Name of the subject: BIOCHEMICAL AND MOLECULAR SYSTEMATICS OF PLANTS

Teacher(s): Dr. Goran Anačkov, Dr. Jelena Aleksić, Dr. Biljana Božin

Status of the subject: elective

Number of ECTS points: 15

Condition: none

Goal of the subject

Introduction to the methodology and latest developments in biochemical and molecular systematics of plants. Acquiring knowledge of biochemical and molecular characters that can be used in biochemical and molecular systematics of plants. Understanding the basic principles of molecular phylogeny and evolution of selected taxa as well as higher plants in general.

Outcome of the subject

Training taxonomists to use modern molecular methods in research, their synthesis, interpretation and comparison with other methods.

Content of the subject

Theoretical lectures

Historical development of molecular and biochemical phylogeny, as well as plant systematics. Proteins (isoenzymes, allozymes, taxonomic significance). Nucleic acids (RNA, DNA), taxonomic and phylogenetic significance at different levels. Plant genomes and their usage in taxonomy, systematics and phylogeny. An overview of the methods used in phylogenetic analyzes. Concepts of speciation and classification, origin and variability of plant species. Barcoding at plants. Primary and secondary plant biomolecules, taxonomic and phylogenetic significance at different levels of classification. Terpenes, essential oils, phenolic compounds (simple phenolics, flavonoids, anthocyanins and other.), alkanes, fatty acids and alkaloids as markers for chemotaxonomic classification and detection of hybridization. Concordance and discordance of evolutionary relationships determined by the application of morphological, biochemical and molecular characters, perspectives on biochemical and molecular systematics, phylogenomics.

Practical lectures

Seminar work includes theoretical preparation for work in the laboratory for biochemical and molecular systematics of plants. Plant cell and DNA isolation. Selection of molecular markers for research at different taxonomic levels. Polymerase chain reaction. Separation of PCR products by electrophoresis. Chemical characterization using various analytical techniques (UV-VIS spectrophotometry, HPLC, GC-MS), selection of markers significant for chemotaxonomy and the ability to separate similar taxa.

Recommended literature

1. Page, R.D.M., Holmes, E.C. (1998). Molecular Evolution – A Phylogenetic Approach. Blackwell Science Ltd., Oxford.
2. Bremer, B., Bremer, K., Thulin, M. (2000). Introduction to Phylogeny and Systematics of Flowering Plants. Dept. of Syst. Bot. Evolutionary Biology Centre, Uppsala University;
3. Singh, D. (2004) Plant Systematics: An Integrated Approach. Science Publishers.
4. Felsenstein, J. (2004) Inferring phylogenies. Sinauer Associates;
5. Wiley, E. O., & Lieberman, B. S. (2011). Phylogenetics: theory and practice of phylogenetic systematics. John Wiley & Sons;
6. DeSalle, P., Rosenfeld, J. (2012) Phylogenomics. Taylor & Francis Group;
7. Hamilton, A. (2013). The evolution of phylogenetic systematics (Vol. 5). University of California Press.
8. Harborne, J.B., Turner, B.L. (1984): Plant Chemosystematics. Academic Press, London-Orlando-San Diego-San Francisco-New York.
9. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F., Donoghue, M.J. (2002): Plant Systematics: A Phylogenetic Approach. Sinauer Associates, USA.
10. Marin, P. (2003): Biohemijska i molekularna sistematika biljaka. NNK International, Beograd. Soltis.
Doctoral dissertations and masters theses in the field of molecular systematics of plants recommended by mentors, as well as scientific papers and websites with current issues in taxonomy and plant systematics.

Number of active classes	Theory:5	Practice: 5

Methods of delivering lectures

Lectures, individual consultations, lab work, seminar papers.

Evaluation of knowledge (maximum number of points 100)

Seminar paper 1 25 points
Seminar paper 2 25 points
Oral exam 50 points

Name of the subject: MODERN CHROMATOGRAPHIC METHODS IN BIOLOGY

Teacher(s): Dr. Danijela Kojić, Dr. Boris Pejin

Status of the subject: Elective Course

Number of ECTS points: 15

Condition: There are no requirements.

Goal of the subject

This course aims to deliver both theoretical and practical knowledge on modern chromatographic methods of importance for biology and related sciences. Students will be introduced to original scientific literature and trained to successfully address research issues (problems) relevant for their Ph. D topics.

Outcome of the subject

ln-depth knowledge of the theoretical principles of chromatographic methods will make students capable to choose, optimise and implement suitable high-efficient chromatographic methods on the real sample of choice. In addition to this, students will master the using of both scientific and technical literature.

Content of the subject

Theoretical lectures

Intoduction into chromatography. Place and role of modern chromatographic methods. Definitions and classifications of chromatographic separation methods. Chromatographic theories – basic principles. Modern theories. Physical forces and interactions. Optimisation of chromatographic separation. Adsorption chromatography. High-performance liquid chromatography. High-performance ion chromatography. Other modern chromatographic methods. Selection of methods. Quantitative chromatographic analysis. Combined chromatographic techniques. Colloquia. Theoretical classes. Lectures related to specific student research problems.

Practical lectures

Practical classes

Recommended literature

- Gordana Milovanović, Ph. D, *Chromatographic Separation Methods*, University of Belgrade, 1985.
- Veronika R. Mayer, *Practical High-Performance Liquid Chromatography*, John Wiley, 2000.
- James M. Miller, *Chromatography – Concepts and Contrasts*, John Wiley, 2005.
- Hans-Joachim Hübschmann, *Handbook of GC-MS: Fundamentals and Applications*, John Wiley, 2015

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, Interactive teaching, Student consultations (Tutorial), Colloquia,
Theoretical and experimental classes, Term paper

Evaluation of knowledge (maximum number of points 100)

Colloquia – 10 points, Term Paper – 10 points, Written Exam – 30 points, Oral Exam – 50 points

Name of the subject: BIOCHEMISTRY AND MOLECULAR BIOLOGY OF INSECTS

Teacher(s): Dr. Željko D. Popović, Dr. Elvira Vukašinović

Status of the subject: elective

Number of ECTS points: 15

Condition: Biochemistry, Molecular Biology, Animal Physiology

Goal of the subject

The aim of this course is to provide students with information about biochemical and molecular processes in insects (in general), as well as in specific insect species that are well-known model organisms.

Outcome of the subject

After the course students should be familiar with different biochemical and molecular processes in insects, as well as to understand how these processes reflect on insect biology and ecology.

Content of the subject

Theoretical lectures

(1) Short introduction – hallmarks of insect morphology, systematics and ecology. (2) Biochemical and molecular aspects of active development. (3) Structure of insect genomes. (4) Biochemical aspects of integument composition and means of transportation. Water metabolism. (5) Diet, digestion and intermediary metabolism. Biochemistry of muscles and flight. (6) Immune response in insects. (7) Pheromones and hormones in reproduction. Biochemical basis of communication of social insects. (8) Biochemical and molecular aspects of insect dormancy. (9) Biochemical aspects of insect response to stress. (10) Application of genetic engineering and „-omics" technologies in entomology.

Practical lectures

Students will be obliged to prepare a seminar paper using scientific articles that are either related to the topics of the course and/or, if possible, related to the topic of their PhD thesis research.

Recommended literature

(1) Lawrence I. Gilbert (2012) Insect Molecular Biology and Biochemistry. Academic Press.
(2) Nation, J.L. (2008) Insect Physiology and Biochemistry. 2nd edition. CRC Press.
(3) Hochachka P.W & Somero, G. N. (2002) Biochemical Adaptation. Mechanism and Process in Physiological Evolution. Oxford University Press. Oxford. UK.
(4) Hadley, N.F. (1994) Water relations of Terrestrial Arthropods. Academic Press. London. UK.
(5) Leather, S.R., Walters, K.F.A., Bale, J.S. (1993) The Ecology of Insect Overwintering. Cambridge University Press, Cambridge, UK.
(6) Harborn, J.B. (1982) Introduction to Ecological Biochemistry. 2nd edition. Academic Press. London. UK.

Number of active classes	Theory: 5	Practice:5

Methods of delivering lectures

Oral lectures, consultations and seminar presentations.

Evaluation of knowledge (maximum number of points 100)

Seminar paper: 70

Oral exam: 30

Name of the subject: INTEGRATIVE PHYSIOLOGY

Teacher: Dr. Tatjana Čelić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

Gaining knowledge of the processes that take place in all living organisms, including the regulation of these processes at the molecular and cellular levels, at the level of tissues, organs and the whole organism, as well as their interaction and integration.

Outcome of the subject

After successfully completing the course, students will be able to understand and describe how the basic functions of the organism are regulated at several levels of the organization, as well as to acquire the ability to analyze scientific papers and experimental results.

Content of the subject

Theoretical lectures

Introduction to Integrative Physiology. Basic cellular processes: integration and coordination. Homeostasis and control. Integration of Organic System Function. Liquid and electrolyte balance. Metabolism and energy balance. Reproduction and development. Endocrine control of growth and metabolism.

Students research work

Students will have the opportunity to plan, create and run an experiment, as well as learn ways to analyze and present results, related to the topic of a student's doctoral dissertation.

Seminars. Short presentation of the given topic in the field of physiology, with emphasis on integrative approach.

Journal Club. Presentation of original scientific paper from the field of integrative physiology.

Recommended literature

Silverthorn, D.U. Human Physiology: An Integrated Approach. (2015) Pearson Education Inc.

Walz, W. Integrative physiology in the proteomics and post-genomics age. (2005) Humana Press Inc. Totowa, New Jersey.

Scientific and review papers from the field.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, consultations, students research work, seminar, *Journal Club*.

Evaluation of knowledge (maximum number of points 100)

Students research work - up to 30 points; *Seminar* - up to 10 points; *Journal Club* – up to 10 points; *Final exam (oral exam)* – up to 50 points

Name of the subject: REPRODUCTIVE TOXICOLOGY		
Teacher(s): Dr. Nebojša Andrić, Dr. Kristina Pogrmić Majkić		
Status of the subject: Elective		
Number of ECTS points: 15		
Condition: -		
Goal of the subject The course provides knowledge about the impact of chemicals from the environment (with emphasis on the chemicals with endocrine disruptors potential) on the reproductive function.		
Outcome of the subject After completion of the course, it is expected that the students will be able to: 1. Explain the effects of chemicals on female and male reproductive systems 2. Explain the molecular mechanisms of chemicals action 3. Explain the effects of chemicals on hypothalamic-pituitary and immune systems 4. Apply methods to investigate the toxic effects of chemicals on reproduction 5. Independently select scientific literature and prepare a seminar on a specific subject		
Content of the subject *Theoretical lectures* Environmental chemicals as endocrine disruptors. Molecular mechanism of chemicals actions. Developmental toxiclogy. Adult exposure and impacts on male reproductive health and fertility. Adult exposure and impacts on female reproductive health and fertility. Chemicals and puberty. Chemicals and preganancy. Chemicals and related systems that have implication for reproduction: neuroendocrine and immune systems. Chemicals and cancer of reproductive system. Toxicological testing: animal experimetns and alterantive models. *Practical lectures* Experimental models: primary culture of immature and preovulatory granulosa cells; analysis of signlaning pathways and functions of granulosa cells after chemicals exposure in different experimental conditions; analysis of the results and preparation of manuscripts		
Recommended literature Woodruff, TJ, Janssen SJ, Guillette Jr LJ, Guidice LC. Environmental Impacts on Reproduction Health and Fertility, Cambrigde University Press, 2010 Fudvoye et al. Endocrine disrupters. Vitamins and Hormones, Volume 94, Elsevier 2013 Review papers in the filed		
Number of active classes	Theory: 5	Practice: 5
Methods of delivering lectures Lectures, experimental work, presentation of the articles from the filed of the reproductive toxicology		
Evaluation of knowledge (maximum number of points 100) Oral exam 30 Seminars 70		

Course Title: ADVANCED PLANT GENETICS		
Professor: Dr. Nataša Kočiš Tubić		
Required/Elective Course: elective		
Number of ECTS: 15		
Prerequisites: Previous consultation with a professor that will define form of engagement and course tasks depending on previous courses and current acquirements of a student.		
Course Objective: The course objective is to adopt knowledge on organisation of the nuclear and non-nuclear plant genome; methods and strategies of different molecular markers analyses (nuclear and chloroplast markers); how does information of genetic diversity and genetic structure contribute to understanding the causes, mechanisms and consequences of plant invasions; marker-assisted selection (MAS) in breeding of economic important plants		
Course Outcome: After successfully realized the pre-exam and exam commitments student is able to: (i) explain role and importance of genetic polymorphism in natural plant populations; (ii) observe special characteristics of different molecular markers, distinguish their advantages and disadvantages depending on type of genetic analysis; (iii) define the importance of population genetics research in understanding the expansion of invasive plant species; (iv) explain role and importance of molecular markers and genetic mapping in plant breeding		
Course Content: *Theory* Organisation of the plant genome. Role and importance of genetic polymorphism. Characteristics and application of diffrent molecular markers, nuclear and chloroplast, in assessment of genetic diversity, plant species identification, genetic delimitation of biological species, and in phylogenetic analyses. Plant DNA barcoding: choosing and using. DNA barcoding: from gene to genome, NGS technology and super-barcoding. Genetics of plant invasion: genetic diversity and genetic structure in invasive plant populations; genetic mehanisms underlying the expansion of invasive plant species; importance of using genetic analyses in invasive plant management and reconstruction of invasion histories. Linkage maps, QTL (quantitative traits loci) analysis, MAS- marker-assisted selection. *Practice* The structure of practical work is in accordance with candidat's field of research and the subject of PhD thesis.		
Reccomended literature: New literature and papers published in leading international scientific journals.		
Total hours:	Lectures: 5	Student research work: 5
Methods of instruction: lectures, student research work, consultations		
Assessment (maximum number of points 100)		
Requirements Seminar: 40 points; Oral exam: 60 points		

Name of the subject: GENOMIC METHODS IN GENETIC ANALYSES

Teacher(s): Dr. Mihajla Djan, Dr. Nevena Veličković

Status of the subject: Elective

Number of ECTS points: 15

Condition:

Goal of the subject

The aim of this course is to introduce students to the novel technologies for studying the function and structure of genomes, as well as to present methods for interpreation and analysis of genomics data.

Outcome of the subject

After successfully realized pre-exam and exam obligations student can:
- describe and understand the current next-generation genomics technologies
- acquire and use computational skills and statistical methods for handling and analyzing of genomics data
- plan, design and carry out a next-generation experiment to address a particular biological question

Content of the subject

Theoretical lectures

Genome structure and organization. Historical overview of next generation sequencing technologies. Library preparation and comparative analysis of next generation sequencing technologies. RAD-Seq, RRLS, GBS, CroPS. Microarrays and transcriptomics. RNA-Seq. Gene expression and regulatory networks. Statistical analysis of genomic data. Comparative genomics. Metagenomics. Genomics databases. Genomic data manipulation. Galaxy server. Genome assembly – de novo sequence assemblers. Gene expression analysis (DeSeq2). Regulatory networks (Cytoscape).

Practical lectures

Discussions, interpretation and critical evaluation of the latest scientific information in the field of genomic methods in genetic analysis. Application and usage of bioinformatics tools and databases for genomic data analysis.

Recommended literature

1. Arthur M. Lesk. 2017. Introduction to genomics. Oxford University Press.
2. Jonathan Pevsner. 2015. Bioinformatics and functional genomics. John Wiley & Sons.
3. Relevant review scientific papers

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, computer-based practical work, tuitions, Journal Club - students present and discuss the top articles in genomics, seminars

Evaluation of knowledge (maximum number of points 100)

Student projects – 40; Oral exam – 60

Name of the subject: DEVELOPMENTAL ORIGINS OF HEALTH AND DISEASE AND EPIGENETICS

Teacher(s): Dr. Svetlana Fa

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The goal of the subject is to introduce the students to the concept of Developmental Origins of Health and Disease – DOHaD and the role of epigenetics, in order to learn how unfavorable conditions during early development reprogram embryo/fetus therefore predisposing it to later in life diseases

Outcome of the subject

After successful completion of the subject students are able to:

- explain the concept of Developmental Origins of Health and Disease
- explain potential epigenetics mechanisms involved in the early programming of the disease and what epigenetic reprogramming represents
- describe the role of the nutrition, stress and environmental chemical exposure during early development in creating risk for development of later in life diseases
- make connection between early programming of embryo/fetus and transgenerational health consequences
- make connection between early programming of embryo/fetus and impaired reproductive health
- describe developmental stages in zebrafish embryogenesis
- design and perform experiments for testing the effects of different exposures during embryogenesis on epigenetic profile and development of disease later in life.

Content of the subject

Theoretical lectures

The concept of Developmental Origins of Health and Disease. Periconceptional period, a critical window in time and DOHaD. Introduction to epigenetic mechanisms: the probable mechanisms in DOHaD. Effects of environmental chemical exposure, stress and nutrition of the parents on early offspring development and DOHaD, the role of epigenetics. Placenta and the linkage between *in utero* environmental changes and preterm birth, newborn weight and the development of later in life diseases. How the father might epigenetically program its offspring for the risk of developing later in life diseases. Transgenerational epigenetic inheritance of diseases. Sexual dimorphism and the influence of environment, genetics and ancestors on developing diseases. Developmental and epigenetic origins of male reproductive pathologies. Developmental origins of female fertility impairment, the effects of endocrine-disrupting chemicals

Practical lectures

Performing experiments of zebrafish embryo exposure to environmental chemicals and raising zebrafish after the treatment; Learning to recognize the stages of zebrafish embryonic development; Learning methods for DNA methylation analysis, MSRE-qPCR (*Methylation Sensitive Restriction Enzyme* qPCR); Gene expression and DNA methylation analysis of target genes after the treatment in early stage and later in adulthood. Writing a seminar paper

Recommended literature

Rosenfeld, C.S. (Ed.), 2016. The Epigenome and Developmental Origins of Health and Disease. Academic Press, Elsevier Inc.

Gluckman, P.D., Hanson, M.A. (Eds.), 2006. Developmental Origins and Health and Disease. Cambridge University Press, New York.

Research articles on the subject

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, Consultations , Seminars

Evaluation of knowledge (maximum number of points 100)

Oral exams 30

Seminars 70

Name of the subject: MITOCHONDRIAL DYNAMICS

Teacher(s): Dr. Silvana Andrić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

Goal of this course is to acquire knowledge about the molecular mechanisms and signaling pathways and their interactions in the regulation and synchronization of mitochondrial biogenesis. Students should gain the ability in scientifically based interpretation of the experimental data from the field of regulation of mitochondrial biogenesis.

Outcome of the subject

At the end of this course students will be able to understand and describe the general features of the mitochondrial biogenesis, intracellular signaling properties and methods of network detection, transduction, transmission, propagation and amplification of information in order to achieve adequate control of mitochondrial biogenesis, as well as to acquire the capacity for analysis and discussion scientific papers in the field.

Content of the subject

Theoretical lectures

Functional morphology of mitochondria and overview of processes that maintain homeostasis of the mitochondria. Basic characteristics of mitochondrial biogenesis. Mitochondrial genome. Regulatory proteins involved in transcription of mitochondrial genes. Transcriptional regulators of mitochondrial proteins encoded by nuclear genes: the key role of NRF1 and NRF2. The key role of transcription in the regulatory cascade coactivator of mitochondrial biogenesis: PPAR coactivator1 (PGC1) family. Signaling pathways that activate PGC1. Network of signaling pathways and regulatory proteins on the relation mitochondria-nucleus. Molecular events that regulate mitochondrial biogenesis in extreme conditions (physical and psychological stress, cold, starvation, excessive physical exertion, illness). Regulation of mitochondrial biogenesis in the metabolic syndrome and aging.

Practical lectures

Each student will have an individual project assignment in the research related to the molecular events that regulate mitochondrial biogenesis. The degree of mitochondrial biogenesis will be determined by monitoring the number of mitochondria (MitoTrack assay), transcription analysis and analysis of expression and interaction of regulatory proteins. The various *in vivo* experimental models that mimic situation in human populations will be used.

Seminars. Short presentation of the specified topics connected with the subject of student's PhD thesis.

Journal Club. Presentation of the original peer-review scientific paper from the field.

Recommended literature

Miller BF & Hamilton KL (2012) *A perspective on the determination of mitochondrial biogenesis.* Am J Physiol Endo Met 302: E496–99.

Piantadosi CA & Suliman HB (2012) *Redox regulation of mitochondrial biogenesis.* *www.sciencedirect.com/science/article/pii/S0891584912011392*

O'Neill HM, Holloway GP & Steinberg GR (2012) *AMPK regulation of fatty acid metabolism and mitochondrial biogenesis: Implications for obesity*. Mol Cell Endo *www.sciencedirect.com/science/article/pii/S0303720712003334*

Herrmann JM, Longen S, Weckbecker D & Depuydt M (2012) Biogenesis of Mitochondrial Proteins *www.springerlink.com/content/n1l0202h5043k532/*

Medeiros DM (2008) Assessing Mitochondrial Biogenesis *http://krex.k-state.edu/dspace/bitstream/handle/2097/1042/MedeirosMethods2008.pdf;jsessionid=60C921DE4C5258682936D254CF5C15C3?sequence=5*

Leuenberger D, Curran SP & Koehler CM (2005) *Mitochondrial Biogenesis* in The Biogenesis of Cellular Organelles. Springer

Koehler CM & Bauer MF. (2004) *Mitochondrial Function and Biogenesis Series* in Topics in Current Genetics Vol.8. Springer

Review peer-review scientific paper from the field of mol. events & signaling path. in regulation of mitochondrial biogenesis.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical lectures – interactive lectures, consultation, and group discusion. *Student research work* – active participation in the planing and conducting the experiments, as well as analysis, interpretation and discussion of the results. *Seminar* – short presentation (10 – 15 minutes) connected with the subject of student's PhD thesis. *Journal Club* – Presentation of the original peer-review scientific paper from the field.

Evaluation of knowledge (maximum number of points 100)

Student research work – up to 30 points; Seminar – up to 10 points; Journal club – up to 10 points; Oral exam – up to 50 points.

Course Title: PHYSIOLOGY OF ADAPTATIONS OF ANIMALS TO CHEMICAL STRESS

Professor: Dr. Sonja Kaišarević

Required/Elective Course: elective

Number of ECTS: 15

Prerequisites: -

Course Objective: Gaining knowledge on general principles of molecular, cellular and physiological mechanisms animals developed to overcome the challenge of exposure to chemical stress.

Course Outcome: After completing the course, student will adopt general principles related to physiological aspects of adaptations of animals to chemical stress, understand current scientific literature and competently take part in discussions related to topics covered by this course.

Course Content:

Lectures

Classes of toxic compounds, their distribution and release into environment. Chemical stress. Absorbtion, distribution, metabolism, and elimination of toxic compounds. Membrane transporters. Receptors and signaling pathways. Molecular mechanisms, regulation, and physiological role of biotransformation and cellular mechanisms for detoxification as adaptative mechanisms. Role of the system of antioxidant defence. Changes in cellular and physiological functions in organisms exposed to chemical stress - changes in energy demands, respiratory, reproductive, excretory, immune, nervous, endocrine system. Adaptive homeostasis. Examples of invertebrate and vertebrate species adapted to life in polluted environment – case studies and specific adaptations.

Student research work

Experimental work: students will conduct selected analyses on cell cultures and/or tissues from animals exposed to chemical stress – planning, creating and conducting experiments, analyses and presentation of the results.

Presentation and critical analyses of current scientific papers related to topics covered by the theoretical part of the course.

Reccomended literature:

Presentations from lectures, texts and experimental protocols provided by the lecturer.

Review and scientific papers related to topics covered by the course.

Total hours:	Lectures: 5	Student research work: 5

Methods of instruction:

Interactive presentations, consultations, group discussions, experimental laboratory work, analysis and presentation of the results.

Assessment (maximum number of points 100)

Requirements

Pre-exam obligations (student research work) – up to 50 points; Final exam (oral exam) – up to 50 points

Name of the subject: MOLECULAR ECOTOXICOLOGY

Teacher(s): Dr. Ivana Teodorović, Dr. Aleksandar Pavić

Status of the subject: elective

Number of ECTS points: 15

Condition: Chemistry / Environmental chemistry, Biochemistry, Physiology

Goal of the subject

Understanding the potential and possibilities for application of contemporary knowledge, techniques and methods used in molecular biology into ecotoxicology and environmental sciences.

Outcome of the subject

Successful students will get the overview of contemporary approaches and trends in ecotoxicology and ecotoxicogenomics and understand the possibilities for application of fundamental knowledge as well as techniques and methods typically used in molecular biology into ecotoxicology and studies of adverse effects of chemicals on human and environmental health. They will gain an in-depth knowledge on mode of action (MoA) of most relevant xenobiotics and the propagation of adverse effects from molecular initiating event to adverse outcome at the higher level of biological organisation (AOP - Adverse Outcome Pathway framework). Successful students would be capable of integrating MoA and AOP concepts in ecotoxicological studies as well as applied research - prospective and retrospective environmental risk assessment of chemicals (ERA), to process and interpret their own and literature data and results in accordance with contemporary ecotoxicological principles and regulatory demands.

Content of the subject

Theoretical lectures: Molecular ecotoxicology - frameworks, concepts and theories. Ecotoxicologically relevant pollutants and their classification according to adverse biological effects and mode of action (MoA) at target molecular sites. Molecular and genetic similarities and species specific differences in responses to toxic stress. MoA and QSAR based predictive methods / models for assessing biological effect of new / emerging contaminants, their metabolites, transformation products and mixtures. Adverse outcome pathways (AOP) framework. Propagation of adverse biological effects from molecular initiating event, via key events and key biological relations to adverse outcome at individual (disease, death) and population level (behaviour, impaired reproduction, population decline). Integration of AOP and MoA concepts in contemporary ecotoxicology and risk assessment (ERA) of chemicals. Ecotoxicogenomics - theories, basic concepts and application of gene expression, trascriptomics, proteomics and metabolomics into fundamental and applied environmental research. Basic information on bioinformatics and its role in molecular ecotoxicology. Current practice, success stories and future perspectives for application of molecular ecotoxicology in chemical risk assessment and environmental studies.

Practical lectures: Selected biotechnological platforms for assessing biological effects of toxicologically and ecotoxicologically relevant xenobiotics and their mixtures. Gene expression in laboratory and field / real life type of studies. Introduction to and exercises with open platforms and databases: EPA ECOSAR, EPA MoATox Database, OECD AOP Knowledge Base, AOP Wiki

Recommended literature

Scientific reviews and research papers published in relevant international journals (available via KOBSON). Open platforms and databases: EPA ECOSAR, EPA MoATox Database, OECD AOP Knowledge Base, AOP Wiki

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures/consultations, discussion groups. independent literature research, independent / supervised laboratory research

Evaluation of knowledge (maximum number of points 100)

Topical mini-review 50 points, oral exam 50 points

Name of the subject: CHRONOBIOLOGY

Teacher(s): Dr. Tatjana Kostić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject:
Objective of this course is to acquire knowledge about the basic concepts of chronobiology and molecular mechanisms underlying the regulation of biological rhythms associated with reproduction. The course is focused on the study of circadian and seasonal rhythms of gene expression of endogenous biological clock and its role in the regulation and synchronization of the functions of male and female gonads of mammals.

Outcome of the subject
At the end of this course students will be able to understand and describe the basic mechanisms of the molecular clock in neuroendocrine, endocrine and reproductive system, to understand the role of the central and peripheral clock in the reproductive system and the basic mechanisms of synchronization of reproduction. Using the analysis of examples from clinical practice and studies in laboratory animals, students should develop the ability of critical thinking and discussion of scientific papers in the field of chronobiology.

Content of the subject
Theoretical lectures
Overview of the basic principles of chronobiology and types of biological rhythms (circadian and seasonal). The function of the molecular clock based on the auto-regulative principle of negative feedback at the level of transcription / translation of the clock genes. The central regulator of rhythm and synchronization with the peripheral clock. Biological rhythm of the hypothalamic-pituitary-gonadal axis. Effects of the biological clock on the biosynthesis of steroid hormones in female and male. Time synchronization at the level of gametogenesis and in maintenance of homeostasis of the reproductive function. Time orchestrated hierarchical neuroendocrine control of ovulation. Circadian clock and fertility: the role of ovarian clock. Circadian clock and fertility: the role testicular clock. The role of the biological clock in reproductive disorders of men and women (work in shifts and "jet-lag").

Practical lectures
Each student will have an individual project assignment in the research related to the biological clock in the Leydig-cells. Timelines of the experiments: 6, 9, 11, 14, 17, 20, 23, 02, +24 hours. Experimental animals: peripubertal, adult and old laboratory rats. In addition, the experimental model of hypogonadal-hypogonadism as a model of disturbed homeostasis of the reproductive system will be used.

Seminars. Short presentation of the specified topics connected with the subject of student's PhD thesis.

Journal Club. Presentation of the original peer-review scientific paper from the field of of chronobiology.

Recommended literature
Dunlap JC, Loros JJ & DeCoursey PJ (2009) *Chronobiology: Biological Timekeeping*. Sinauer Associate Inc.
Foster R & Kreitzman L (2011) *The Rhythms Of Life: The Biological Clocks That Control the Daily Lives of Every Living Thing*. [Kindle Edition] Sinauer Associate Inc.
Chedrese PJ (2009) *Reproductive Endocrinology: A Molecular approach* (www.mediafire.com/?9366lbl86xuga2c)
Review peer-review scientific paper from the field of chronobiology.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures
Theoretical part – Lectures/Consultative discussions. *Students research work* – participation in the planning and execution of the experiments and the analysis, interpretation and discussion of the experimental results from the field of chronobiology. *Seminars* - Short presentation of the specified topics connected with the subject of student's PhD thesis. *Journal Club.* Presentation of the original peer-review scientific paper from the field of chronobiology.

Evaluation of knowledge (maximum number of points 100)
Seminar(s) – up to 5 points ; Presentation of the original scientific paper (Journal club) - up to 20 points; Scientific project problem – up to 30 points ; Oral exam – up to 45 points.

Name of the subject: MOLECULAR AND CELLULAR BASES OF CARDIOVASCULAR DISEASES

Teacher(s): Dr. Bojana Stanić

Status of the subject: Elective

Number of ECTS points: 15

Condition: None

Goal of the subject

Introduction to the molecular and cellular mechanisms involved in the development and progression of cardiovascular diseases, with a special emphasis on the effect of drugs and other environmental chemicals. The students will be provided with up-to-date information by exploring the topics related to etiology, molecular pathology and molecular therapeutic approaches in the treatment of cardiovascular diseases.

Outcome of the subject

After successful completion of the course, the students should be able to understand, explain and follow contemporary molecular concepts and trends related to cardiovascular diseases and understand the effect of drugs and various environmental chemicals on the cardiovascular system. The students should also adopt the skills necessary for critical analysis of the literature data in an oral and written form and apply the acquired knowledge to design and execute their research projects related to molecular and cellular biology of cardiovascular diseases.

Content of the subject

Theoretical lectures

Basic principles of molecular and cellular biology of the cardiovascular system, animal models, coronary diseases, vascular biology, molecular mechanisms and signaling pathways in atherosclerosis, molecular diagnostics of cardiovascular diseases, molecular and cellular mechanisms of action of drugs and other environmental chemicals in the cardiovascular system, cardiovascular toxicology, contemporary therapeutic approaches.

Practical lectures

Experimental model: continual human endothelial cell line EA.hy926; monitoring of cell viability, nitrite production, cell adhesion to the extracellular matrix, cell migration, adhesion of human monocytes to endothelial cells, permeability of the confluent endothelial cell monolayer to monocytes and small molecules, as well as assessment of protein and mRNA expression, analysis of signaling pathways and function of endothelial cells following exposure to drugs and various environmental chemicals in different experimental conditions; preparation of the manuscript based on the obtained results.

Recommended literature

Cardiovascular Diseases: Genetic Susceptibility, Environmental Factors and their Interaction. Nikolaos Papageorgiou (ed.) Academic Press, 2016. 9780128033128

Cardiovascular Toxicology. Daniel Acosta (ed.) CRC Press, 2008. ISBN 9781420044737

Original and review articles pertaining to the topics of the subject

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures followed by video presentations, consultations, analysis of articles relevant in the field, laboratory work and analysis of the results, essays on the particular topic, oral presentation

Evaluation of knowledge (maximum number of points 100)

Interpretation of experimental data, participation in discussions, essays on the particular topic – max. 60 points. Oral exam – max. 40 points.

Name of the subject: NETWORKS OF SIGNALING PATHWAY IN REPRODUCTION

Teacher(s): Dr. Tatjana Kostić, Dr. Silvana Andrić,

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject:

Objective of this course is to acquire knowledge about networks of signaling pathways and their interactions in the regulation and synchronization of reproductive function. Students should gain the ability in scientifically based interpretation of experimental data in the field of signal transduction networks in reproduction.

Outcome of the subject:

At the end of this course students will be able to understand and describe the general features of the intracellular signaling pathways and methods of network detection, transduction, transmission, propagation and amplification of information in order to achieve adequate reproductive biological response, as well as to acquire the capacity for analysis and discussion of scientific papers in the field cell signaling in reproduction.

Content of the subject

Theoretical lectures

Overview of types of cellular communication and signal transduction pathways in reproduction. Network of signaling pathways activated by reproductive messengers. Signaling pathways and sexuality. Signaling pathways involved in sex determination. Network of signaling pathways that regulate the development of the ovaries and testes. Network of signaling pathways in the regulation of biosynthesis of female sex hormones and oogenesis. Network of signaling pathways in the regulation of biosynthesis of the male sex hormones and spermatogenesis. Signaling pathways activated during puberty and maturation of the hypothalamic-pituitary-gonadal axis. Network of signaling pathways that include estrogens, androgens and progesterone. Signaling in coitus and fertilization. Signaling pathways in implantation and placental formation. Signaling networks during pregnancy, preparing the fetus for birth, childbirth and lactation. Signaling pathways during reproductive aging and the menopause and andropause.

Practical lectures

Each student will have an individual project assignment in the research related to the signaling network in the theca/granulosa cells of females and Leydig cells of males. The different *in vivo* experimental models will be used: pubertal male and female laboratory rats; hypogonadal-hypogonadism; androgenization; superovulation; castration; *"knock-out"* mice (*Insr/Igf1r, Cyp11Cre* SKO/DKO) which are important for maintaining reproductive function.

Seminars. Short presentation of the specified topics connected with the subject of student's PhD thesis.

Journal Club. Presentation of the original peer-review scientific paper from the field.

Recommended literature

Bradshaw RA & Dennis EA (2004) *Handbook of Cell Signaling, three volume set 1-3.* Academic Press.

Chedrese PJ (2009) *Reproductive Endocrinology: A Molecular approach*. (www.mediafire.com/?9366lbl86xuga2c)

Hörner M & Weber W (2012) *Molecular switches in animal* cells. FEBS Letter 586: 2084-2096.

Pinilla L, Aguilar E, Dieguez C, Millar RP & Tena-Sempere M (2012) *Kisspeptins and reproduction: physiological roles and regulatory mechanisms.*Physiol Rev 92(3):1235-1316.

Payne A & Hardy M (2007) The Leydig Cell in Health & Disease.www.springerlink.com/content/p47h130171162546/

Jonson MH (2007) *Essential Reproduction*. Blackwell.

Review peer-review scientific paper from the field of networks of signaling pathways in reproduction.

Number of active classes	Theory: 5	Practice: 5 SRW

Methods of delivering lectures

Theoretical lectures – integrative lectures, consultations, group discussions. *Students research work* – participation in planning and conducting the experiment as well as data analysis, interpretation and discussion. *Seminar* - Short presentation (10 - 15 min) of the specified topics connected with the subject of student's PhD thesis. *Journal Club* - Presentation of the original peer-review scientific paper with the subject of student's PhD thesis.

Evaluation of knowledge (maximum number of points 100)

Students research work – up to 30 points; Seminar – up to 10 points; "*Journal Club*" – up to 10 points; Oral exam – up to 50 points.

Name of the subject: MOLECULAR REGULATION OF THE OVARIAN FUNCTION

Teacher(s): Dr. Nebojša Andrić, Dr. Kristina Pogrmić Majkić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

The course provides knowledge about molecular mechanisms in the regulation of mammalian ovarian function.

Outcome of the subject

After completion of the course, it is expected that the students will be able to:
1. Explain mechanisms in the control of folliculogenesis
2. Explain mechanisms in the control of granulosa cells function
3. Describe mechanisms in the control of ovulation
4. Explain mechanism in the control of corpus luteum function
5. Independently select scientific literature and prepare a seminar on a specific subject

Content of the subject

Theoretical lectures

Mechanisms that control early folliculogenesis. Ovarian cycle. Gonadotropins regulation of granulosa cells. Gonadotropins regulation of theca cells. Autocrine and paracrine regulation of the ovary. Molecular control of the ovulation. Prostaglandins. Oocyte: mejotic resumptio: The role of oocyte and its molecules in regulation of the ovarian function. Molecular control of corpus luteum.

Practical lectures

Experimental models: primary culture of immature and preovulatory granulosa cells; analysis of signlaning pathways activity after stimulation with gonadotropin hormones in different experimental conditions; analysis of the results and preparation of manuscripts

Recommended literature

Russell DL, Robker RL (2007) Molecular mechanisms of ovulation: co-ordination through the cumulus complex. Hum Reprod Update 13:289-312.

Richards, J. S. and Pangas, S. A. (2010) The ovary: basic biology and clinical implications, J Clin Invest 120(4): 963-72.

Richards, J. S. and Pangas, S. A. (2011) New insights into ovarian function, Handb Exp Pharmacol (198): 3-27.

Adhikari, D. and Liu, K. (2009) Molecular mechanisms underlying the activation of mammalian primordial follicles, *Endocrine reviews* 30(5): 438-64.

JoAnne s Richards and Mario Ascoli (2018) Endocrine, paracrine and autocrine Signaling pathways that regualte ovulation. Trends in Endocrinology&Metabolism, 313-325

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, experimental work, presentation of the articles from the filed of female reproductive endocrinology

Evaluation of knowledge (maximum number of points 100)

Oral exam 30
Seminars 70

Name of the subject: MOLECULAR MECHANISMS & SIGNALING PATHWAYS IN REGULATION OF TESTICULAR FUNCTIONS

Teacher(s): Dr. Silvana Andrić, Dr. Tatjana Kostić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject:

Objective of this course is to acquire knowledge about the molecular mechanisms and signaling pathways and their interactions in the regulation and synchronization of testicular function in mammals. Students should gain the ability in scientifically-based interpretation of the experimental data in the area of the signaling pathways that regulate testicular function.

Outcome of the subject

At the end of this course students will be able to understand and describe the general features of the intracellular signaling pathways and method of network detection, transduction, transmission, propagation and amplification of information in order to achieve adequate testicular function. Students will acquire the ability to analyze and discuss scientific papers in the field of signaling networks pathways that regulate testicular function.

Content of the subject

Theory

Functional anatomy of the testis and the regulation of exocrine function (spermatogenesis). Regulation of testicular endocrine function: production of male sex hormones (androgens). Signaling pathways involved in prenatal differentiation of testicular cells. Network of signaling pathways that regulate the differentiation of postnatal testicular cells. Molecular markers of different populations of Leydig cells. Network of signaling pathways that are active during puberty and maturation of the hypothalamic-pituitary-testicular axis. cAMP and cGMP signaling in the regulation of testicular steroidogenesis. MAPK/PRKC in regulation of testicular steroidogenesis. Signaling networks that include androgens. Signaling pathways of reproductive aging and andropause. The molecular mechanisms and signaling pathways that are activated in the testes, as an adaptation to a disturbed homeostasis of the organism.

Practice

Each student will have an individual project assignment in the research related to the molecular events that regulate testicular function. The various *in vivo* experimental models (pubertalni male laboratory rats; hypogonadism, castration of males and androgenization; knock-out "mice (*Insr/Igf1r, Cyp11Cre* SKO/DKO)) will be used.
Seminars. Short presentation of the specified topics connected with the subject of student's PhD thesis.
Journal Club. Presentation of the original peer-review scientific paper from the field.

Recommended literature

Payne A & Hardy M (2007) *The Leydig Cell in Health & Disease*. Springer
www.springerlink.com/content/978-1-59745-453-7#section=302000&page=1
A History of Leydig cells *www.springerlink.com/content/gq5l6158rw000558/*
Anatomy and History of Steroidogenesis *www.springerlink.com/content/w7r3878l707610r5/fulltext.pdf*
Fetal Leydig cells *www.springerlink.com/content/xh23582111648665/fulltext.pdf*
Regulation of Leydig Cells During Pubertal Development *www.springerlink.com/content/mr4r204555hx2u77/fulltext.pdf*
Skinner MK & Griswold MD (2007) *Sertoli Cell Biology.* Elsevier
Brehm R & Steger K (2005) *Sertoli Cell Diff* *www.springerlink.com/content/978-3-540-29446-7#section=550071&page=1*
Spermatogenesis *www.springerlink.com/content/w671675207626628/fulltext.pdf*
Sertoli Cells *www.springerlink.com/content/h58458108r654072/fulltext.pdf*
The Differentiation of Male Germ Cells *www.springerlink.com/content/u568558l0k8p7896/fulltext.pdf*
Alukal JP & Lamb DJ (2005) *The Sertoli cell: morphology, function, and regulation*. Cambridge University Press
www.ebooks.cambridge.org/chapter.jsf?bid=CBO9780511635656&cid=CBO9780511635656A012
Review peer-review scientific paper from the field of mol. mech. & sign. path. in regulation of testicular function.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical part – Lectures/Consultative discussions. *Students research work* – participation in the planning and execution of the experiments and the analysis, interpretation and discussion of the experimental results from the field of chronobiology.
Seminars - Short presentation of the specified topics connected with the subject of student's PhD thesis.
Journal Club. Presentation of the original peer-review scientific paper from the field of chronobiology.

Evaluation of knowledge (maximum number of points 100)

Seminar(s) – up to 5points ; Presentation of the original scientific paper (Journal club) - up to 20 points; Scientific project problem – up to 30 points ; Oral exam – up to 45 points.

Name of the subject: REPRODUCTIVE ENDOCRINOLOGY

Teacher(s): Dr. Tatjana Kostić, Dr. Silvana Andrić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

The aim of this course is to acquire knowledge about the complexity and interconnection of different mechanisms of endocrine control of reproductive function and scientifically based interpretation of experimental data in this field.

Outcome of the subject

After successfully completing the course the student should master the offered knowledge and acquire the ability to critically analyze scientific papers in this field, to acquire the basic knowledge and skills necessary for the realization of the project assignment.

Content of the subject

Theoretical lectures

Neuroendocrinology of reproduction. Testicular function of adult individuals, spermatogenesis. Endocrine testicular activity and steroidogenesis in Leydig cells. Testicular function control, endocrine, paracrine and autocrine control of Leydig cell function. Ovarian function, growth and maturation of the follicles. Endocrine function of the ovary. Menstrual cycle control. Estrus cycle in different mammalian species. Puberty and maturation of the hypothalamic-pituitary-gonadal axis. Fertilization, implantation and placental formation. Endocrinology of pregnancy. Childbirth, lactation, maternal behavior. Endocrinology of infertility in women and men. Menopause. Stress and reproduction.

Practical lectures

Students will choose a common project assignment - literature study, preparation of a work plan, experimental work, processing of results, writing a paper; project assignment will be from the subject area and will be chosen by students in consultation with the subject teachers.

Seminars. Brief presentation of the given topic in the field.

Journal Club. Presentation of the original peer-review scientific paper from the field.

Recommended literature

Group of authors: Reproductive Endocrinology, J.F.Straus and R.L.Barbieri (Eds), Elsevier Saunders, 2016.
Group of authors: Reproductive Endocrinology: A Molecular approach, Chedrese PJ (eds), Springer , 2015.
Review papers and original scientific papers from the field of reproductive endocrinology.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical lectures – integrative lectures, consultations, group discussions. *Students research work* – participation in planning and conducting the experiment as well as data analysis, interpretation and discussion. *Seminar* - Short presentation (10 - 15 min) of the specified topics connected with the subject of student's PhD thesis. *Journal Club* - Presentation of the original peer-review scientific paper with the subject of student's PhD thesis.

Evaluation of knowledge (maximum number of points 100)

Students research work – up to 30 points; Seminar – up to 10 points; "*Journal Club"* – up to 10 points; Oral exam – up to 50 points.

Name of the subject: GENETIC POLYMORPHISM IN ANIMAL POPULATIONS

Teacher(s): Dr. Mihajla Djan, Dr. Nevena Veličković

Status of the subject: Elective

Number of ECTS points: 15

Condition:

Goal of the subject

The course objective is to adopt knowledge on role and importance of genetic polymorphism in natural animal populations and to learn methods of detection of genetic variability in natural and captive animal populations. Student gets informed with methods and programs of genetic conservation of natural animal populations.

Outcome of the subject

After successfully realized pre-exam and exam obligations, student is able to:
- explain role and importance of genetic polymorphism in natural animal populations
- explain organisation and methodology for determination of genetic variability within population
- observe special characteristics of different molecular markers, distinguish their advantages and disadvantages depending on type of genetic analysis in population
- define importance of genetic diversity, considering methods and programs of genetic conservation of natural animal populations

Content of the subject

Theoretical lectures

Genetic polymorphism: term, role and importance. Genetic variability within and among populations. Comparative review of genetic markers for polymorphism detection in animal populations. Genetic polymorphism in continuous populations - problem of population number decrease - case report. Genetic polymorphism in continuous populations - expansion problem - case report. Genetic polymorphism in continuous populations - problem of population fragmentation - case report. The role of genetic polymorphisms in integrative taxonomy. NGS technologies in detecting the genetic polymorphism of animal populations. Review of sequenced animal genomes, Significance of genomic projects in modern biology. RAD-seq - application and capabilities. Application of genetic markers in the management of natural animal populations. Genetic variability of wildlife animals, detection and maintenance of variability in natural populations, genetic conservation methods and programs.

Practical lectures

Discussions, interpretation and critical evaluation of the latest scientific information in the field of genomic methods in genetic analysis. Application and usage of bioinformatics tools and databases for genetic and genomic data analyses.

Recommended literature

1. Avise JC, Molecular Markers, Natural History and Evolution, Sinauer Associates, 2nd Edition, 2004.
2. Hedrick PW. Genetics of Populations. Jones & Bartlett Pulishers, 3rd edition, 2004.
3. Relevant review scientific papers

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, computer-based practical work, tuitions, Journal Club - students present and discuss the top articles in the field, seminars

Evaluation of knowledge (maximum number of points 100)

Student projects – 40; Oral exam – 60

Name of the subject: MOLECULAR MECHANISMS OF CELLULAR COMMUNICATION

Teacher(s): Dr. Tatjana Kostić, Dr. Silvana Andrić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

Objective of this course is to enable students to understand and learn integrated knowledge of the communications between the cells and their environment, as well as signaling pathways involved in the transfers of the information in the cells till ultimate effectors systems. In addition, students should gain the ability of scientific-based interpretations of the experimental data from the field of molecular mechanisms of cell communications.

Outcome of the subject

At the end of this course students will be able to understand and describe characteristics of intracellular signaling pathways and ways of formation of networks for detection, transduction, transmission, propagation and amplification of the information in order to realized adequate biological response of the cell. In addition, students will have ability to critically analyze scientific papers, scientific hypothesis and the experimental data in the field of molecular mechanisms of cell communication and signaling, and to perform experiment form the field of molecular mechanisms of cell communication and signaling.

Content of the subject

Theoretical lectures

Overview of different ways of cellular communications and basic signaling transduction pathways. Receptors and signaling pathways connected with trimeric G-proteins (G-Proteins Coupled Receptors – GPCRs). Receptors enzymes and receptors connected with enzymes. Receptors and signaling pathways involving proteolysis. Intracellular receptors. Functional organization of the proteins in membranes and their translocation. Basic signaling pathways in apoptosis.

Practical lectures

Analysis of NO-cGMP signaling pathway will be used to present and learn basic methodological approach(s) required for studying communications between the cells. This will include: RT-PCR; Western blot; stimulation/inhibition of the signaling pathways elements; up (over-expression) and/or down regulation (siRNA, dsRNA, anti-sense) of the signaling pathway element(s); analysis of phosphorilation of the signaling pathway element(s).

Seminars. Short presentation of the specified topics connected with the subject of student's PhD thesis.

Journal Club. Presentation of the original peer-review scientific paper from the field of molecular mechanisms of cell communication and signaling.

Recommended literature

Bolander FF (2004): *Molecular Endocrinology*. Elsevier Academic Press

Bradshaw RA & Dennis EA (2004): *Handbook of Cell Signaling, Three Volumes set 1-3.* Academic Press.

Conn MP & Means AR (2000): *Principles of Molecular Regulation*. Humana Press.

Gomperts BD, Kramer IM & Tatham PER (2003): *Signal Transduction.* Elsevier Academic Press

Hancock JT (2005): *Cell Signaling.* Oxford University Press.

Krauss G (2005): *Biochemistry of Signal Transduction and Regulation.* WILEY-VCH.

Wilson J & Hunt T (2002): *Molecular Biology of the Cell Problems Approach Book 4th ed.*Garland Science.

Review peer-review scientific paper from the field of molecular mechanisms of cell communication and signaling.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical lectures – interactive lectures, consultation, and group discusion. *Student research work* – active participation in the planing and conducting the experiments, as well as analysis, interpretation and discussion of the results. *Seminar* – short presentation (10 – 15 minutes) connected with the subject of student's PhD thesis. *Journal Club* – Presentation of the original peer-review scientific paper from the field.

Evaluation of knowledge (maximum number of points 100)

Student research work –up to 30 points; Seminar – up to 10 points; Presentation of the original scientific paper – up to 10 points; Oral exam – up to 50 points.

Name of the subject: BIOCHEMICAL MARKERS OF DISEASES

Teacher(s): Dr. Danijela Kojić, Dr. Željko Popović

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The aim of this course is to introduce students to the basics of molecular medicine, biochemical markers of diseases as well as molecular mechanisms and etiology of the most common disorders. Also, students will be introduced to modern biochemical methods and molecular biology techniques used in clinical biochemistry.

Outcome of the subject

By understanding the molecular basis of various diseases and organ dysfunctions students should be able to take part in the development and analysis of biomarkers in diagnostics and therapy.

Content of the subject

Theoretical lectures

Lectures will cover the following topics: Introduction to molecular medicine; Biomarkers of cardiovascular, hematologic, immunological, pulmonary, gastroenterological and endocrinological diseases and dysfunctions; Biomarkers in transplantation and toxicology; Molecular mechanisms and biochemical markers in cancer; Biochemical markers of viral and bacterial infections; Biochemical methods and molecular biology techniques in clinical biochemistry.

Practical lectures

Student research paper in the relevant field which will cover the browsing of literature, preparation and defence of paper.

Recommended literature

Mandl, J, Machovich, R, Csala, M (2014) Medical Pathobiochemistry. Medicina. Budapest, Hungary
Н. М. Сингх (2006.) Медицинска биохемија. Друштво медицинских биохемичара Србије, Београд.
С. Спасић, З. Јелић-Ивановић, В. Спасојевић-Калимановска (2003.) Медицинска биохемија, Београд;
Trull A.K., Price C., Demers L. (2002): Biomarkers of diseases, Cambridge University Press

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, consultation, preparation and defence of research paper.

Evaluation of knowledge (maximum number of points 100)

Preparation and defence of research paper – 50 points; oral exam – 50 points

Name of the subject: BIOINFORMATICS IN THE STUDY OF NUCLEIC ACIDS AND PROTEINS

Teacher(s): Dr. Edvard Petri, Dr. Jelena Purać, Dr. Željko Popović

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The course will introduce students to bioinformatics concepts and methods used in the analysis of nucleic acids and proteins in biological research.

Outcome of the subject

After completing the course, students should be able to understand and use different commercially available programs for the analysis of nucleic acids and proteins. Also, students should learn to apply bioinformatics to solve specific biological problems.

Content of the subject

Theoretical lectures

Bioinformatics is an integrated discipline of biology, mathematics and programming, which has broad applications in various scientific fields. Most of today's biological research uses some biological databases, as well as methods for studying the organization, structure, function and evolution of biological macromolecules. During this course, students will learn the most important concepts, methods and tools used in bioinformatics analysis of nucleic acids and proteins. Students will learn about the following topics: a) biological databases of nucleotide and amino aced sequences and how to search for information in biological databases b) database similarity searching c) determining alignments for nucleotide and amino acid sequences, d) determination of phylogenetic trees, e) analysis of the structure and function of biological macromolecules and f) the links between genes and the structure of biomolecules – the structural basis of genetic conservation.

Practical lectures

Students will be required to write term paper that will be consistent with the theoretical material covered in the course, as well as the subject they deal with for their doctoral research.

Recommended literature

Vinay Sharma (2008) Text Book of Bioinformatics, Rastogi Publications
Jenny Gu, Philip E. Bourne (2011) Structural Bioinformatics, second edition, Wiley-Blackwell
Lesk Arthur (2014) Introduction to bioinformatics, Oxford university press

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical instruction will be taught in lectures or consultations. Practical instruction will be done using computers.

Evaluation of knowledge (maximum number of points 100)

Term paper: 70 points
Course activity: 30 points

Name of the subject: STRUCTURAL BIOLOGY OF PROTEINS

Teacher(s): Dr. Edward Petri

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

Structural biology is necessary for understanding the role of proteins in biological processes as well as the connection between protein structure and function. The objective of the course Structural biology of proteins is to introduce students to methods for determining, modeling and analyzing protein structure, to teach them how to use structural biology databases, and to apply structural biology methods in biological research.

Outcome of the subject

Upon successfully completion of the course students will be able to:
- Understand the structural basis of biological processes
- Recognize different methods for determining, modeling and analyzing the structure of biomolecules
- Assess the use of structural biology for certain conditions and in solving certain biological problems
- Use tools for molecular visualization, modeling and analysis of protein structure
- Critically read scientific literature containing structural information
- Use structural biology databases from the Internet (PDB, SWISS PROT, NCBI, BLAST, EBI ....)

Create and analyze high-resolution images of protein structures for publications or theses

Content of the subject

Theoretical lectures

Students will learn how to apply structural protein biology methods for their research, including: a) methods for protein visualization, b) determining, modeling and analyzing protein structure, v) predicting protein structure g) structural bioinformatics, d) analyzing protein-ligand interactions f) the relationship between structure and function of proteins and the structural basis of protein sequence conservation.

Practical lectures

Practical classes will be organized in the form of computer exercises aligned with the theoretical program of the course, which will allow students to master the use of programs for three-dimensional macromolecular visualization and analysis.

Students will also be required to write a seminar paper that will cover material presented in the theoretical and practical parts of the course on a topic related to their doctoral research.

Recommended literature

1. Luckey M *Membrane Structural Biology 2nd ed.* Cambridge Press 2014
2. Niketic, V., *Principi structure i aktivnosti*. Hemijski Fakultet, Beograd, 1995.
3. Serdyuk, I., Zaccai, N., Zaccai, J., *Methods in molecular biophysics: structure, dynamics, function*, 2010
4. Branden, C. & Tooze, J. *Introduction to Protein Structure*, 2nd Edition, Garland Publishing, New York.
5. Primary scientific literature

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical instruction is given in the form of lectures and consultations, and practical instruction is organized in the form of computer exercises

Evaluation of knowledge (maximum number of points 100)

Seminar preparation: 50 points
Seminar presentaion: 50 points

Name of the subject: MECHANISMS OF CELLULAR STRESS RESPONSES

Teacher(s): Dr. Jelena Purać, Dr. Elvira Vukašinović

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The goal of this course is to provide students with knowledge about the mechanisms of cellular responses to stress.

Outcome of the subject

After completing the course, students should understand the different mechanisms of cellular response to stress and that different systems function cooperatively as an integrated cellular defense system. Given the universality of these mechanisms, the students will be able to understand knowledge gained in this course in the context of different biological disciplines.

Content of the subject

Theoretical lectures

All organisms need to have a system to defend against stress, which is in addition to that role, is involved in re-establishment of a normal physiological state after stress. Defense mechanisms are found in every cell and some of these are preserved from prokaryotes to eukaryotes, indicating their great importance for the survival of cells. Defense against stress is associated with the idea of homeostasis, the tendency to regulate the internal state, regardless of changes in the environment. During the course, students will be introduced to five different systems for defense against stress: a) systems for basal signal transduction b) stress proteins, c) response to oxidative stress, d) metallothionein and related systems and e) mixed function oxygenase. Students need to understand that there is a significant overlap and connection between different systems which help in coordinating cellular responses.

Practical lectures

Students will be required to write term paper that will be consistent with the theoretical material covered in the course, as well as the subject they deal with for their doctoral research.

Recommended literature

Nico M. van Straalen, Dick Roelofs (2011) An Introduction to Ecological Genomics, 2nd edition, Oxford University Press

Andre Korsloot, Cornelis A. M. van Gestel, Nico M. van Straalen (2004) Environmental Stress and Cellular Response in Arthropods, Taylor & Francis

Ulrich Feige (1996) Stress-Inducible Cellular Responses, Springer

Downes, C. P., Wolf, C. R., Lane, D. P. (Eds.). (2014) Cellular responses to stress (Vol. 85) Princeton University Press

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Theoretical instructions are taught in lectures or consultations.

Evaluation of knowledge (maximum number of points 100)

Term paper: 70 points

Course activity: 30 points

Name of the subject: MEMBRANE BIOLOGY

Teacher(s): Dr. Andjelka Ćelić

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The goal of the course, ***Membrane Biology*** is to integrate students' previous knowledge of biological membranes gained during their studies, and introducing them to more detailed analyses of individual cell membrane elements, with a particular focus on receptors and ion channels.

Outcome of the subject

Upon successful completion of this course, students will be able to:
- understand the concept of biological membranes
- be familiar with receptors and ion channels as the most common targets of pharmacologically active substances
- recognize the latest methods and techniques used in the study of biological membranes and membrane proteins
- monitor and critically read scientific literature in the field of membrane biology
- apply the knowledge gained in this course to their own scientific research

Content of the subject

Theoretical lectures

Topics that will be covered in the lectures:
- Membrane composition, lipid diversity, bilayer structure
- Models of membranes: monolayer membranes, planar bilayers, liposomes, micelles, nanodiscs
- Proteins that interact with membranes
- Integral membrane proteins
- Ion channels - function, structure, conformational changes, oligomerization
- G protein receptors - structure, activation, function, regulation and signaling
- Membrane enzymes, transducers and transporters

The contents of the course will be designed to be in line with the individual interests of the students in order to enable detailed studies of areas closer to the student's own scientific research.

Practical lectures

Reading, critical analysis, and discussions of the primary scientific literature. One of the students' obligations will be to write a seminar paper on a topic related to the theoretical lectures but at the same time in lined with the focus of their own doctoral research.

Recommended literature

1. Luckey M *Membrane Structural Biology 2nd ed.* Cambridge Press 2014
2. Yeagle P *The Membranes of Cells 3rd ed.* Academic Press, Elsevier 2016
3. Grisshammer R, Buchanan SK *Structural Biology of Membrane Proteins* Royal Society of Chemistry 2006
4. Smrcka A *G protein Signaling: Methods and Protocols* Humana Press Elsevier 2004
5. Serdyuk, Zaccai, Zaccai *Methods in Molecular Biophysics: structure, dynamics, function* Cambridge 2007

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Classes will be delivered in the form of lectures and consultations.

Evaluation of knowledge (maximum number of points 100)

Seminar paper 50 points, presentation of seminar paper 50 points.

Name of the subject: MOLECULAR MECHANISMS OF CANCEROGENESIS

Teacher(s): Dr. Andjelka Ćelić

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

Cancer is a group of diseases characterized by uncontrolled cell growth and invasiveness that allows it to spread throughout the body from its primary site of origin. It is the leading cause of death worldwide and one of the most studied processes in biomedical research, and yet the process is still incompletely understood. Given the complexity of the problem, an understanding of the origins of cancer also implies a complete understanding of the fundamental biological principles and fundamentals of cell function. The objective of the course, ***Molecular Mechanisms of Carcinogenesis*** is to integrate knowledge acquired by students in their previous courses (molecular and cell biology, physiology, genetics, immunology ..) as well as to introduce students to the contemporary achievements of biomedical research, in order to help them develop an understanding of the molecular, cellular and pathophysiological basis of cancer.

Outcome of the subject

Upon completion of the course, students will be expected to have mastered the theoretical basics of cancer biology, be familiar with the latest methods and techniques used in cancer research and the development of new therapies, and to be able to follow and critically read the scientific literature in the field.

Content of the subject

Theoretical lectures

Topics that will be covered in lectures:

- The nature of cancer
- DNA structure and stability, mutation and repair ratios
- Regulation of gene expression, tumor viruses, growth factors and oncogenes vs. growth inhibition and tumor suppressors
- The cell cycle
- Apoptosis and p53
- Cell immortality and tumorigenesis
- Invasiveness and metastases
- Immune system, infections and inflammation
- Stem cells
- Drug design, clinical testing, pharmacogenomics
- Development of anti-tumor therapies and treatments

The details of the course will designed to be in line with the individual interests of the students so as to enable a detailed study of topics closer to the student's own scientific research.

Practical lectures

Reading, critical analysis, and discussions of the primary scientific literature. One of the students' obligations will be to write a seminar paper on a topic related to the theoretical lectures but at the same time in lined with the focus of their own doctoral research.

Recommended literature

1. Lauren Pecorino *Molecular Biology of Cancer: Mechanism, Targets and Therapeutics* 3rd ed. Oxford 2012
2. Robert A. Weinber *The Biology of Cancer* 2nd ed. Garland Science 2013
3. Lewis J. Kleinsmith *Principles of Cancer Biology* Benjamin Cummings 2005

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Classes will be delivered as lectures and consultations

Evaluation of knowledge (maximum number of points 100)

Course activities 30 points. Seminar paper and presentation 70 points.

Name of the subject: PREPARATION OF DOCTORAL DISSERTATION

Teacher(s): -

Status of the subject: Obligatory

Number of ECTS points: 20

Condition:
The doctoral dissertation is defended after passing the exams in all subjects and after fulfilling all the obligations determined by the study program. It consists of the preparation and public defense of the doctoral dissertation. The doctoral dissertation is submitted and produced during the second or third year of doctoral studies. The application procedure, the conditions for drafting and the manner of defending the doctoral dissertation are laid down in the Statute and the corresponding acts of the Faculty of Science and the University.

Goal
The doctoral dissertation is a student's independent research work and represents a synthesis of theoretical knowledge and practical work through which the student acquires the ability for scientifically based interpretation of experimental data from a selected narrow scientific field of Biology/Molecular Biology.

Outcome of the subject
Through the process of developing and defending a doctoral dissertation, the student gains the ability of
- independent collection of information and data from professional and scientific literature;
- logical thinking, formulation of working hypotheses and goals of the dissertation and drawing conclusions;
- placing different scientific and professional information, giving opinions and exchanging ideas;
- planning and carrying out experimental work;
- team research work;
- scientifically based interpretation of experimental data and obtained results;
- successful application of the principles of good laboratory practice in the planning, execution and control of experiments;
- successful synthesis of relevant scientific data with conclusions drawn.

Content of the subject
As a rule, the doctoral dissertation contains the following chapters:
Content, Introduction, Objective, Literature Review, Material and Methods, Results, Discussion, Conclusions, Literature.
In addition to the aforementioned chapters, each doctoral dissertation contains a biography of the candidate and key documentation in Serbian and English. In the case of teaching in English, the doctoral dissertation is written in English with a broader statement in the Serbian language and legends of pictures and tables in the Serbian language.
In addition to the above elements, the doctoral dissertation may contain additional elements such as List of Tables, List of Figures, Attachments, List of Abbreviations, etc.

Recommended literature
Relevant scientific and professional literature in the field of doctoral dissertation.

Number of active classes	Theory:-	Practice: -

Methods of delivering lectures
- collecting and studying literature
- collecting data for experimental work
-planning and performing experiments
-data processing
-writing and oral defense of the doctoral dissertation

Evaluation of knowledge (maximum number of points 100)
1. The doctoral dissertation is defended before the Commission.
2. The dissertation defense is oral and public.
3. The day, place and time of the defense of the doctoral dissertation shall be published on the notice board of the relevant Department and / or on the Faculty website at least three days before the defense.
4. Upon the defense of the doctoral dissertation, the Commission shall withdraw and then make a public announcement decision on whether the dissertation was successfully defended.
5. The Commission for the Defense of the Doctoral Dissertation shall decide by a majority vote.

Name of the subject: PREPARATION OF A SCIENTIFIC PAPER FOR PUBLICATION IN A JOURNAL FROM THE SCI LIST		
Teacher(s): -		
Status of the subject: Obligatory		
Number of ECTS points: 10		
Condition: -		
Goal Independent student scientific-research work through which the ability to synthesize theoretical knowledge and practical work and present the results to the international scientific community is acquired.		
Outcome of the subject Through the process of writing a scientific paper for publication in a journal from the SCI list, the student acquires the ability of: - independent collection of information and data from professional and scientific literature; - logical thinking, formulation of working hypotheses, goals and drawing conclusions; - placing various scientific and professional information, giving opinions and exchanging ideas; - scientifically based interpretation of experimental data and obtained results; - successful synthesis of relevant scientific data with conclusions.		
Content of the subject The student is obliged to publish at least 1 scientific paper in a journal on the SCI list, in the field of the topic of the doctoral dissertation, which contains the results obtained by working on the doctoral dissertation and on which the student is the first author.		
Recommended literature Relevant scientific and professional literature in the field of the topic of the doctoral dissertation		
Number of active classes	Theory:	Practice: 20
Methods of delivering lectures -collection and study of literature -processing the results of research work in the field of the topic of the doctoral dissertation -writing a scientific paper and active participation in the process of submitting a paper to a journal from the SCI list		
Evaluation of knowledge (maximum number of points 100) After accepting a scientific paper for publication in a journal from the SCI list, the student advisor or mentor of a doctoral student submits proof to the Student Services that the paper has been accepted and / or a printed version of the published paper, thus giving the student the maximum number of points and ECTS.		

Name of the subject: SEMINAR I		
Teacher(s):		
Status of the subject: Obligatory		
Number of ECTS points: 30		
Condition: -		
Goal The objective of the course is to acquaint students with the most up-to-date methods and results in the relevant narrow scientific field of research, as well as training them in the planning and preparation of the doctoral dissertation.		
Outcome of the subject The final outcome of the course is the successful preparation and realization of research work leading to the preparation of a doctoral dissertation.		
Content of the subject The seminar is a thematic, narrowly oriented, specialized form of teaching that is conducted in specific terms with students, and is in the direct function of research leading to the preparation of a doctoral dissertation. The program of work of each seminar is formed in accordance with the needs of the preparation of doctoral dissertations and depends on the topic, structure and complexity of the doctoral dissertation. Seminars are the basis of study research work. The student, in consultation with the advisor, prepares Seminar I in the form of a presentation, which includes the presentation and explanation of the topic of the doctoral dissertation in the light of the literature and presentation of the methods that will be used during the research work. The defense of the seminar will be conducted in joint terms. The student defends the seminar publicly before a five-member committee nominated by the Departmental Council for each school year and before the PhD students attending the course.		
Recommended literature Scientific and professional literature in the field of doctoral dissertation subject as agreed with the advisor (mentor).		
Number of active classes	Theory:	Practice: 20
Methods of delivering lectures The basic form of teaching at the seminar is the independent research work of the student, which is realized in agreement with the advisor (mentor).		
Evaluation of knowledge (maximum number of points 100) Presentation - 30 points Seminar defense - 70 points		

Name of the subject: SEMINAR II		
Teacher(s):		
Status of the subject: Obligatory		
Number of ECTS points: 30		
Condition: -		
Goal The objective of the course is to train the student to prepare a doctoral dissertation.		
Outcome of the subject The final outcome of the course is a critical analysis of the results in order to successfully complete the doctoral dissertation.		
Content of the subject The seminar is a thematic, narrowly oriented, specialized form of teaching that is conducted in defined terms with students, and is in the direct function of developing a doctoral dissertation. The program of work of each seminar is formed in accordance with the needs of developing a specific doctoral dissertation and depends on the topic, structure and complexity of the doctoral dissertation. The student, in consultation with the advisor (mentor), prepares Seminar II in the form of a presentation that includes presentation of the results obtained during the doctoral dissertation, their critical discussion and conclusions. The defense of the seminar will be conducted in joint terms. The student defends the seminar publicly before a five-member committee nominated by the Departmental Council for each school year and before the PhD students attending the course.		
Recommended literature Scientific and professional literature in the field of doctoral dissertation subject to agreement with the advisor (mentor).		
Number of active classes	Theory:	Practice:20
Methods of delivering lectures The basic form of teaching at the seminar is the independent research work of the student, which is realized in agreement with the advisor (mentor).		
Evaluation of knowledge (maximum number of points 100) Presentation - 30 points Seminar defense - 70 points		

Name of the subject: MATHEMATICAL AND STATISTICAL METHODS IN BIOLOGICAL RESEARCH

Teacher(s): Dr.Vladimir Kostić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

Enabling students to independently use basic modern mathematical and statistical methods in research through the integration of theoretical knowledge and the development of programming skills to analyze empirical data and perform scientific reasoning.

Outcome of the subject

Students will master techniques of mathematical modeling with differential equations and techniques of multivariate statistical analysis, as well as their implementation on selected biological and ecological phenomena using the software package R.

Content of the subject

Theoretical lectures

Introduction to Scientific Modeling - deterministic and statistical models. Mathematical modeling of dynamic processes via differential equations. Model of empirical food webs - model setup, analysis, simulations and conclusions. Basics of statistical modeling. Descriptive data research techniques (EDA) - descriptive statistics in biology and ecology, tables, charts. Basic tests of univariate statistical analysis. Basic tests of multivariate statistical analysis. Cluster analysis. Principal component analysis and factor analysis.

Practical lectures

Introduction to R programming language. Data preparation and processing in R Studio environment. Programming basics in R. Writing algorithms in R for scientific computation - determining the stability indicators of empirical food webs. Descriptive statistical methods in R. Univariate statistical analysis in R. Multivariate statistical analysis in R.

Recommended literature

1. K. Soetaert, P. M. J. Herman, A Practical Guide Ecological Modeling: Using R as a Simulation Platform, Springer (2008)
2. D. Borcard, F. Gillet, P. Legendre, Numerical Ecology with R, Springer (2018)
3. C. Dyltham, Choosing and Using Statistics – A Biologists's Guide, Wiley-Blackwell (2011)

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Within theoretical lectures, starting with an understanding of key mathematical and statistical models in biological research, tools for their deeper analysis are gradually introduced, and finally guidelines for independent scientific research are proposed. Practical training consists of working on a computer in the R programming language using the R Studio package.

Evaluation of knowledge (maximum number of points 100)

Knowledge assessment is in the form of presentation of a self-realized project and consists of an oral exam of theoretical knowledge (50 points) and mastered programming skills in R (50 points).

Name of the subject RESEARCH METHODOLOGY

Teacher(s): Dr. Vesna Milankov

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal

The course aims at enabling students for presenting research results, writing research articles and a PhD thesis and evaluating the scientific research.

Outcome of the subject

Competent presentation and publication of scientific information. Research competence.

Content of the subject

Theoretical lectures

Modern methods of collecting information and processing and analyzing research data in biological disciplines. Methods and techniques of researching and presenting results. Writing and presenting a doctoral thesis and a research article. Preparing manuscripts for publication – from manuscript writing to publishing. Digital data and e-publications. Forms of scientific publications. Scientometrics. Ranking research publications. Reviewing articles. Evaluation of reserchers and publications. Ethics in science – The codex of good scientific practice. Abuses of science. Logic errors. General and subject-specific scientific methods. Analysis of relevant scientific publications.

Recommended literature

Briscoe, M.H. (1996) Preparing scientific illustrations. 2nd ed. Springer-Verlag, New York.

Ebel, H.F., Bliefert, C., Russez, W.E. (2004) The art of scientific writing. Wiley-VCH Verlag GmbH & Co. KGaA.

Milankov, V. & Jakšić P. (2007) Методологија научноистраживачког рада у биолошким дисциплинама. ПМФ. (уџбеник) [*Research methodology in biological disciplines.Faculty of Sciences.textbook*]

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Oral and database searching in computer lab.

Evaluation of knowledge (maximum number of points 100)

Pre-exam obligations: 30

Oral exam: 70