course objective	To introduce students to modern principles and methods of research work by enabling them to actively work in research teams while being supervised by a mentor.
Learning outcomes	1. Skills in using previously acquired theoretical knowledge in research work and in applying research methods in the selected laboratory. 2. Skills in applying scientific methodology in an independent and responsible manner.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-2	2	Research work	Critical conversation and discussion; collaborative learning within analysis of different types of information sources	Records, evaluation, diary on the scientific and research practice		
Total	**2**					

Consultation hours	By appointment.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	0	0	60

Course content / teaching units

Field work:

- Preparation for field work (appropriate clothing and footwear, security measures and safety, keeping a field work diary)
- Field work: learning about the methods of sampling, making of collections, conservation and labelling of samples
- Measurements performed on field

Laboratory work:

- Introduction to laboratory routines
- Keeping of a laboratory diary
- Introduction to and learning about the laboratory techniques
- Participation in the laboratory work
- Independent work on the selected tasks

Recommended reading	
Optional reading	
Conditions for obtaining teacher's signature	Successful completion of scientific research practice and approved diary on scientific research practice.
Exam passing procedure	
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	Student survey to evaluate the overall quality of the course. Analysis of student success at the exams.

Elective Courses

Course title	**Plant Microtechnique and Microscopy**
Code	BMZ82
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Vera Cesar Assist. Prof. Dr. Jasenka Antunović Dunić
Associate teachers	Assist. Prof. Dr. Lidija Begović Assist. Prof. Dr. Selma Mlinarić
Course entry requirements (Preceding courses)	Physical Foundations of Instrumental Methods in Biology, Cell Biology, Plant Anatomy
Course objective	To enable students to acquire knowledge and develop skills in the preparation of cytological and histological samples and to use the light and fluorescence microscope.
Learning outcomes	1. Skills in applying appropriate fixation and tissue preparation techniques depending on the structure of the plant material. 2. Ability to make preparations suitable for planned research and to make appropriate photo documentation. 3. Ability to analyse the quality of self-prepared plant material. 4. Ability to interpret the structure of tissues on preparations by applying previous knowledge of cell and tissue structure. 5. Developed skills in critical interpretation of scientific research results.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1, 3, 4, 5	1	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	12	20
2, 3	0.5	Practices	Independent preparation and microscopic examination of material	Records related to students' performance at preparing and examining of materials	21	35
1 - 5	0.25	Written exam	Preparation for written exam	Assessment of practical work, written exam and/or delivered presentation	18	30
1 - 5	0.25	Oral exam	Preparation for oral exam	Oral exam	9	15
Total	**2**				**60**	**100**

	Final grade: **60-70 points: grade 2 (sufficient)** **71-80 points: grade 3 (good)** **81-90 points: grade 4 (very good)** **91-100 points: grade 5 (excellent)**		
Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	15
Course content / teaching units	Lectures: • Introduction to plant microtechniques • Plant sampling procedures • Fixation • Dehydration • Infiltration and embedding • Histochemical and cytochemical reactions: fresh sections, sections embedded in paraffin, methacrylate or epoxy resins • Usage of a rotating microtome and cryostat • Immunolocalisation • In situ hybridisation of nucleic acids • Light microscopy: phase-contrast microscopy, differential-interference-contrast microscopy, fluorescence microscope, confocal microscope • Electron microscopy: TEM and SEM (ESEM) Practices: • Preparation of cytological and histological samples, staining and microscopy • Application of microscopy techniques in the analysis of permanent preparations		
Recommended reading	Ambriović Ristov A. (2007) Metode u molekularnoj biologiji. Institut Ruđer Bošković, Zagreb. Ruzin S.E. (1999) Plant Microtechnique and Microscopy. Oxford University Press, NewYork, Oxford.		
Optional reading	Bowes B.G. (1996) A Colour Atlas of Plant Structure. Manson Publishing Ltd, London. Maliga P., Klessig D.F., Cashmore A.R., Gruissem W., Varner J.E. (1995) Methods in Plant Molecular Biology. A Laboratory Course Manual. Cold Spring Harbor Laboratory Press, New York. O'Brien T.P., McCully M.E. (1981) The Study of Plant Structure. Princples and Selected Methods. Termercarphi Pty. Ltd., Melbourne, Australia. Van De Graaf K.M., Rushforth S.R., Crawely J.L. (1998) A Photographic Atlas for the Botany Laboratory. 3rd ed. Morton Publishing Company, Colorado. Relevant scientific papers referring to the subject area.		
Conditions for obtaining teacher's signature	Students are obliged to attend lectures and practices, to actively participate in the teaching process and to fulfil all course assignments.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. The final grade is determined according to the number of points collected during the lectures and the points achieved in written and oral exams.		
Main language of instruction; other languages	Croatian language, English language		

Method of monitoring the quality and efficiency of teaching	Survey carried out during the course, opportunity given to students to make written remarks and/or suggestions after the lectures. Monitoring of students' success at exams. Carrying out a uniform University Student Survey.

Course title	**Plant Pathoanatomy**
Code	BMZ80
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Ljiljana Krstin
Associate teachers	Assoc. Prof. Dr. Tanja Žuna Pfeiffer
Course entry requirements (Preceding courses)	Plant Anatomy, Plant Morphology with Field Work (attended)
Course objective	To teach students how to recognise changes in the anatomical structure of plant organs caused by pathogens.
Learning outcomes	1. Knowledge about the most common causes of plant diseases. 2. Ability to predict changes in the anatomical structure of plant organs caused by diseases. 3. Ability to determine pathological changes in plant cells and tissues on freshly prepared microscopic preparations. 4. Ability to compare plant defence mechanisms against pathogen attack and disease development. 5. Ability to evaluate professional and scientific papers dealing with plant pathoanatomy. 6. Knowledge about relations between changes in plant anatomy and reduced yield and ability to critically assess the importance of implementing plant protection measures and of growing pathogen-resistant plants.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-6	0.5	Lecture	Critical conversation and discussion	Records related to active and independent participation in conversations and discussions	5	10
1-5	0.5	Practices	Independent preparation of microscopic samples, comparison of structures of healthy and diseased plant tissues	Records related to students' activities within practices with provision of feedback	25	40
1-6	0.5	Written exam	Preparation for written exam	Written exam	15	25

	1-6	0.5	Oral exam	Preparation for oral exam	Oral exam	15	25
	Total	**2**				**60**	**100**
	Final grade: **60-70 points: grade 2 (sufficient)** **71-80 points: grade 3 (good)** **81-90 points: grade 4 (very good)** **91-100 points: grade 5 (excellent)**						
Consultation hours	By appointment						
Teaching	**Lectures**			**Seminars**		**Practices**	
Hours - total	15			0		15	
Course content / teaching units	Lectures: • Anatomical structure of plants • Abiotic and biotic factors as causes of pathogenic changes in cellular structures and plant tissues • Pathological changes of cellular structures and organelles • Pathological changes of plant tissues Practices: • Preparation of fresh microscopic samples of healthy and diseased plant tissues • Analysis and comparison of healthy and diseased plant tissues						
Recommended reading	Agrios G.N. (2005) Plant Pathology. 5th ed. Academic Press, New York. Trigiano R.N., Windham M.T., Windham A.S. (eds) (2006) Plant Pathology: Concepts and Laboratory Exercises, Taylor & Francis.						
Optional reading	Bačić T. (2003) Morfologija i anatomija bilja. Josip Juraj Strossmayer University of Osijek, Pedagoški fakultet, Osijek. Lepeduš H., Cesar V. (2010) Osnove biljne histologije i anatomije vegetativnih organa. Sveučilište Josipa Jurja Strossmayera u Osijeku, Odjel za biologiju, Osijek. Žuna Pfeiffer T., Krstin Lj., Štolfa I., Lovaković T., Tikas V., Lepeduš H. (2014) Praktikum iz anatomije biljaka. Sveučilište Josipa Jurja Strossmayera u Osijeku, Odjel za biologiju, Osijek. Original scientific papers referring to the subject area.						
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.						
Exam passing procedure	During the course, the teacher monitors and evaluates performance of each student, which refers to 40% of the final grade. Passing of written exam refers to 30% of the final grade, and passing of oral exam refers to the remaining 30% of the final grade.						
Main language of instruction; other languages	Croatian language, English language						
Method of monitoring the quality and efficiency of teaching	Periodic evaluation of students and teachers is planned to be carried out in order to assure and continuously improve the quality of teaching and of the study programme. During the last week of lectures, an anonymous student survey will be carried out to evaluate the overall quality of the course. Student success at exams will be also monitored.						

Course title	**Plant Toxicity Tests**
Code	BMZ73
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Janja Horvatić
Associate teachers	Assist. Prof. Dr. Vesna Peršić Martina Varga, Ph.D. Vera Tikas, expert advisor
Course entry requirements (Preceding courses)	Cell Biology, Biochemistry, Plant Physiology
Course objective	To explain to students the effects of a known factor on the test organism in a laboratory condition, as well as its possible influence on the living organisms in the environment. To develop students' practical skills for testing of toxicants' effects on plants.
Learning outcomes	1. Ability to apply various plant toxicity tests. 2. Ability to analyse the effects of toxicants on some plant species. 3. Development of students' natural science literacy within performing laboratory toxicity test. 4. Ability to critically implement laboratory tests on plants, and to analyse and interpret obtained data on the toxicity of some compounds.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	0.5	Lecture	Active participation in conversations and discussions	Records taken during conversations and discussions	6	10
3,4	0.5	Practices	Independent experimental work	Records related to student performance at practices and provision of feedback	12	20
1-4	0.75	Written exam	Preparation for written exam	Written exam	24	40
1-4	0.25	Oral exam	Preparation for oral exam	Oral exam	18	30
Total	**2**				**60**	**100**

Final grade:
60-69.9 points: grade 2 (sufficient)
70-79.9 points: grade 3 (good)
80-89.9 points: grade 4 (very good)
90-100 points: grade 5 (excellent)

Consultation hours	By appointment

Teaching	Lectures	Seminars	Practices
Hours - total	15	0	15
Course content / teaching units	Lectures: • Types of tests • Test organisms • Laboratory tests • Individual presentation of the toxicity of metals and xenobiotics to algae, which by their toxicity and/or presence in industry or environment deserve special attention • Source and amount of xenobiotics in water • The Lemna toxicity test – indicators of toxicity monitored on plant growth (determination of fresh and dry matter, total plant surface area), on concentration of photosynthetic pigments and on the amount of protein Practices: • The Lemna toxicity test • Determination of toxicity of various metals and xenobiotics on the growth, development, concentration of photosynthetic pigments, and growth inhibition of Lemna minor and Lemna gibba species • Statistical analysis of results, comparison and evaluation of obtained results		
Recommended reading	Hock B., Elstner E.F. (2004) Plant Toxicology. CRC Press. OECD Guidelines for the testing of chemicals- Revised proposal for a new guideline 221Lemna sp. Growth Inhibition Test (http://www.oecd.org/dataoecd/16/51/1948054.pdf)		
Optional reading	Naumann B., Eberius M., Appenroth K. J. (2007) Growth rate based dose – response relationships and EC-values of ten heavy metals using the duckweed growth inhibition test (ISO 20079) with *Lemna minor* L. clone St. Journal of Plant Physiology, Volume 164, Issue 12 https://www.elsevier.com/books/bioassays/hader/978-0-12-811861-0		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	Before taking oral exam, students are obliged to pass written exam. The final grade is determined according to the number of points for student's performance and the points achieved in written and oral exams.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.		

Course title	**Biogeographic Inventory**
Code	BMZ54
Study programme	Graduate University Study Programme in Biology
Semester	III winter semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Davorka Hackenberger Kutuzović
Associate teachers	Assist. Prof. Dr. Željka Lončarić
Course entry requirements (Preceding courses)	
Course objective	To develop students' skills for working in projects related to inventory and monitoring of habitats, flora and fauna. To introduce them to key methods of designing a credible and reliable inventory of plant and animal taxa and sizes of their populations.
Learning outcomes	1. Knowledge about basic concepts of biodiversity (definition, benefits and ecological values). 2. Ability to determine the vulnerability status of species. 3. Ability to plan an inventory and to apply flora and fauna inventory methods (direct and indirect), monitoring methods and geocoding, and to use cartographic networks and databases on biodiversity. 4. Ability to use geoinformation systems for inventorying or monitoring of biodiversity. 5. Ability to select and apply appropriate absolute and relative methods for estimating population sizes or inventory methods for different habitat types.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Critical conversation and discussion	Records related to student attendance and activity	5	10
4-5	0.5	Practices	Work on the experimental task	Monitoring of students' performance at interpretations and tasks	10	20
1-3, 5	0.5	Written exam	Preparation for written exam	Written exam	15	25
1-3, 5	0.5	Oral exam	Preparation for oral exam	Oral exam	20	45
Total	**2**				**50**	**100**

Final grade:
50.1-62.5 points: grade 2 (sufficient)
62.6-75 points: grade 3 (good)

	75.1-87.5 points: grade 4 (very good) **87.6-100 points: grade 5 (excellent)**		
Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15
Course content / teaching units	Lectures: • Biodiversity (definition, benefits and ecological values) • Determination of the vulnerability status of plant and animal species • Characteristics of terrestrial habitats in Croatia according to the EU Habitats Directive • Reasons for inventory planning, methods of flora and fauna inventory, monitoring methods • Geocoding of data, the use of GIS, remote research and cartographic networks, biodiversity databases, spatial data analysis • Absolute and relative methods of population density measurement Practices: • Practices are divided into three units, so that students get the opportunity to learn, apply and evaluate different methods, and to simulate the process of inventory design: preparation for inventorying (cartographic preparation, database review, selection of inventory methods, number and schedule of sampling), inventorying of different habitat types (forest, wetland, meadow and anthropogenic), field data processing, geocoding, methods used for estimation of population density		
Recommended reading	Henderson P.A. (2003) Practical methods in ecology. Blackwell, UK. Levequ, C., Mounolou J.C. (2003) Biodiversity. John Wiley & Sons, Ltd. Topić J., Vukelić J. (2009) Priručnik za određivanje kopnenih staništa u Hrvatskoj prema direktivi o staništima EU. Državni zavod za zaštitu prirode, RH.		
Optional reading	Evans K.M. (2006) Endangered species, protecting biodiversity. Thomson Gale. Radović J., Čivić K., Topić R., Posavec Vukelić V. (2009) Biološka raznolikost Hrvatske. Drugo izmijenjeno izdanje. DZZP, Zagreb. Sutherland W.J. (2010) Ecological Census Techniques - a handbook. Cambridge University Press, New York. QGIS – user manual		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	Before taking oral exam, students are obliged to pass written exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.		

Course title	**Biochemical Mechanisms of Toxicity**
Code	BMZ74
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Branimir Hackenberger Kutuzović
Associate teachers	Assoc. Prof. Dr. Sandra Ečimović
Course entry requirements (Preceding courses)	
Course objective	To enable students to acquire knowledge about biochemical mechanisms that precede the toxicity effect or that refer to the final toxic effect.
Learning outcomes	1. Knowledge about the basic biochemical mechanisms of toxicity. 2. Ability to examine the properties of biotransforming enzymes and their role in the biotransformation of xenobiotics. 3. Ability to analyse basic reactions of biotransformation. 4. Ability to estimate the most likely mechanism of toxic action based on the structure of xenobiotics. 5. Ability to elaborate and discuss practical examples from toxicology.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Lecture attendance and active participation	Records on lecture attendance and student activity	5	10
5	0.5	Practices	Practical examples and case studies from toxicology	Records on attendance at practices and monitoring of students' performance at case study analysis	10	15
1-5	0.5	Written exam	Preparation for written exam	Written exam	20	35
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	25	40
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment

Teaching	Lectures	Seminars	Practices
Hours - total	15	0	15
Course content / teaching units	Lectures: • Basic properties of biotransforming enzymes • Biotransformation and metabolism • Stereochemical approach to xenobiotic biotransformation • The first and second phase of biotransformation • Nomenclature of enzymes included in biotransformation • Distribution of biotransformation enzymes in organisms • Hydrolysis reactions • Reduction reactions • Oxidation reactions • Xenobiotic activation • P450 knockout mouse • Glucuronic acid conjugation • Sulphation reactions • Methylation reactions • Acetylation reactions • Conjugation with amino acids • Conjugation with glutathione • Rhodanese • Phosphorylation reaction • QSAR Practices: • Students will perform analysis of specific examples from toxicological practice		
Recommended reading	Klaassen D.C. (2008) Casarett & Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill, New York. Timbrell J.A. (2008) Principles of Biochemical Toxicology. CRC press.		
Optional reading	Stenersen J. (2004) Chemical Pesticides: Mode of Action and Toxicology, CRC press.		
Conditions for obtaining teacher's signature	Regular attendance of lectures and successful completion of practical assignments.		
Exam passing procedure	During the course, the teacher monitors and evaluates the work of each student, which makes up to 25% of the final grade. Written exam contributes with 34% to the final grade, while oral exam makes up 41% of the final grade.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.		

Course title	**Biomolecules in Food**
Code	BMZ77
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Valentina Pavić
Associate teachers	
Course entry requirements (Preceding courses)	
Course objective	To teach students about the structure and properties of food biomolecules, about chemical and energy transformations that are crucial for the function of biomolecules and to introduce students to the principles of modulation of metabolic reactions as a basis of biological processes in physiological and pathophysiological conditions of the organism.
Learning outcomes	1. Knowledge about the chemical structure of natural and synthetic compounds and their potential antioxidant activity. 2. Ability to evaluate the coordination of catabolic and anabolic processes. 3. Ability to understand the concept of deficient nutrient utilization in everyday life. 4. Ability to classify the bioavailability of biomolecules from food, and to determine the factors that affect the bioavailability of particular groups of compounds. 5. Knowledge about effects of nutrition on the development and prevention of specific diseases and conditions.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	10	20
1-5	1	Seminar	Interpretation of scientific papers and application of obtained results at concepts learned within lectures	Monitoring of students' performance at interpretations and tasks	40	60
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	10	20
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment

Teaching	Lectures	Seminars	Practices
Hours - total	15	15	0
Course content / teaching units	Lecture: • Biological role of active molecules in food • Biomolecular interactions • Secondary metabolites of plants • Damages caused by free radicals • Antioxidant properties of natural metabolites • Assessment of the protective role of phytochemicals • Oxidative stress and diseases • The role of nutrition in the prevention of various diseases • The role of nutrition in gene expression Seminar: • Membrane lipids of skeletal muscle and insulin resistance • Natural isothiocyanate sulforaphane in cancer cell apoptosis • Function of soy lecithin phospholipids in emulsions • Recovery of biomolecules from food residues • Influence of food on medicine absorption • Phytosterols • Nonspecific interactions between food additives and biomolecules		
Recommended reading	Belitz H.-D., Grosch W., W., Schieberle P. (2004) Food Chemistry. Springer-Verlag, Berlin Fennema O.R. (1996) Food Chemistry. Marcel Dekker, Inc, New York		
Optional reading	Watson D. (1998) Natural Toxicants in Food. Sheffield Academic Press, Sheffield. Rice-Evans C.A., Packer L. (2003) Flavonoids in Health and Disease. Marcel Dekker, Inc, New York.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	Prior to taking oral exam, students are obliged to prepare and present the seminar paper. The final grade consists of points achieved at oral exam and of points obtained during the course.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.		

Course title	**Dendrology**
Code	BMZ95
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Ljiljana Krstin
Associate teachers	Assist. Prof. Dr. Zorana Katanić Assist. Prof. Dr. Dubravka Špoljarić Maronić
Course entry requirements (Preceding courses)	
Course objective	To teach students about the role of trees, shrubs and semi-shrubs in terrestrial ecosystems and to enable them to understand their ecological, economic and horticultural importance.
Learning outcomes	1. Ability to evaluate the role of woody species in terrestrial ecosystems. 2. Ability to compare morphological characteristics of autochthonous and allochthonous species of trees, shrubs and semi-shrubs in the Republic of Croatia. 3. Ability to examine the adaptations of woody plants to different ecological conditions. 4. Ability to assess the influence of biotic and abiotic factors on forest ecosystems. 5. Skills in using professional and scientific literature related to dendrology.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	15	25
1-5	1	Seminar	Interpretation of scientific papers and application of obtained results at concepts learned within lectures	Monitoring of students' performance at interpretations and tasks	30	50
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	15	25
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**

Hours - total	15	30	0
Course content / teaching units	Lectures: • Plant life-forms • The role of the woody stem in the plant life strategy • Wood anatomy - primary and secondary growth • The vascular system: morphology and evolution • Comparative anatomy and morphology of the vegetative and generative organs with the emphasis on the evolutionary and ecological context • Ontogeny and phylogeny of the tree species • Strategies of the reproduction and dissemination • The position of the woody species in the plant evolution and systematics • Paleodendrology • Exchange of the matter and energy in woody plants • Biotic and abiotic impacts on growth, development and status of woody plants • Interactions of trees and other organisms • Potential and realised ecological niche • Dendrometric parameters • Dendrochronology as a retroactive monitoring of the habitat conditions • Woody species as edificators of the forest ecosystems • Global ecological amplitude of the trees and forests • Variability of forests in space and time Seminars: • Successional and degradation phases of forests • Trees in non-forest habitats • Importance of trees in the circulation of matter and energy in nature • Rare and endangered tree species • Rare and endangered forest types • Rainforests, semi-rainforests, forest management, forest plantations		
Recommended reading	Idžojtić M. (2013) Dendrologija-cvijet, češer, plod, sjeme. Udžbenici Sveučilišta u Zagrebu, Sveučilište u Zagrebu Šumarski fakultet, Hrvatske šume d.o.o., Zagreb. Idžojtić M. (2009) Dendrologija-list. Udžbenici Sveučilišta u Zagrebu, Sveučilište u Zagrebu Šumarski fakultet, Hrvatske šume d.o.o., Akademija šumarskih znanosti, Zagreb. Šilić Č. (1990) Ukrasno drveće i grmlje. Svjetlost, Sarajevo. Šilić Č. (1983) Atlas drveća i grmlja. Svjetlost, Sarajevo Vlahović S. (2019) Primijenjena dendrologija – I. svezak: Drveće i grmlje – Bogatstvo našeg okoliša. Školska knjiga, Zagreb. Vlahović S. (2019) Primijenjena dendrologija – II. svezak: Drveće i grmlje – Bogatstvo našeg okoliša. Školska knjiga, Zagreb.		
Optional reading	Rauš Đ. (1987) Šumarska fitocenologija. Udžbenici Sveučilišta u Zagrebu, Sveučilište u Zagrebu Šumarski fakultet, Zagreb. Rauš Đ. (1992) Šume u Hrvatskoj. Sveučilište u Zagrebu Šumarski fakultet, Hrvatske šume, Zagreb. Rauš Đ., Vukelić J. (1995) Silvae nostrae Croatiae. Ministarstvo poljoprivrede i šumarstva Republike Hrvatske: Hrvatske šume, Zagreb. Vukelić J. (2012) Šumska vegetacija Hrvatske. Udžbenici Sveučilišta u Zagrebu, Šumarski fakultet, Zagreb, Državni zavod za zaštitu prirode, Zagreb Vukelić J., Rauš Đ. (1998) Šumarska fitocenologija i šumske zajednice u Hrvatskoj. Udžbenici Sveučilišta u Zagrebu, Šumarski fakultet, Zagreb.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After the course, students take the oral		

	exam. The final grade consists of points achieved at oral exam and of points obtained during the course.
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.

Course title	**Ecotoxicology**
Code	BMZ87
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Branimir Hackenberger Kutuzović
Associate teachers	Assoc. Prof. Dr. Sandra Ečimović Assoc. Prof. Dr. Davorka Hackenberger Kutuzović
Course entry requirements (Preceding courses)	
Course objective	To teach students about the basic principles of ecotoxicology, and to use examples of described complex interactions of biological structures and pollutants within an ecosystem to explain to students modern approaches to the issue of pollutant effects on various structural parts of the ecological system, as well as on the entire biosphere.
Learning outcomes	1. Knowledge about basic concepts of ecotoxicology. 2. Ability to analyse the influence of pollutants on organisms and on the population stability and dynamics. 3. Ability to carry out monitoring and biomonitoring of pollution of terrestrial and aquatic systems. 4. Skills in proper sampling for pollution monitoring and biomonitoring. 5. Skills in proper selection of organisms to be used in experiments and for monitoring.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	0.5	Lecture	Lecture attendance and active participation	Records related to student attendance and activity	10	15
1-5	0.5	Practices	Solving of experimental tasks	Monitoring of students' performance at solving of tasks	10	15
1-5	0.5	Written exam	Preparation for written exam	Written exam	20	40
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	20	30
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15
Course content / teaching units	Lectures: • Introduction to ecotoxicology and its basic concepts • Basic groups of pollutants • Influence of pollutants on the population stability and dynamics • Effects of pollutants on individual organisms • Predicting the environmental influence of pollutants • Monitoring and biomonitoring of pollution in terrestrial and aquatic systems • Ecotoxicological risk assessment • Ecotoxicological risk management Practices: • Field probing and screening • Sampling design • Selection of organisms for experiments and for monitoring • Multilayer biomonitoring design • Determination of pollution sources on the field • Gradient of pollution in aquatic and terrestrial environment • Air pollution gradient • Determination of critical points in an area • Development of a professional ecotoxicological basis		
Recommended reading	Hoffman D.J., Rattner B.A., Burton G.A., Cairns J. (2003) Handbook of ecotoxicology. CRC Press LLC. Newman M.C., Clements W.H. (2008) Ecotoxicology. A comprehensive treatment: CRC Press, Taylor & Francis Group. Newman M.C. (2009) Fundamentals of Ecotoxicology. CRC Press.		
Optional reading	Mumtaz M. (2010) Principles and practice of mixtures toxicology. WILEY-VHC. Robinson L., Thorn I. (2005) Toxicology and Ecotoxicology in Chemical Safety Assessment. Blackwell Publishing Ltd.		
Conditions for obtaining teacher's signature	Regular attendance at lectures, successfully completed practices, Preparation and presentation of seminar paper.		
Exam passing procedure	Before taking oral exam, students are obliged to pass written exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	Evaluation form		

Course title	**Entomology**
Code	BMZ88
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Enrih Merdić
Associate teachers	Assist. Prof. Dr. Mirta Sudarić Bogojević Assist. Prof. Dr. Nataša Turić Assist. Prof. Dr. Goran Vignjević
Course entry requirements (Preceding courses)	
Course objective	To present to students the diversity of insects, to emphasise the connection of insects and humans, and to enable students to use methods of working with insects in order to independently design and perform scientific research into a group of insects.
Learning outcomes	1. Ability to evaluate the number and adaptability of insects in relation to other animals. 2. Ability to compare the basic determinants of specialist entomologies. 3. Knowledge about the relationship between humans and insects. 4. Ability to carry out a scientific research study into a group of insects. 5. Ability to evaluate the results of scientific research study.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	0.5	Lecture	Critical conversation and discussion	Student attendance and records on their activities	9	15
4-5	0.5	Seminar – project-based teaching	Independent work on the research assignment	Records and monitoring of students' performance in project-based teaching	9	15
4-5	0.5	Practices – project-based teaching	Independent work on the research assignment	Records and monitoring of students' performance in project-based teaching	24	40
4-5	0.5	Final exam	Written exam	Review and evaluation of project	18	30
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	15
Course content / teaching units	• Introduction to entomology • Insects as the most important group of animals in the world, explanation of the reasons: (a) the immense diversity and flexibility; (b) the ratio of insects to humans • Explanation of the relationship between humans and insects through the fundamental determinants of specialised entomology: transmission of diseases (medical entomology), food production (agricultural entomology), production of wood products (forest entomology), molestants (urban entomology) • Brief overview of the morphological and anatomical features of insects • Insect sampling methods, stuffing and collection • Design and completion of an entomological research project		
Recommended reading	Becker N., Petrić D., Zgomba M., Boase C., Dahl C., Madon M., Kaiser A. (2010) Mosquitoes and Their Control. Springer, Heilderberg. Gullan P. J., Cranston P.S. (2000) The insects: An outline of Entomology. Blackwell Science, USA. Service M. (2012) Medical Entomology for Students. 5th ed. Cambridge University Press.		
Optional reading	Peddigo L.P. (2002) Entomology and Pest Menagment. Prentice Hall. Romoser W.S., Stoffolano J.G. (1998) The Science of Entomology. WCB Mcgraw – Hill Companies.		
Conditions for obtaining teacher's signature	Regular attendance of classes.		
Exam passing procedure	Students will complete the course upon submission of a report on project assignment.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.		

Course title	**Enzyme Kinetics**
Code	BMZ76
Study programme	Graduate University Study Programme in Biology
Semester	IV semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Mirna Velki
Associate teachers	
Course entry requirements (Preceding courses)	
Course objective	To teach students about the basic principles and equations of enzyme kinetics and to enable them to apply methods for measuring enzyme activity and calculating enzyme reaction parameters.
Learning outcomes	1. Knowledge about the kinetics of enzymatically catalysed reactions. 2. Ability to estimate the relationship of chemical structure of enzymes with their mechanism of action. 3. Ability to calculate basic kinetic parameters. 4. Ability to analyse the enzymatic reaction rate and the effect of inhibitors on enzymes. 5. Skills in application and adaptation of methods for measuring of enzyme activity.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	5	10
1-5	0.5	Practices	Work on the experimental task	Monitoring of student performance	15	30
1-5	0.5	Written exam	Preparation for written exam	Written exam	20	30
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	20	30
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	Mondays, 10.00 – 11.00 a.m.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15

Course content / teaching units	Lectures incorporate the basics of biochemistry, physiology and molecular biology. Lectures: • Basic principles of enzymatic catalysis • Basic equations of enzyme kinetics • Enzyme reaction phases • Michaelis-Menten model • Measurements of enzymatic reaction rate • Influence of pH on enzyme catalysis • Types of inhibition of enzymatic reactions • Influence of inhibitors on kinetic constants • Kinetics of allosteric enzymes • Enzyme kinetics in physiological systems Practices: • Measurement of the rate of selected enzymatic reactions • Calculation of kinetic constants of enzymes • Determination of inhibition type based on changes in constants • Planning of the enzyme assays • Determination of the optimum conditions for physiological system enzymes
Recommended reading	Bisswanger H. (2017) Enzyme Kinetics: Principles and Methods, Third, enlarged and improved Edition, Wiley-VCH. Bisswanger H. (2011) Practical Enzymology, Second, Completely Revised Edition, Wiley Blackwell. Marangoni A.G. (2003) Enzyme kinetics : a modern approach, Wiley-Interscience. Taylor K.B. (2002) Enzyme Kinetics and Mechanisms, Kluwer Academic Publishers.
Optional reading	Scientific papers and review papers.
Conditions for obtaining teacher's signature:	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.
Exam passing procedure	Before taking oral exam, students are obliged to pass written exam, which can be substituted by a seminar paper. The final grade refers to the points achieved on written and oral exam and the points obtained during lectures.
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	Student survey, possibility to make oral or written remarks after lectures. Monitoring of students' success at exams.

Course title	**Genome Evolution**
Code	BMZ79
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Zorana Katanić
Associate teachers	
Course entry requirements (Preceding courses)	Genetics, Molecular Biology, Evolution
Course objective	To enable students to understand the basic concepts of genome evolution and to make them familiar with the research methodology used in this scientific discipline.
Learning outcomes	1. Skills in reviewing the basics of genome organisation and function in different organisms. 2. Ability to predict the action and significance of different mechanisms of genome evolution. 3. Skills in applying research methods related to the size, organisation, function, and evolution of the genome. 4. Ability to critically review relevant scientific literature.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	10	20
1-4	1	Seminar	Critical interpretation and presentation of scientific research; preparation and presentation of a seminar paper	Monitoring of students' performance at interpretations and presentation of scientific research; analysis of a seminar paper	30	50
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	20	30
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	0
Course content / teaching units	Lectures: • Size and organisation of genomes in different organisms • Genetic control of cell size • Mechanisms of genome evolution • Evolution of gene structure and gene expression • Basic differences of mitochondrial DNA • Evolution of plastid DNA • B-chromosomes • Sex chromosomes • Mechanism and significance of chromatin reduction and chromosome elimination • Methods for investigating the size, structure, function and evolution of the genome Seminars: • Working on assignments: review of literature and selection of a seminar paper topic; presentation of a seminar paper		
Recommended reading	Cooper G.M., Hausman R.E. (2010) Stanica: Molekularni pristup. Medicinska naklada, Zagreb. Gregory T.R. (2005) The Evolution of the Genome. Elsevier Academic Press. Scientific papers referring to the subject area.		
Optional reading	Alberts B., Bray D., Lewis J.L, Raff M., Roberts K., Watson J.D. (2007) Molecular biology of the cell. 5th ed. Garland Publishing, Inc., New York - London. Ambriović Ristov A. et al. (2007) Metode u molekularnoj biologiji. IRB, Zagreb. Saitou N. (2017) Evolution of the Human Genome I. Springer, Japan.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After lectures, students take oral exam. The final grade consists of points achieved at oral exam and of points obtained during the course.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	After the course, an anonymous survey will be carried out among students to evaluate their subjective impression about the organisation and quality of teaching; during the lectures, students will have opportunity to make written or oral remarks; monitoring of students' success at exams.		

Course title	**Plant Stress Physiology**
Code	BMZ83
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Janja Horvatić
Associate teachers	Martina Varga, Ph.D. Vera Tikas, expert advisor
Course entry requirements (Preceding courses)	Plant Physiology 2, Biochemistry 2, Molecular Biology
Course objective	To teach students about the influence of abiotic and biotic factors on plants, and to train them to perform experiments, to apply cell and molecular biology methods and to use scientific references.
Learning outcomes	1. Ability to analyse defence mechanisms of plants against adverse conditions (drought, salinity, low and high air temperatures, lack of oxygen, UV and light stress, pathogen attack). 2. Ability to estimate the influence of adverse environmental conditions on the occurrence of oxidative stress in plant cells. 3. Knowledge about components of the antioxidant system. 4. Ability to critically review relevant scientific literature. 5. Development of knowledge by critical interpretation of scientific research results.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	0.5	Lecture	Lecture attendance and active participation	Records related to student performance	5	10
4,5	0.5	Practices	Performance at experimental task	Monitoring of student performance	10	20
1-5	0.75	Seminar	Preparation of seminar paper by interpreting scientific papers and concepts learned within lectures	Monitoring of student performance at interpreting and solving of exercises	25	40
1-5	0.25	Oral exam	Preparation for oral exam	Oral exam	20	30
Total	**2**				**60**	**100**

Final grade:
60-69.9 points: grade 2 (sufficient)
70-79.9 points: grade 3 (good)
80-89.9 points: grade 4 (very good)
90-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	15
Course content / teaching units	Lectures: • Abiotic stress: shortage of water and drought; low temperature (cooling and freezing); high temperature (heat stress and heat shock); increased salt content in the soil; anoxia and hypoxia; light and UV stress; air and water pollution. • Biotic stress: competition between plant species; response to the predator and pathogen attack. • Pollution influence on plants (heavy metals, atmospheric pollution and xenobiotics); resistance mechanisms; pollution of water and soil; the use of chemicals in agriculture. • Surface protection of plants and defence substances Seminars: • Each student shall individually write and present a seminar paper dealing with plant stress physiology topics Practices: • Students will be working individually in laboratory on some selected issues		
Recommended reading	Taiz L., Zeiger E., Moller I.M., Murphy A. (2015) Plant Physiology and Development. 6th ed. Sinauer Associates, Inc.		
Optional reading	Ambriović Ristov A. (2007) Metode u molekularnoj biologiji. Institut Ruđer Bošković, Zagreb (http://www.mmb.irb.hr/) Buchanan B., Gruissem W., Jones R. (2002) Biochemistry & Molecular Biology of Plants. American Society of Plant Physiologists Rockville, Maryland (http://www.aspb.org/publications/biotext/) Original scientific papers.		
Conditions for obtaining teacher's signature	Regular attendance and active participation in lectures.		
Exam passing procedure	The final grade consists of points that students obtain for preparation and presentation of seminar paper and of points that they obtain for performance and activities at experimental tasks.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.		

Course title	**Geoinformation Science in Biological Research**
Code	BMZ94
Study programme	Graduate University Study Programme in Biology
Semester	III winter semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Oleg Antonić
Associate teachers	Assoc. Prof. Dr. Davorka Hackenberger Kutuzović Assist. Prof. Dr. Željka Lončarić
Course entry requirements (Preceding courses)	
Course objective	To introduce students to geoinformation science, and to explain the role of geoinformation technologies in biological research. To train students how to work with spatial data, how to perform spatial analysis and digital cartography, and how to use commercial and free software packages.
Learning outcomes	1. Ability to design the organisation of spatial data sampled within a biological experiment. 2. Ability to prepare digital spatial basis and integrate it into the geoinformation system. 3. Ability to review the physical foundations and fundamental principles of remote researching. 4. Ability to determine appropriate application of geoinformation technologies in practical examples. 5. Skills in independent creation of a cartographic presentation by using digital cartography methods.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1 - 5	0.5	Lecture	Participation in discussions during lectures	Records related to attendance and participation in discussions	15	25
2, 5	0.5	Practices	Performance at solving of tasks	Assessment of performance during practices	15	25
1-5	0.5	Written exam	Preparation for written exam	Written exam	15	25
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	15	25
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)

<table>
<tr><td></td><td colspan="3">71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)</td></tr>
<tr><td>Consultation hours</td><td colspan="3">By appointment</td></tr>
<tr><td>Teaching</td><td>Lectures</td><td>Seminars</td><td>Practices</td></tr>
<tr><td>Hours - total</td><td>15</td><td>0</td><td>15</td></tr>
<tr><td>Course content / teaching units</td><td colspan="3">Lectures:
• Definition and the scope of geoinformation science
• Organisation and display of the spatial data
• Geographic Information System (GIS)
• Projections and spatial transformations
• Digitalisation, scanning and vectorisation
• Georeferencing
• Raster and vector GIS
• Thematic layers
• Attribute tables
• Operations with the raster and vector themes
• Digital relief model and geomorphometric derivatives
• Spatial interpolations
• Spatial modelling
• Physical fundamentals of the remote research
• Orthophotograph
• Multispectral scanners
• The Earth surface spectral signature
• Passive and active sensors
• The most important satellite platforms
• Spatial, temporal, spectral and thematic resolution
• Subjective interpretation and delineation
• Controlled and uncontrolled automatic classification
• Spectral channels as continuous estimators of the biological and environmental variables
• Spatial and temporal series and monitoring on large areas
• Virtual sampling and preparation of the matrix for the numerical analysis
• Significance of the geoinformation technologies in the biological research with demonstration on practical examples
• Overview of commercial and free geoinformation software
Practices:
• Basic operations with the vector and raster spatial data
• Usage of GPS devices
• Design of thematic digital map
• Application of the basic geostatistical methods, the geomorphometric analysis and the data analysis obtained with the remote research in the context of biological research</td></tr>
<tr><td>Recommended reading</td><td colspan="3">Barret E.C., Curtis L.F. (1999) Environmental Remote Sensing.
Burrough P.A., McDonnell R.A. (1998) Principles of geographical information systems.
Hengl T., Reuter H.I. (2009) Geomorphometry: Concepts, Software, Applications. Elsevier, Amsterdam, London, New York.</td></tr>
<tr><td>Optional reading</td><td colspan="3">Bernhardsen T. (2002) Geographic Information System, An Introduction, 3rd ed. John Willey and Sons, Toronto.
Frančula N. (2003) Digitalna kartografija.
Hengl T. (2004) Geografski informacijski sustavi u inventarizaciji prirodnih resursa. Sveučilište u Osijeku, Osijek.
Oluić M. (2001) Snimanje i istraživanje Zemlje iz Svemira: sateliti, senzori, primjena.</td></tr>
</table>

Conditions for obtaining teacher's signature	Attendance at lectures and practices, and gaining of minimum 30 points.
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of each student. After the course, students pass the written exam with a minimum of 15 points. After having passed the written exam, students take the oral exam and pass it with a minimum of 15 points.
Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Evaluation form

Course title	**Geology and Paleontology**
Code	BMZ96
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Filip Stević
Associate teachers	Assist. Prof. Dr. Dubravka Špoljarić Maronić Assoc. Prof. Dr. Tanja Žuna Pfeiffer
Course entry requirements (Preceding courses)	
Course objective	To enable students to understand the basic geological processes and paleontological methods, as well as factors that influenced the development of life on Earth.
Learning outcomes	1. Knowledge about basic geological processes, geological periods and types of rocks. 2. Ability to review the conditions of development of life on Earth, extinction and evolution of species. 3. Ability to analyse basic characteristics of fossil remains and their role as indicators of environment state. 4. Knowledge about the application of paleontology and basic research methods in paleontology.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	1	Lecture	Critical conversation and discussion	Records related to active and independent participation in conversations and discussions	10	20
3-4	0.5	Seminar	Independent preparation of seminar paper	Records related to active and independent preparation of seminar paper with provision of feedback	25	40
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	25	40
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment

Teaching	Lectures	Seminars	Practices
Hours - total	30	15	0
Course content / teaching units	Lectures: • Application of geology and paleontology; introduction to basic concepts; connection with other sciences • Division of geology • Genesis and structure of Earth - causes and consequences of internal and external dynamics • Overview of geological periods, land distribution, floating of continents, tectonic shifts and climate change • Genesis, classification and dating of rocks (igneous, metamorphic and sedimentary rocks) • Paleontological taxonomy • Species evolution (origin and development of life), extinction of organisms, biodiversity • Fossils (paleobotany, paleozoology, paleoanthropology) • Biostratigraphy • Paleoecology Seminars: • Terrestrial and aquatic ecosystems over time • Fossil deposits • Conductive fossils • Algae in paleontological research • Forensic paleontology • Application of paleontology (biomineralisation, formation of ore deposits, fossil fuels and rocks, geotourism)		
Recommended reading	Briggs D.E.G, Crowther P.R. (2003) Paleobiology II. Blackwell. Herak M. (1990) Geologija. Školska knjiga, Zagreb.		
Optional reading	Benton M.J. (2000) Vertebrate Palaeontology, 2nd ed. Blackwell Science Ltd., London. Clarkson E.N.K. (1998) Invertebrate Palaeontology and Evolution, 4th ed. Blackwell Science Ltd., London. Mc Kerrow W.S. (1981) The Ecology of Fossils- an ilustrated guide. MIT Press. Milsom C., Rigby S. (2010) Fossils at a Glance, 2nd ed. Wiley-Blackwell, London. Plummer C.C., McGeary D., Carlson D.H. (1999) Physical Geology, 8th ed. The McGrawHill Companies, Boston. Retallack G.J. (2001) Soils of the Past: an Introduction to Paleopedology. 2nd ed. Blackwell, Oxford. Sremac J. (1999) Opća Paleontologija. Skripta, PMF. Stewart W.N., Rothwell G.W. (1993) Paleobotany and the evolution of plants. 2nd ed. Cambridge University Press, Cambridge, UK.		
Conditions for obtaining teacher's signature	Students are obliged to attend and actively participate in lectures and to prepare seminar papers independently.		
Exam passing procedure	Student's performance within the course is evaluated during lectures, and at the written and oral exam. Each student prepares and presents a seminar paper, for which there are certain number of points awarded according to determined criteria.		
Main language of instruction; other languages	Croatian language		

Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.

Course title	**Immunocompetence and Transplantation**
Code	BMZ84
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Lidija Begović
Associate teachers	
Course entry requirements (Preceding courses)	Biochemistry 3, Immunology
Course objective	To enable students to understand the concepts and importance of transplantation and immune system reaction during transplantation, the role and importance of tissue tolerance, and to assess the problems associated with transplantation of tissues and organs.
Learning outcomes	1. Improved theoretical knowledge and insights into the basic modern techniques for determining immunocompetence during organ transplantation. 2. Ability to determine methods of isolation of individual cell populations from peripheral blood, spleen and lymph nodes, and methods of cell storage from peripheral and umbilical blood. 3. Ability to determine the class I HLA antigen, the panel of reactive antibodies in serum, the cross-match test, the HLA class II gene and HLA phenotype and genotype, and to conduct genealogical research. 4. Ability to analyse and evaluate problems related to tissue and organ transplantation.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	5	10
2-3	0.5	Practices	Work on experimental assignment	Monitoring of student performance within experimental assignment	25	30
1-4	0.5	Written exam	Preparation for written exam	Written exam	15	30
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	15	30
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)

<table>
<tr><td></td><td colspan="3">91-100 points: grade 5 (excellent)</td></tr>
<tr><td>Consultation hours</td><td colspan="3">By appointment</td></tr>
<tr><td>Teaching</td><td>Lectures</td><td>Seminars</td><td>Practices</td></tr>
<tr><td>Hours - total</td><td>15</td><td>0</td><td>15</td></tr>
<tr><td>Course content / teaching units</td><td colspan="3">Lectures:
Transplantation of cells, tissues and organs: history, application, types of transplantation, problems (immunobiological, surgical, ethical, legal)
Immune system: the role, organs (primary, secondary), cells (lymphocytes, granulocytes, mediators), immunity (congenital, acquired, active, passive), immune response (cellular, humoral)
Main tissue matching system (HLA system): basic characteristics, role, location, polymorphism, imbalance of matching, products, tissue representation, crossing-over, terminology, application
Molecular structure of the HLA region (HLA class I region, central region, HLA class II region), HLA class I and class II genes (structure, role), HLA class I and class II molecules (structure, role)
Minor systems of tissue tolerance (system H-Y, HA-2)
Transplant reaction, recipient reaction against transplant, transplant reaction against recipient, criteria of recipient selection for transplantation of solid organs (kidney, liver, heart, pancreas), tissues and hematopoietic cells, waiting lists
Chimerism: application, importance, prognostic value, methods of determination
Practices:
Isolation of individual cell populations from peripheral blood, spleen, lymph nodes
Methods of storing cells from peripheral and umbilical cord blood
Determination of HLA class I antigen (Microlymphocytotoxicity test: MLCT)
Determination of a panel of reactive HLA antibodies in serum (% P RA)
Cross-match test (CM)
Class II HLA gene determination (Polymerase Chain Reaction -Sequence Specific Primers: PCR-SSP)
Determination of HLA phenotype, HLA genotype, genealogy</td></tr>
<tr><td>Recommended reading</td><td colspan="3">Andreis I., Batinić D., Čulo F., Grčević D., Marušić M., Taradi M., Višnjić D. (2004) Imunologija. Medicinska naklada, Zagreb.
Marsh S.G.E., Parham P., Barber L.D. (2000) The HLA facts book. Academic Press, London.</td></tr>
<tr><td>Optional reading</td><td colspan="3">Bader P., Neithammer D., Willasch A., Kreyenberg H., Klingebiel T.(2005) How and when we monitor chimerism after allogeneic stem cell transplantation?. Bone Marrow Transplantation, 35, 107-119.
Janeway C.A., Travers P., Walport M., Shlomchik M.J. (2001) Immunobiology 5, The Immune system in health and disease. Garland Publishing, New York.
Starzl T.E. (2004) Chimerism and tolerance in transplantation. Colloquium of the National Academy of Science, 101 (2), 607-614.</td></tr>
<tr><td>Conditions for obtaining teacher's signature</td><td colspan="3">Students are obliged to participate in lectures actively and to fulfil all assignments within the course.</td></tr>
<tr><td>Exam passing procedure</td><td colspan="3">During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After lectures and practices, students take a written exam and then an oral exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.</td></tr>
</table>

Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.

Course title	**Plant Cell and Tissue Culture**
Code	BMZ78
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Jasenka Antunović Dunić
Associate teachers	
Course entry requirements (Preceding courses)	Cell Biology, Plant Anatomy, Plant Physiology 1
Course objective	To teach students how to use techniques of plant tissue culture in vitro and how to practically apply micropropagation methods.
Learning outcomes	1. Knowledge about the importance of micropropagation methods. 2. Ability to analyse the basic scientific findings about successful micropropagation. 3. Ability to explain scientific and biotechnological approach to the *in vitro* technology. 4. Ability to critically review relevant scientific literature. 5. Skills in applying appropriate methods and techniques for successful micropropagation.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1 - 4	0.5	Lecture	Lecture attendance and active participation; Critical conversation and discussion	Records on students' activity during lectures; portfolio	15	25
5	0.5	Practices	Laboratory work; independent completion of an experimental task	Records on students' performance at tasks; portfolio	12	20
1 - 5	0.5	Written exam	Preparation for written exam or writing of an academic essay	Written exam or essay	24	40
1 - 5	0.5	Oral exam	Preparation for oral exam	Oral exam or presentation and analysis of an essay	9	15
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	Wednesdays, from 12.00 – 14.00 p.m.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15
Course content / teaching units	Lectures: • Pathways of organogenesis and regeneration from plant cell, tissue and organ culture • Planting culture: composition of nutrient media, axenicity of plant material, influence of physical factors on culture growth, choice of explants, subcultivation • Cell proliferation and callus tissue growth • Structural, physiological, biochemical and genetic aspects of in vitro organogenesis • Meristem culture • Somatic embryogenesis • Protoplast culture • Application of plant tissue culture in genetic engineering and in classical selection methods: genetic transformation of plants, vegetative micropropagation • Application in biotechnology: production of clones, bioproduction of useful substances Practices: • Setting up a culture: preparation of nutrient media, axenicity of plant material, manipulation in axenic conditions • Growing of callus • Procedures of successful regeneration		
Recommended reading	Leva A., Rinaldi L.M.R. (2012) Recent Advances in Plant in vitro Culture. IntechOpen (eBook) (https://www.intechopen.com/books/recent-advances-in-plant-in-vitro-culture) Jelaska S. (1994) Kultura biljnih stanica i tkiva. Školska knjiga, Zagreb.		
Optional reading	Relevant scientific papers referring to the subject area.		
Conditions for obtaining teacher's signature	Students are obliged to attend lectures and practices, to actively participate in the teaching process and to fulfil all course assignments.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. The final grade is determined according to the number of points collected during the lectures and the points achieved in written and oral exams.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	Survey carried out during the course, opportunity given to students to make written remarks and/or suggestions after the lectures. Monitoring of students' success at exams. Carrying out a uniform University Student Survey.		

Course title	**Avian Metabolism**
Code	BMZ98
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Sandra Ečimović
Associate teachers	
Course entry requirements (Preceding courses)	Biochemistry 1, Biochemistry 2, Biochemistry 3
Course objective	To introduce students to the characteristics of bird metabolism, and to teach them how to link those characteristics with bird physiology and way of life.
Learning outcomes	1. Ability to analyse new insights into the metabolic pathways of carbohydrate, fat, protein, and nucleotide remodelling. 2. Ability to connect the knowledge about anatomical structure and lifestyle of birds with specific metabolic adaptations. 3. By using birds as example, students will be able to predict analogous metabolic adaptations in other species, and to compare them with humans. 4. Ability to develop the idea of easier transfer of fats in the body and their more efficient usage for energy purposes, which can contribute to solving of today's great problem of obesity (which is intensively researched without adequate positive results), and to contribute to new scientific research and findings in that area.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Lecture attendance and active participation	Records, evaluation	5	15
1-4	1	Seminar	Attendance of lectures, preparation of seminar paper	Records, evaluation	30	45
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	25	40
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment

Teaching	Lectures	Seminars	Practices
Hours - total	15	15	0
Course content / teaching units	• Carbohydrate metabolism, importance of gluconeogenesis • Aerobic and anaerobic metabolism, white and red muscle fibres • Fat metabolism, fatty acids in birds, fatty acid synthesis • Uropygial gland fat • Transfer of fat from food to tissues, specificity of lipoprotein structures • Fat transfer in oocyte, vitellogenin • Fat decomposition, ketone bodies • metabolism of protein and amino acids • Short-lived and long-lived proteins • Ubiquitin and proteasomes • Calpains, cathepsins, peptidases • Nitrogen excretion and uric acid synthesis • Xenobiotic metabolism • Metabolic adaptation in birds • Oxygen transfer • Egg metabolism • Bird hormones (insulin, glucagon, pancreatic polypeptide, somatostatin) • Control of hormone secretion, hormone receptors, effects of hormones on metabolism		
Recommended reading	Kralik G., Has-Schön E., Kralik D., Šperanda M. (2008) Peradarstvo. Biološki i zootehnički principi. Sveučilište J. J. Strossmayera u Osijeku i Sveučilište u Mostaru, Osijek, Hrvatska. Lewis S. (2004) Avian Biochemistry and Molecular Biology, Cambridge University Press, Cambrige, United Kingdom.		
Optional reading	Berg J.M., Tymoczko J.L., Stryer L. (2013) Biokemija, translation of the 6th edition of 2007. (Freeman & Comp., New York). Školska knjiga, Zagreb. Schat, K.A., Kaspers, B., Kaiser, P. 2014: Elsevier Ltd., United Kingdom. Original scientific papers.		
Conditions for obtaining teacher's signature	Regular attendance of lectures, successful completion of seminars.		
Exam passing procedure	Attendance of lectures, active participation, prepared seminar paper contribute to the final grade with a share of 70%, while passing of oral exam refers to 30% of the final grade. Prior to taking oral exam, students are obliged to submit a seminar paper.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Student survey after the course; reviews during the course and possibility to give oral or written remarks after lectures; monitoring of student success at exams.		

Course title	**Modelling of Biological Processes**
Code	BMZ72
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Prof. Dr. Branimir K. Hackenberger
Associate teachers	Assist. Prof. Dr. Željka Lončarić
Course entry requirements (Preceding courses)	
Course objective	To teach students how to use basic methods of mathematical modelling of biological processes at molecular to ecological level.
Learning outcomes	1. Knowledge about algorithms of basic types of mathematical models and their possible applications. 2. Ability to analyse basic ecological principles that operate at the level of an organism, population, community and ecosystem. 3. Ability to critically revise environmental principles for interpretation of different mathematical models. 4. Skills in assessment and usage of models described in literature.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lectures	Lecture attendance and active participation	Records, evaluation	5	10
1-4	0.5	Seminars	Attendance of seminars and active participation	Records, evaluation, submission of a seminar paper	25	50
1-4	0.5	Exam (written exam)	Preparation for written exam	Written exam	15	20
1-4	0.5	Final exam	Exam preparation	Oral exam	15	20
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	0

Course content / teaching units	Lectures: • Discrete dynamical systems • Compartmental analysis and differential equations • Logistic models • Recursive functions • Stochastic processes • Interpretation of stochastic data • Creation of stochastic models • Model validation • Model of human population • Review of matrix algebra • The eigenvalue and eigenvector analysis • Empirical models • Interpolation • The statistics of simple regression • Continuous models • Geometric analysis and non-linear equations • Continuous stochastic processes Seminars: • Within seminar classes, students shall create models based on research examples and actual data
Recommended reading	Mooney D., Randall S. (1999) A Course in Mathematical Modeling.
Optional reading	Bender A.E. (2000) An Introduction to Mathematical Modeling, Dover Publications, Mineola. Britton F.N. (2003) Essential Mathematical Biology, Springer Verlag, London.
Conditions for obtaining teacher's signature	Regular attendance of lectures, successful completion of seminars.
Exam passing procedure	During the course, the teacher monitors and evaluates performance of each student, which refers to 10% of the final grade. Preparation of the seminar paper contributes to the final grade with 50%, passing of written exam and of oral exam with 20%, respectively.
Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Student survey to evaluate the overall quality of the course. Analysis of student success at the exams.

Course title	**Molecular Genetics**
Code	BM758
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	4
Course status	Elective
Course teacher	Assist. Prof. Dr. Lidija Begović
Associate teachers	
Course entry requirements (Preceding courses)	Biochemistry 1, Genetics, Molecular Biology
Course objective	To enable students to understand the molecular basis of inheritance and organisation of genetic material, with special emphasis put on the structure and function of the eukaryotic genome. To develop students' skills in applying research methods in molecular genetics.
Learning outcomes	1. Acquired knowledge of nucleic acid structure, information transfer, gene expression, genome organisation, application of recombinant DNA technology and its role in the research into genome structure and function. 2. Ability to critically review the need to link molecular research methods and knowledge of molecular mechanisms of inheritance. 3. Skills required for analysing the results obtained within experiments performed at practices. 4. Ability to compare and correlate research methods in molecular genetics and their application in contemporary studying of molecular genetics, as well as in biology, medicine and biotechnology.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	1	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	15	20
2-4	1.5	Practices	Work on the experimental task	Monitoring of student performance within experimental assignment	20	30
1-4	1	Written exam	Preparation for written exam	Written exam	10	20
1-4	0.5	Oral exam	Preparation for oral exam	Oral exam	15	30
Total	**4**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	30	0	15
Course content / teaching units	Lectures: • Molecular basis of the inheritance: DNA and RNA as genetic material and the flow of the genetic information (basic information about replication, transcription, reverse transcription and translation) • Informational content of the primary, secondary and tertiary structure of nucleic acids, genetic code and genes Genome projects • Procaryotic and eukaryotic genome • Classification of the genomic DNA sequences according to the number of copies, portion and classification of the coding and non-coding sequences • "DNA identity", minisatellites and microsatellites • The genome size and the C-value paradox • Reorganisations in genome: recombination mechanisms • Transposable elements and their role in the genome evolution • DNA in the eukaryotic genome: nucleosomes, chromatin and chromosomes • Genome compartments, euchromatin and heterochromatin • Centromeres and telomeres, epigenetic inheritance • Transcription in the regulation and formation of a genome: RNA mechanisms • The basic characteristics of the human genome, isohore organisation and comparisons with the sequenced genomes of other species • Significance of the structural organisation of the interphase nucleus in the genome function Practices: • Isolation of the eukaryotic genomic DNA • Decomposition by restriction endonucleases, electrophoresis and isolation of DNA fragments from agarose gel • Cloning: preparation of the vectors and ligations, preparation of the competent cells and transformation • Growing of bacterial clones on selective media, plasmid DNA mini-preparation and screening of positive clones • Southern hybridisation method. Computer analyses of DNA nucleotide sequences		
Recommended reading	Tamarin R.H. (2004) Principles of genetics. 6th edition. McGraw-Hill Companies, Inc. William S. Klug, Michael R., Cummings C., Spencer A., Palladino M.A., Killian D. Concepts of Genetics, 12th edition, Pearson.		
Optional reading	Alberts B., Bray D., Lewis J., Raff M., Roberts K., Watson J.D. (2004) Molecular biology of the cell. 6th edition. W.W. Norton & Company. Strachan T., Read A., Strachan T. (2018) Human molecular genetics. 5th edition. Garland Science. Optional reading list will contain review articles referring to the course topics and current issues.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After lectures and practices, students take a written exam and then an oral exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.		

Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.

Course title	**Molecular Mechanism of Oxidative Stress**
Code	BMZ75
Study programme	Graduate University Study Programme in Biology
Semester	I semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Lidija Begović Assist. Prof. Dr. Selma Mlinarić
Associate teachers	
Course entry requirements (Preceding courses)	Biochemistry 1
Course objective	To enable students to understand the mechanisms of oxidative stress at molecular, subcellular and cellular levels and to develop students' skills required for experimental work by selection of appropriate analytical methods.
Learning outcomes	1. Ability to assess the mechanisms of oxidative stress at molecular, subcellular and cellular level. 2. Ability to critically analyse basic scientific findings about oxidative stress mechanisms. 3. Acquired knowledge about principles of dynamic bonds between biochemical response and structural changes caused by oxidative stress. 4. Ability to analyse processes involved in the antioxidant response. 5. Ability to organise an experiment by selecting appropriate methods and techniques to test selected issues and hypotheses.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-4	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	10	20
5	0.5	Practices	Designing of and performance at experimental task	Monitoring of student performance	20	30
1-5	0.5	Written exam	Preparation for written exam	Written exam	20	30
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	10	20
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	0	15
Course content / teaching units	Lecture: • Oxygen and reactive oxygen species • Damages of biomolecules and cell structures due to oxidative stress • Oxidants and cell signalling • Non-enzymatic antioxidants: ascorbic acid, glutathione, vitamin E, carotenoids, phenols • Antioxidative enzymes: catalase, peroxidase, superoxide dismutase, glutathione reductase and monodehydroascorbate reductase • The Halliwell-Asada cycle Practices: • Induction of oxidative stress in experimental conditions • Methods for determination of antioxidant enzyme activity • Determination of total antioxidant activity and the amount of non-enzymatic antioxidants • Determination of photosynthetic pigment concentration		
Recommended reading	Jenks M.A., Hasegawa P.M. (eds.) (2005) Plant abiotic stress. Blackwell Pub. Rao K., Raghavendra A., Reddy K. (2006) Physiology and molecular biology of stress tolerance (pp. 1-14). Springer: Dordrecht, Nertherlands. Hopkins W.G. (2009) Plant Physiology 4th ed. John Wiley & Sons, Inc. Hoboken, SAD.		
Optional reading	Relevant scientific papers referring to the subject area.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After lectures and practices, students take a written exam and then an oral exam. Points gained at written and oral exam are added to the points that students collected up to the final exam, thus making a total number of points to be converted to final grade.		
Main language of instruction; other languages	Croatian language, English language		
Method of monitoring the quality and efficiency of teaching	After the course, an anonymous survey will be carried out among students to evaluate their subjective impression about the organisation and quality of teaching; during the lectures, students will have opportunity to make written or oral remarks; monitoring of students' success at exams.		

Course title	**Ornithology**
Code	BMZ89
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Alma Mikuška
Associate teachers	
Course entry requirements (Preceding courses)	
Course objective	To support strengthening of students' knowledge and skills in the field of ornithology in order to make them responsible members of the scientific research community. To raise students' awareness of the values of Croatian ornithofauna in the international context.
Learning outcomes	1. Ability to apply scientific methodology used in ornithology. 2. Knowledge of the protocol for field research of birds. 3. Skills to carry out field work independently (bird identification). 4. Ability to implement activities and ways to preserve biodiversity and to protect birds using new knowledge about the biology and ecology of birds. 5. Skills for cooperation with the scientific community and professional institutions that can contribute to more effective research and protection of birds in Croatia and Europe.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-5	0.5	Lecture	Critical discussion and conversation; collaborative learning, Flipped classroom, Field research	Records related to active participation in lectures	15	20
2,3	1	Seminar	Independent preparation of seminar paper referring to topics of relevance in ornithology research	Analysis of a seminar paper and provision of feedback	30	50
1-5	0.5	Oral exam	Preparation for oral exam	Oral exam	15	30
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	0
Course content / teaching units	Lecture: • Introductory lecture - course content, reading list and students' obligations • Anatomy and morphology of birds • Flight adjustments • Bird evolution • Evolution of flight (Ratitae) • Number of species • Taxonomy and systematics of birds • Bird migrations • Navigation and orientation in birds • Croatian ornithofauna: history of research, contemporary research, list of species, status of bird species in Croatia, endangered species, protection • Bird research methods - observation, faunal and ecological research, marking (ringing) of birds, monitoring population dynamics and counting birds. • Important areas for birds in Croatia Seminar: • Students have to prepare and publicly present a seminar paper about one bird taxon. In the paper, students refer to biological, ecological and zoographical characteristics of birds, their status in the world and in Croatia (if the taxon is present in Croatia) • If the taxon is endangered, students need to define the reasons for endangerment and protection measures • The seminar paper topic can be related also to general characteristics of birds, such as flight adaptations, bird evolution, migrations, bird behaviour, etc. • During the seminar classes, students will get acquainted with the ornithofauna of the Kopački Rit Nature Park and the city of Osijek		
Recommended reading	Bibby C.J., Burgess N.D., Hill D.A. (1992) Bird Census Techniques. London: Academic Press. Lowette I.J., Fitzpatrick J.W. (ed.) (2016) Handbook of bird biology. 3rd ed. Cornell Laboratory of Ornithology. New York. USA Svensson L., Mullarney K., Zetterström D. (Martinović M., Lučić V. (ur hr izdanja) (2018) Ptice Hrvatske i Europe. Biom, Zagreb. Tutiš V., Kralj J., Čiković D., Barišić S. (Ed.) (2013) Crvena knjiga ptica Hrvatske. Ministarstvo zaštite okoliša i prirode i Drţavni zavod za zaštitu prirode, Zagreb.		
Optional reading	Kralj J., Barišić S., Tutiš V.,Ćirković D.(Ed.) (2013) Atlas selidbe ptica Hrvatske. HAZU, Zavod za ornitologiju Zagreb. Mikuska J., Mikuška T., Romulić M. (2002) Ptice - vodič kroz biološku raznolikost Kopačkog rita. Matica hrvatska, Osijek. Hrvatska akademija znanosti i umjetnosti-Zavod za ornitologiju 2011. Prstenovanje ptica u znanosti i zaštiti prirode. Zagreb.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments.		
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students. Seminar issues related to the ornithofauna of Croatia are discussed on field, in the area of Kopački Rit and the surroundings of Osijek. After lectures and field work, students write a seminar paper on the topic in ornithology. Within the oral exam, students present a seminar paper to the teacher. The final grade is determined according to number of points that students obtain during lectures, seminars, and at the oral exam.		

Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	During the course, the teacher performs evaluation for learning by continuous monitoring of the learning process and student achievement, thus determining and adapting his/her teaching. After the course, the teacher conducts a survey among students to evaluate their subjective impression about the teaching quality, all with the aim to improve future teaching.

Course title	**Underwater Biological Research**
Code	BMZ93
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assist. Prof. Dr. Željka Lončarić
Associate teachers	Prof. Dr. Branimir Kutuzović Hackenberger
Course entry requirements (Preceding courses)	
Course objective	To enable students to acquire theoretical and practical knowledge about modern methods of biological underwater research, and about its planning and implementation.
Learning outcomes	1. Knowledge about modern methods of biological underwater research. 2. Skills required for realisation of simple underwater research and sampling in water bodies, and on river surface.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-2	1	Practices	Practical classes attendance and active participation	Records, evaluation	10	15
1-2	0.5	Written exam	Preparation for written exam	Written exam	25	35
1-2	0.5	Oral exam	Exam preparation	Oral exam	25	45
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	0	0	30

Course content / teaching units

Practices:
- Particularities of underwater biological research
- Similarities and differences of freshwaters and sea
- Research in the river flows
- Water column probing
- Sediment probing
- Underwater orientation and tracing

	• Labelling methods • Underwater mapping methods • Remote underwater research • Surface research • Forms of sampling • Particularities of staying underwater • Autonomous diving theory • Submarines and their usage for biological research • Collection of environmental data • Inventory sampling of streambed and sediment • Water column sampling • Usage of IR camera for inspection and research • Usage of sonar. Creating sampling sketch and profile • Diving with the autonomous diving gear
Recommended reading	Clark A.R. (2000) Open Water Diver. SSI Croatia, Rijeka. Coyer J., Steller D., Witman J. (1990) The Underwater Catalog: A Guide to Methods in Underwater Research, Shoals Marine Laboratory, Ithaca.
Optional reading	Rand M.G. (1995) Fundamentals of Aquatic Toxicology. Taylor and Francis, Philadelphia – London. Miller C.B. (2003) Biological oceanography. Blackwell Publishing, Malden. Medwin H., Clay C.S. (1997) Fundamentals of Acoustical Oceanography. Academic Press, New York.
Conditions for obtaining teacher's signature	Regular attendance of lectures and active participation.
Exam passing procedure	During the course, the teacher monitors and evaluates performance of each student, which refers to 10% of the final grade. Passing of written exam refers to 40% of the final grade, while passing of oral exam refers to 50% of the final grade.
Main language of instruction; other languages	Croatian language, English language
Method of monitoring the quality and efficiency of teaching	Student survey to evaluate the overall quality of the course. Analysis of student success at the exams.

Course title	**Supramolecular Structures**
Code	BMZ81
Study programme	Graduate University Study Programme in Biology
Semester	II semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Ivna Štolfa Čamagajevac
Associate teachers	Ana Vuković, assistant
Course entry requirements (Preceding courses)	
Course objective	To enable students to use computer software for 3D imaging of macromolecule structure (Chime, Jmol, Web-Lab) and to upgrade their knowledge in biochemistry.
Learning outcomes	1. Ability to estimate the relationship between the structure and function of macromolecules. 2. Development of knowledge and skills required for the preparation of teaching materials ("tutorials") that contain images and animations of macromolecules prepared by computer software. 3. Ability to critically interpret the results of students' own research into macromolecules performed in computer software.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-3	0.5	Lecture	Critical conversation and discussion	Records related to student performance during lectures	5	10
1-3	0.75	Seminar	Independent performance and commenting performed tasks; interpretation of scientific papers	Monitoring of students' performance at interpretations and tasks	20	40
1-3	0.75	Written exam	Writing of an academic essay	Essay	25	50
Total	**2**				**50**	**100**

Final grade:
50.1-62.5 points: grade 2 (sufficient)
62.6-75 points: grade 3 (good)
75.1-87.5 points: grade 4 (very good)
87.6-100 points: grade 5 (excellent)

Consultation hours	Two hours a week according to schedule defined at the beginning of the academic year and additional consultation hours as agreed with students.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	0

Course content / teaching units	• Structural protein motifs in interaction with information macromolecules • Regulatory proteins in gene expression • Enzymes • Membrane channels and pumps • Receptors • Protein assemblies in photosynthesis • Macromolecules and molecular assemblies that are crucial for the immune response • Viruses • Nucleosomes and ribosomes • Topics selected according to students' interest • Within seminars, students will be presenting topics of their interest
Recommended reading	Berg J.M., Tymoczko J.L., Gatto G.J., Stryer L. (2019) Biochemistry (9th edition). Macmillian International Higher Education, New York. Stryer L., Berg J., Tymoczko J. (2013) Biokemija (6th edition, 1st Croatian edition). Školska knjiga, Zagreb.
Optional reading	Web pages: http://www.rcsb.org/pdb/home/home.do http://bcs.whfreeman.com/berg7 http://bcs.whfreeman.com/biochem6 www.whfreeman.com/biochem5 www.clunt.edu/BioDev/omm/exhibits.htm www.biologie.uni-hamburg.de/lehre/bza/eanfang.htm http://biology.kenyon.edu/BMB/chime.htm http://www.proteopedia.org/wiki/index.php/Main_Page http://www.ks.uiuc.edu Original scientific papers and review papers
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.
Exam passing procedure	During the course, the teacher monitors and evaluates the activities of students by awarding points according to determined criteria. After the course, students take a written exam and then oral exam. During the semester, students can take three preliminary exams and substitute them for the written exam if passing each preliminary exam with more than 60% of the total number of points.
Main language of instruction; other languages	Croatian language
Method of monitoring the quality and efficiency of teaching	During the course, the teacher continuously evaluates student achievement, and gives students the opportunity to make oral or written comments. After the course, students are given a survey in which they give their subjective opinion about quality and organisation of teaching, all with the aim to improve future teaching.

Course title	**Protection and Revitalisation of Aquatic Ecosystems**
Code	BMZ97
Study programme	Graduate University Study Programme in Biology
Semester	III semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Melita Mihaljević
Associate teachers	
Course entry requirements (Preceding courses)	Aquatic Ecosystems
Course objective	To introduce students to the basics of protection of aquatic ecosystems, and to the revitalisation methods.
Learning outcomes	1. Ability to apply indicators for assessment of water quality and of ecological status of waters, in accordance with applicable regulations. 2. Ability to perform assessment of ecological status of aquatic ecosystems. 3. Ability to determine measures for revitalisation of aquatic ecosystems. 4. Skills in reviewing recent literature on aquatic ecosystem revitalisation.

Learning outcome	**Share of ECTS**	**Form of teaching**	**Activities of learning and teaching**	**Assessment**		
				Methods of monitoring and evaluation	**Grading Points**	
					min	**max**
1-4	0.5	Lecture	Critical conversation and discussion	Records, evaluation	10	15
1-4	0.5	Seminars	Independent case study analysis	Records, evaluation of seminar paper	15	20
1-4	0.5	Preliminary written exam	Preparation for written preliminary exam	Written exam	15	20
1-4	0.5	Final exam	Preparation for final exam	Oral exam	20	45
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	As agreed with students.

Teaching	Lectures	Seminars	Practices
Hours/week total	15	15	0
Course content / teaching units	Lecture: • Structure and function of aquatic ecosystems • Water quality - indicators, classification • Usage of waters and sources of water pollution • Water monitoring • Legal framework for water protection - national and international conventions (EU Water Directive) • Aquatic ecosystem management • Water revitalisation methods • Trends in changes in aquatic ecosystems and climate change Seminars: • Water protection in strategic documents for nature and environmental protection in the Republic of Croatia (National Environment Protection Strategy and National Environment Protection Action Plan, Water Management Strategy, Nature Protection Act, Laws and regulations on waters) • Revitalisation of lakes - examples of implementation • Revitalisation of wetland ecosystems - examples • Current state of selected aquatic ecosystems in the Republic of Croatia (endangerment, protection and revitalisation projects) • Ecological network NATURA 2000 - aquatic ecosystems		
Recommended reading	Wetzel R.G. (2001) Limnology - Lake and River Ecosystems. 3rd ed. Academic Press, San Diego.		
Optional reading	Jørgensen S.E., Vollenweider R.A. (ed.) (1989) Guidelines of Lake Management: Vol. 1, Principles of Lake Management. International Lake Environment Committee Foundation. Shiga		
Conditions for obtaining teacher's signature	Attendance at lectures and seminars by obtaining minimum 25 points, and achieving of at least 40% of the total number of points at the preliminary exam.		
Exam passing procedure	During the course, the teacher monitors and evaluates the work of each student, which makes up to 25% of the final grade. Preliminary exam or final written exam contribute with 25% to the final grade, while oral exam makes up to 45% of the final grade.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Periodic evaluation of students and teachers is planned to be carried out in order to assure and continuously improve the quality of teaching and of the study programme. During the last week of lectures, an anonymous student survey will be carried out to evaluate the overall quality of the course. The analysis of students' success at exams will be carried out.		

Course title	**Biochemical Basis of Drug Action**
Code	BMZ99
Study programme	Graduate University Study Programme in Biology
Semester	IV semester
Workload/ECTS credits	2
Course status	Elective
Course teacher	Assoc. Prof. Dr. Valentina Pavić
Associate teachers	
Course entry requirements (Preceding courses)	
Course objective	To explain to students a biochemical basis of drug action mechanism. To explain the connection of specific biochemical interactions of some drugs with the molecular cell systems and to elaborate their mechanisms of action.
Learning outcomes	1. Ability to understand the meaning of drugs and to distinguish between actions and effects of drugs. 2. Knowledge about classification of drug actions. 3. Ability to formulate drug interactions with receptors or enzymes, ability to distinguish between antagonists and activators. 4. Ability to rank drug interactions. 5. Ability to define the relationship between drug structure and activity. 6. Ability to critically assess the potentially harmful consequences of excessive and unjustified use of drugs. 7. Knowledge about occurrence of resistance to antimicrobial drugs.

Link between learning outcomes, teaching and students' activities

Learning outcome	Share of ECTS	Form of teaching	Activities of learning and teaching	Assessment		
				Methods of monitoring and evaluation	Grading Points	
					min	max
1-7	0.5	Lecture	Critical conversation and discussion	Records related to active participation in conversations and discussions	10	20
1-7	1	Seminar	Interpretation of scientific papers and application of obtained results at concepts learned within lectures	Monitoring of students' performance at interpretations and tasks	40	60
1-7	0.5	Oral exam	Preparation for oral exam	Oral exam	10	20
Total	**2**				**60**	**100**

Final grade:
60-70 points: grade 2 (sufficient)
71-80 points: grade 3 (good)
81-90 points: grade 4 (very good)
91-100 points: grade 5 (excellent)

Consultation hours	By appointment.		
Teaching	**Lectures**	**Seminars**	**Practices**
Hours - total	15	15	0
Course content / teaching units	Lecture: • Relations between structure and activity of drugs • Pharmacodynamics of action, absorption, distribution, metabolism and elimination of drugs • Phases of biotransformation • Cellular action of drugs • Mechanisms of drug action • Mechanisms of drug passage through the membrane Seminars: • Biochemical mechanisms of resistance to antibiotics • Drug interaction with ion channels • Drug interactions with enzymes • Disruption of cell membrane function by drugs • Adrenergic and antiadrenergic drugs • Parasympathomimetics • Mechanisms of action of anti-inflammatory drugs • Mechanisms of action of antifungal drugs • Mechanisms of action of antibiotic drugs		
Recommended reading	Franklin T. (2012) Biochemistry and Molecular Biology of Antimicrobial Drug Action, 6th ed. Springer, New York, USA.		
Optional reading	Berg J.M., Tymoczko J.L., Stryer L. (2006) Biochemistry, 6th ed. Freeman & Comp., New York. Gareth T. (2011) Medicinal Chemistry: An introduction, 2nd ed. John Wiley & Sons, New York, USA.		
Conditions for obtaining teacher's signature	Students are obliged to participate in lectures actively and to fulfil all assignments within the course.		
Exam passing procedure	Prior to taking oral exam, students are obliged to prepare and present the seminar paper. The final grade consists of points achieved at oral exam and of points obtained during the course.		
Main language of instruction; other languages	Croatian language		
Method of monitoring the quality and efficiency of teaching	Survey on the subjective impression about the organisation of the course will be carried out after the course; during the course, students will be given an opportunity to make oral or written remarks; the teacher monitors students' success at exams.		