

Name of the course: Biostatistics 151745
Course teacher: doc. dr. sc. Rosa Karlič, prof. dr. sc. Sven Jelaska
Doctoral study: Biology
Research field associated with the course programme: biology
Type of instructions: Lectures, 10; Exercises, 10
Credit value (ECTS): 7
Expected learning outcomes: By completing the course, students will understand and be able to apply statistical methods to analyze, interpret and presents data.
<p>Course objectives:</p> <p>Lectures: Sources and scales of data. Distribution of data (comparison, normality testing). Descriptive statistics. Statistical tests. Power of test, effect size, determining necessary sample size. Chi-square and analyses of variance. Non-parametric statistics. Correlation and regression. Multivariate statistics: multiple regressions, cluster analyses, ordination methods (PCA, RDA, CCA), CART. Gene set enrichment analysis, multiple hypothesis testing.</p> <p>Practicals: Practical will be performed in computer lab, and will be related to the lectures.</p>
<p>Students activities and evaluation of student work over the course of instruction: Attendance to lectures and practicals is obligatory.</p>
<p>Methods of monitoring quality that ensure acquisition of exit competences: Attendance to lectures is monitored as well as practicals. Exam is written and oral.</p>
<p>Required literature: Karlič, R., Jelaska S: Biostatistika. Predavanja (CD i/ili On-line). Šmilauer, P., Lepš, J. (2014) Multivariate Analysis of Ecological Data using CANOCO 5. Cambridge University Press, ISBN 110769440X, 9781107694408, str. 376. Diez, D. M., Barr, C. D. and Cetinkaya-Rundel, M. (2015) Open Intro Statistics Third Edition. str. 436.</p>
<p>Optional literature: Korpelainen, E., Tuimala, J., Somervuo, P., Huss, M. and Wong, G. (2015) RNA-seq Data Analysis A Practical Approach. CRC Press, Taylor & Francis Group. ISBN 978-1-4665-9501-9, str. 332. Magurran, A.E. (2013) Measuring Biological Diversity. John Wiley & Sons, ISBN 1118687922, 9781118687925, str. 264. Rosner, B. (2016) Fundamentals of Biostatistics, Eighth Edition, Cengage Learning, ISBN 978-1-305-26892-0</p>

Name of the course: Scientific Research Methodology 151746
Course teacher: Prof. Dunja Leljak-Levanić, PhD, Faculty of Science, University Zagreb Prof. Sofia Ana Blažević, PhD, Faculty of Science, University Zagreb
Doctoral study: Biology
Research field associated with the course programme: all scientific fields
Type of instructions: 15 hours lectures; 5 hours seminars
Credit value (ECTS): 7
Expected learning outcomes: Acquiring knowledge about the scientific method and experimental design. Understanding the links between statistical and mathematical methods and design of experiment. Introduction with the specificities of scientific communication, publishing the research results, availability of scientific literature, relevant data sources retrieving process and the evaluation of scientific work.
Course objectives: <i>Experimental design</i> The hypothesis or question – answer model - hypothesis, the role of hypotheses in an experimental "design"; shortcomings of hypothesis: restrictive and too general hypothesis, an alternative system of questions and answers. Variability, replication, repetition, control - variability in biological research, noise of the experiment, variability, standard deviation, number of replication and repetition; role of preliminary research and prestatistic for a successful outcome of the experiment, the selection of controls, balanced and unbalanced experimental design, Classification, sampling, aliasing - classification as a method of reducing the "noise" of the experiment; types of sampling, sample and subsamples; controls Ethics in research - ethics to the institution, colleagues, research ethics (how to treat human or animal experimental material) Elements and composition of research paper Literature referencing styles and new tools, software for citations and referencing (Endnote, Mendeley) How to publish research results, peer review process, plagiarism Relevant scientific information sources, bibliographic and citation databases (Web of Science, Scopus...), full-text sources Use of citation and data referencing tools (Mendeley, itd) Scientific work evaluation, bibliometric and scientometric analysis, citation analysis, journal evaluation (IF, SJR, h-index etc.), peer review
Students activities and evaluation of student work over the course of instruction: Seminar essay, practical work on data bases
Methods of monitoring quality that ensure acquisition of exit competences: written and oral form of examination
Required literature: David J. Glass, M.D.: <i>Experimental Design for Biologists</i> Novartis Institutes for Biomedical Research, Cambridge, Massachusetts, 2007 Ruxton, Graeme; Colegrave, Nick (2010-11-04). <i>Experimental Design for the Life Sciences</i> , Oxford University Press Wilson EB, <i>An Introduction to Scientific Research</i> , McGraw Hill Book Comp. Inc., New York., 1952. Day RA, <i>How to Write & Publish a Scientific Paper</i> , 3rd Ed. Oryx Press, Phoenix, New York, 1988.
Optional literature: Silobrčić V, <i>Kako sastaviti, objaviti i ocijeniti znanstveno djelo</i> , Medicinska naklada, Zagreb, 1994. Jokić, M. <i>Bibliometrijski aspekti vrednovanja znanstvenog rada</i> , Zagreb, Sveučilišna knjižara, 2005. Jermen, N., Letina, S., Jokić, M. <i>Croatian scientific productivity and visibility in the field of biology measured by journals indexed in WoS 1991–2005</i> . <i>Periodicum biologorum</i> , 115(2013), 1, 37-47.

Name of the course: Trophic level and energy flow in ecosystem 151747
Course teacher Maria Špoljar, PhD, Full Professor; Marko Miliša, PhD, Associate Professor; Mirela Sertić Perić, PhD, Assistant Professor, University of Zagreb, Faculty of Science, Department of Biology
Doctoral study: Biology
Research field associated with the course programme: Biology, Ecology
Type of instructions: Lectures and seminar (15+5)
Credit value (ECTS): 7
Expected learning outcomes: Acquiring the knowledge on basic laws of energy flow through ecosystems and methods for measurements of energy flow; acquiring the knowledge on trophic levels and procedures used for their analysis.
Course objectives: Basic concept of the ecosystem as inseparable unity of living and non-living matter. Organization degrees of living matter from a molecular to ecosystem level. Circulation of matter in nature. Biota component as a basic force for circulation of matter in nature. Primary and secondary production. Nutrition types. Trophic structure and ecological pyramids. The laws of thermodynamics and energy flow in ecosystem. Conversion, conservation and utilization of energy in the ecosystems. The models of energy flow through aquatic and terrestrial ecosystems. Available food resources in ecosystems. Ecosystem eutrophication. Degradation of biocenoses and energy flow deterioration in the ecosystem. Food chains, food webs and trophic levels in the ecosystems. Research methods for tracking food web dynamics in various ecosystems. The concept of production and consummation of organic matter in the terrestrial, marine and freshwater communities. Primary producers, consumers (secondary production) and decomposers. Seminar: Themes will be in accordance with course objectives.
Students activities and evaluation of student work over the course of instruction: From students is expected to attend both lectures and seminars. They will hold seminar, elaborate specific topic and submit in written form prior the exam. Students will present their themes and actively participate in discussion.
Methods of monitoring quality that ensure acquisition of exit competences: Final evaluation will be a combination of student achievements during the course, their results and final exam.
Required literature: Harte J 2011: Maximum Entropy and Ecology: A Theory of Abundance, Distribution, and Energetics (Oxford Series in Ecology and Evolution) Oxford University Press Hauer FR & Lamberti GA 2007: Methods in Stream Ecology. Academic press, Elsevier Inc. Oxford. Krebs, C.J., 1999: Ecological methodology. Ed. Claudia M. Wilson, Harper & Row Publishers, New York. Remert, H., 1998: Oekologie. Springer-Verlag, Berlin Wetzel, R.G., 2001: Limnology: Lake and River Ecosystems. Third Edition, Academic Press, San Diego.
Optional literature: Higashi, M., Burns, T.P., 1991: Theoretical studies of ecosystems, The network perspective. Ed. Cambridge University Press, New York.

Name of the course: Biological Evaluation And Conservation Of Terrestrial And Freshwater Ecosystems 151748
Course teacher: Prof. Zlatko Mihaljević, Department of Biology, Faculty of Science, Univ. of Zagreb Assoc. prof. Antun Alegro, Department of Biology, Faculty of Science, Univ. of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Biology, Ecology
Type of instructions: Lectures (15 hours), seminars (5 hours)
Credit value (ECTS): 7
Expected learning outcomes: experiments planning, data analysis, environmental management plans: presentations and recommendations
Course objectives: The main objective of the course is acquisition of general principles of terrestrial and freshwater ecology, and practical application of acquired knowledge in evaluation and conservation of different ecosystems. Students will be introduced with multiple stressors of freshwater ecosystems and with development of assessment systems based on aquatic communities.
Course content: <ul style="list-style-type: none"> - basic components of ecosystems - ecosystem classification on global and regional scale - overview of ecosystem typology, natural and anthropogenic ecosystems - landscape and its components - origin and development of Central European and Mediterranean landscape - landscape components in ecological valorization of environment - Ecosystem services - fundamental importance to human well-being, for health, livelihoods, and survival - Basic characteristics of freshwater ecosystems: lakes and reservoirs, streams and rivers, springs and groundwater. - Croatian and EU Freshwater Policy: Water Framework Directive and management of freshwater ecosystems - Freshwater pollution and degradation - Macrozoobenthos as biological quality element - Effects of organic pollution on freshwater ecosystems - Ecological response to hydromorphological degradation and restoration - Multiple stressors in freshwater - Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems - Main principles of assessment systems development for lakes and rivers - Freshwater protection and conservation - conservation methods of natural and anthropogenic ecosystems, protection of habitats and plant species - valorization of protection results, legislative, social and ecological aspects of protection - aims of ecosystem valorization and valorization criteria - typology and classification of terrestrial ecosystems - analysis of terrestrial ecosystems, historical analysis - selection of ecosystem characteristics suitable for valorization - estimation of biotic potential of ecosystem - ecosystem elements and mapping possibilities - highly threatened ecosystem types - biodiversity, its importance and typology - biodiversity measures - species-area relationship - relationship between species number and natural resources - endemic species, levels and causes of endemism - endemic species in the flora of Croatia - presence of rare and threatened species and habitats in the regions of Croatia
Students activities and evaluation of student work over the course of instruction: Active participation in course; preparation of seminar in written form (in the form of professional or scientific manuscript).

Methods of monitoring quality that ensure acquisition of exit competences:

Seminar evaluation that have to be in the form of professional or original scientific paper (up to 15 pages); assessment of problem solving tasks

Required literature:

- Bergstedt, J., 1992: Handbuch Angewandter Biotopschutz. Ecomed, Landsberg.
- Colditz, G., 1994: Auen, Moore, Feuchtwiesen. Gefährdung und Schutz von Feuchtgebieten. Birkhäuser, Basel.
- Dierssen, K., Dierssen, B., 2001: Moore. Ulmer, Stuttgart.
- Dörfler, E., Dörfler, M., 1990: Neue Lebensräume. Verlag Harri Deutsch. Frankfurt am Main.
- Geist, J., Hawkins, S., 2016: Habitat recovery and restoration in aquatic ecosystems: Current progress and future challenges. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 26: 942–962.
- Konold, W., 1996: Naturlandschaft Kulturlandschaft. Ecomed, Landsberg.
- Mason, C.F., 2002: Biology of Freshwater Pollution, Harlow, England.
- Merz, P., 2000: Pflanzenwelt Mitteleuropas und der Alpen. Ecomed, Landsberg.
- Mihaljević, Z., Kerovec, M., Mrakovčić, M., Plenković, A., Alegro, A., Primc-Habdija, B., 2011. Testiranje bioloških metoda ocjene ekološkog stanja (Okvirna direktiva o vodama, 2000/60/EC) u reprezentativnim slivovima Panonske i Dinaridske ekoregije. PMF, Sveučilište u Zagrebu, Zagreb.
- Mihaljević, Z., i sur. 2018. Klasifikacijski sustav ekološkog potencijala za umjetna i znatno promijenjena tijela površinskih voda – Stajačice Panonske i Dinaridske ekoregije. Biološki odsjek PMF-a, Sveučilišta u Zagrebu, Zagreb.
- Mihaljević, Z., Miliša, M., Pozojević, I., 2019. Report on fitting a macroinvertebrate classification method with the results of the completed intercalibration of the EC GIG (R-EX5 and R-EX6). Department of Biology, Faculty of Science, University of Zagreb, Zagreb.
- Rosenberg, D.M., Resh, V.H. ed., 1993: Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, London, 488.
- Topić, J., Ilijanić, Lj. 2005: Nacionalna klasifikacija staništa. *Drypis* 1 (1,2): 3-119.
- Water Framework Directive – Directive of European Parliament and of the Council 2000/60/EC – Establishing a Framework for Community Action in the Field of Water Policy, of 23 October 2000. Brussels.

Optional literature:

- Aqem Consortium, 2002: Manual for the application of the AQEM system. A comprehensive method to assess European streams using benthic macroinvertebrates, developed for the purpose of the Water Framework Directive. Version 1.0, February 2002
- Herrmann, S., Dabbert, S., Schwarz-von Raumer, H.G., 2003: Threshold values for nature protection areas for bio-diversity – a regional evaluation of economic and ecological consequences, *Agriculture, Ecosystems and Environment* 98: 493-506.
- Urbanič G. 2014. Hydromorphological degradation impact on benthic invertebrates in large rivers in Slovenia. *Hydrobiologia* 729: 191–207.
- Waldthart R., Otte, A., 2003: Indicators of plant species and community diversity in grasslands. *Agriculture, Ecosystems and Environment* 98: 339-351.

Name of the course: Principles Of Conservation Biology 151750
Course teacher: assoc. prof. Perica Mustafić, PhD, Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: ecology, conservation biology
Type of instructions: Lectures and seminars (10+5 hours); practical course (5 hours)
Credit value (ECTS): 7
Expected learning outcomes: In this course students will find in theory and practice the human influence on nature, the value of biological diversity and the reasons and ways of its conservation
<p>Course objectives:</p> <p>The topics to be covered in this course are as follows:</p> <ol style="list-style-type: none"> 1. Biodiversity conservation strategies (ex situ, in situ) 2. Analysis of the viability of populations, small populations, metapopulations 3. Fragmentation, destruction and degradation of habitats 4. Management of ecosystems, overfishing, fishing and hunting 5. Conservation genetics and systematics 6. Invasive and alien species 7. Restoration ecology 8. Practical applications, legal regulations and international conventions
<p>Students activities and evaluation of student work over the course of instruction:</p> <p>Students activities include active participation in lectures and the preparation of seminar papers related to a particular thematic unit; participation in field work; laboratory work related to lectures and field work</p>
<p>Methods of monitoring quality that ensure acquisition of exit competences:</p> <p>Evaluation of seminar papers, participation on the exercises and field work will make 50% of the final grade while the oral exam will be the next 50%.</p>
<p>Required literature:</p> <ol style="list-style-type: none"> 1. Primack, R.B. (2014): Essentials of Conservation Biology, 6th ed. Sinauer Associates, Sunderland, USA. 2. Groom, M.J., Meffe, G.K., Carroll, C.R. (2006) Principles of Conservation Biology, 3rd ed. Sinauer Associates, Sunderland, USA.
<p>Optional literature:</p> <ol style="list-style-type: none"> 1. Van Dyke, F. (2008) Conservation Biology: Foundations, Concepts, Application, 2nd ed. Springer. 2. Primack RB (2012) A Primer of Conservation Biology, 5th ed. Sinauer Associates, Sunderland, USA.

Name of the course: <u>Ecology of Marine Habitats</u> 151751
Course teacher: Tatjana Bakran-Petricioli, PhD, Associate Professor, Senior Scientific Collaborator, University of Zagreb, Faculty of Science, Department of Biology
Doctoral study: Biology
Research field associated with the course programme: field – 1.01. Biology; branch – 1.01.06. General biology
Type of instructions: Lectures (10 hours), seminars (10 hours)
Credit value (ECTS): 7
<p>Expected learning outcomes: Students will be able to:</p> <ul style="list-style-type: none"> - Differentiate the main living communities - habitats - in the littoral zone - Describe basic ecological processes which take place in them - Plan and organise simple research of those communities - Define scientific approach and use it in the research of the life in the sea - Define endangerment of the life in the sea and justify need for its protection - Explain the need for intra- and interdisciplinary collaboration in sea research
<p>Course objectives:</p> <p>Students will get to know ecological processes that determine structure and dynamics of populations and communities of marine benthic organisms – marine habitats. After successfully passing the exam students will be able to independently design simple research in order to better understand those processes. They will be able to observe, identify and describe patterns in nature, to develop testable hypotheses about the causes of observed patterns and design suitable empirical tests to test proposed hypotheses or to monitor a possible impact. They will also be able to evaluate how important those processes are for the management and preservation of bio-resources in the sea.</p> <p>LECTURE CONTENTS:</p> <ol style="list-style-type: none"> 1. Specificities of scientific work in benthic research of the Adriatic Sea. 2. Planning of sampling/experiments in laboratory and on the field. 3. Natural disturbances and dynamics of marine benthic communities. 4. Energetics of marine ecosystem. 5. Communities in the littoral area: supra- and mediolittoral communities, sea-grass meadows, communities of photophilic algae, estuaries, circalittoral communities: coralligen, marine caves, coastal detritic bottoms, mud bottoms. 6. Ecology of habitats in submerged karst in the Adriatic Sea (vruljas, marine lakes, stratified estuaries, anchihaline caves). 7. Biodiversity of benthic habitats. Changes in the Adriatic benthic communities caused by human impact (pollution – toxic substances input, heat pollution, waste dumping; nutrient salts input and eutrophication; habitat disappearance and destruction; over exploitation of marine bio-resources; import of allochthonous species; global warming, sea level rise). 8. Endangered habitats of the Adriatic Sea. 9. Management of marine bio-resources and their preservation (laws and conventions on sea protection, strategic environmental impact assessment, environmental impact assessment studies, sustainable development and is it possible, management and protection of renewable marine bio-resources, integral management of coastal areas). 10. Ecology of protected areas in the Adriatic and their management. <p>Seminars are thematically connected to the lectures within the same week. Literature for the seminars consists of recent scientific, review and expert papers.</p>
<p>Students activities and evaluation of student work over the course of instruction:</p> <ul style="list-style-type: none"> - regular attendance of lectures and seminars, active participation during classes, writing homework and seminar paper, oral presentation of seminar paper in front of the colleagues, regular short written tests in the course of lectures <p>Note: prerequisite for enrolment of this course are attended and passed courses in: Marine Biology</p>

and/or Biological oceanography, and Methods in Marine Research (or equivalents); in case that student does not fulfil this condition she/he is obliged to take entrance colloquium in the first two months of lectures (materials for preparation will be made available)

Methods of monitoring quality that ensure acquisition of exit competences:

The final grade will be consisted of grades of the active participation in lectures, homework and seminar paper grades, grades of the oral presentation of seminar paper, grades of short written tests in the course of lectures, and the final oral exam grade (all mentioned will be counted in the final grade)

Required literature:

- lecture presentations and materials
- selected recent review, professional and scientific articles
- selected parts of the following books (all the listed are available in laboratory):
- Bertness, MD, Gaines, SD, Hay, ME (2001) Marine Community Ecology, Sinauer Associates Inc. Publishers, Sunderland MA, USA
- Kaiser, MJ, Attrill, MJ, Jennings, S, Thomas, DN, Barnes, DKA, Brierley, AS, Polunin, NVC, Raffaelli, DG, Williams, PJ (2005) Marine Ecology - Processes, Systems and Impacts, Oxford University Press, Oxford, UK
- Mann, KH (2000) Ecology of Coastal Waters, Blackwell Science, Abingdon, UK Southwood, TRE, Henderson PA (2000) Ecological methods, Blackwell Science, Abingdon, UK
- Valiela, I (2006) Global Coastal Change, Blackwell Science, Abingdon, UK
- Bakran-Petricioli, T (2011) Manual for determination of marine habitats in Croatia according to EU Habitats Directive (ISBN 978-953-7169-84-8). State Institute for Nature Protection, Zagreb, 184 pp.

Optional literature:

- Alley, M (1998) The Craft of Scientific Writing, Springer Verlag, New York
- Black, KD, Editor, (2001) Environmental Impacts of Aquaculture, Sheffield Academic Press, Sheffield, UK
- Miller, CB (2004) Biological Oceanography, Blackwell Publishing, Oxford, UK
- Silobrić, V (2003) How to write, publish and evaluate scientific paper, Medicinska naklada, Zagreb (in Croatian)
- Quinn, GP, Keough, MJ (2002) Experimental Design and Data Analysis for Biologists, Cambridge University Press, Cambridge

Name of the course: <u>Interactions Of Plants And The Environment</u> 151752
Course teacher: Assoc. Prof. Mirta Tkalec, Ph.D., Faculty of Science, University of Zagreb Assoc. Prof. Željka Vidaković-Cifrek, Ph.D., Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Biology, Botany
Type of instructions: Lectures (10 hours), seminar (5 hours), laboratory work (5 hours)
Credit value (ECTS): 7
Expected learning outcomes: -to describe relationships and interactions among plants and other organisms in their natural environment as well as influence of abiotic environmental factors on plants -to explain mechanisms of interactions and their dependence on environmental conditions
Course objectives: INTERACTIONS BETWEEN PLANTS AND OTHER ORGANISMS – relationships among plants (competition, allelopathy, parasitism, substances included in recognition process among organisms); relationships among plants and animals (pollination, dispersion of seeds, chemical and structural barriers in plant/herbivore interactions, carnivorous plants); relationships between plants and fungi (mycorrhizae); relationships between bacteria and plants in symbiotic nitrogen fixation; relationships between plants and pathogens (viruses, bacteria, fungi); relationships among plants and humans (climate change, pollution) ROLE OF SECONDARY METABOLITES IN INTERACTIONS OF PLANTS AND OTHER ORGANISMS: three main groups of secondary metabolites – terpenes, phenolics, nitrogen-containing compounds. Biosynthesis, amount and distribution in plants, mechanisms of action, roles in plant defence, pollination, allelopathy, phytotoxicity, hypersensitive response and systemic acquired resistance EFFECT OF ABIOTIC ENVIRONMENTAL FACTORS ON PLANT METABOLISM, GROWTH AND DEVELOPMENT: light (intensity, quality, photoperiod), water (availability, quality), soil (structure, composition, content and availability of mineral nutrients, salinity, aeration, pH value), temperature (heat, cold, freezing), other influences (fire, snow, irradiance, pollution) RESPONSE OF PLANTS ON CHANGING ENVIRONMENT – changes in content and types of metabolites, movements of plant organs, developmental responses, adaptation and acclimatisation
Students activities and evaluation of student work over the course of instruction: Attendance and active participation during lectures and experimental work; seminar in oral form
Methods of monitoring quality that ensure acquisition of exit competences: Seminar and oral exam
Required literature: Taiz, L., Zeiger, E. (2010): Plant Physiology. 5th Edition, Sinauer Associates, Inc. Publishers Buchanan, B., Gruissem, W., Jones, R. L. (2015): Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists. Wiley Blackwell.
Optional literature: Lambers, H., Pons, T. L., Chapin, F. S. (2000): Plant Physiological Ecology. Springer, New York. Scott, P. (2008): Physiology and Behaviour of Plants. John Wiley and Sons, Ltd, Chichester. Selected scientific papers

Name of the course: <u>Analysis Of Genetic Diversity</u> 151758
Course teacher: Zlatko Liber, Associate professor, Faculty of Science, University of Zagreb Zlatko Šatović, Full professor, Faculty of Agriculture, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: biology (1.05.); botany (1.05.02), genetics, evolution, phylogeny (1.05.06),
Type of instructions and number of hours: 20 hours (lectures and seminars)
Credit value (ECTS): 7
Expected learning outcomes: Introduce, discuss, compare and apply molecular, statistical and computer methods for the analysis of genetic diversity which are most often used in population- genetic, molecular ecology, spatial genetic, phylogenetic, biology conservation and epigenetic researches.
Course objectives: 1. Introduction to the analysis of molecular diversity; overview of classical and molecular genetics; examples of scientific researches. 2. Genetic markers: basic molecular techniques in the analysis of genetic diversity; morphological and molecular markers; isoenzymes; molecular markers at the DNA level; randomly amplified molecular markers; molecular markers based on known sequences. 3. Descriptive statistics: informativeness of genetic markers; codominant and dominant markers; genotype and allelic frequency; polymorphism information contents; measures of intrapopulation diversity; allelic richness; observed and expected heterozygosity; fixation index; Shannon's information index; frequency of rare alleles; analysis of genetic bottleneck. 4. Measures of genetic distance: distances between populations; frequency of amplified fragments and allele frequency; distances based on evolutionary models; geometric distances; genetic distance between individuals; proportion of shared alleles distance; similarity coefficients for binary data. 5. Multivariate methods: introduction; characteristics of multivariate data; classification of multivariate methods; cluster analysis; types of trees; UPGMA and related algorithms; neighbor joining method; bootstrap method; principal component and principal coordinate methods 6. Genetic structure: Hardy-Weinberg equilibrium; Wright's F statistics; Wahlund effect; index of genetic differentiation; method according Weir and Cockerham; analysis of molecular variance; basic concept of Bayesian statistics; linkage disequilibrium; model based Bayesian analysis (STRUCTURE, BAPS). 7. Spatial and landscape genetics: spatial distribution of genetic diversity; isolation by distance; spatial autocorrelation; Moran's index; Bayesian analysis of spatial population structure (BAPS, TESS); genetic barriers; comparison of bioclimatic and genetic parameters; landscape genetics (POPS). 8. Phylogeography: impact of demographic processes on the geographical distribution of population/species; genetic genealogy; analysis of 'nested clade' vs. coalescent theory; analysis of haplotype and nucleotide diversity; neutrality test; phylogenetic networks; statistical parsimony; strict and relaxed molecular clock. 9. Adaptive genetic diversity: natural selection vs. neutral theory; genetic diversity and adaptive potential of populations/species; neutral genetic markers and markers under selection pressure; genetic drift; methods of identification of markers under selection pressure; marker deviation of overall population genetic differentiation. 10. Epigenetic diversity of natural populations: analysis of epigenetic markers (CRED-RA, MSAP); epigenetic structure of population; relationship between genetic and epigenetic diversity; impact of environmental factors, genetic bottleneck, hybridization, polyploidization and inbreeding depression on epigenetic diversity.
Students activities and evaluation of student work over the course of instruction: Attendance of lectures, making and presentation of seminars, solving of homework exams.
Methods of monitoring quality that ensure acquisition of exit competences: Final mark is the sum of marks of seminars, homeworks and final written exam.

Required literature:

Liber Z., Šatović, Z. 2012. Analysis of genetic diversity. Faculty of Science, Zagreb – script and lectures in PDF format

Optional literature:

Allendorf, F.W., Luikart, G.H. 2007. Conservation and the Genetics of Populations. Blackwell Publishing, Malden

Beebee, T., Rowe, G. 2008. An Introduction to Molecular Ecology: Second Edition. Oxford University Press, Oxford

Felsenstein, J. 2003. Theoretical Evolutionary Genetics. University of Washington, Department of Genetics, Seattle

Frankham, R., Ballou, J.D., Briscoe, D.A. 2002. Introduction to Conservation Genetics. Cambridge University Press, Cambridge

Gillespie, J.H. 1998. Population Genetics: A Concise Guide. The Johns Hopkins University Press, Baltimore - London

Maynard Smith, J. 1998. Evolutionary Genetics: Second Edition. Oxford University Press, Oxford

Nei, M. 1975. Molecular Population Genetics and Evolution. North-Holland Publishing Company, Amsterdam - Oxford

Templeton, A.R. 2006. Population Genetics and Microevolutionary Theory. John Wiley & Sons, Inc., Hoboken

Thompson, J.D. 2005. Plant Evolution in the Mediterranean. Oxford University Press, Oxford

Van Dyke, F. 2008. Conservation Biology: Foundations, Concepts, Applications. Second Edition. Springer Science + Business Media B.V., Springer-Verlag GmbH, Heidelberg

Weir, B.S. 1996. Genetic Data Analysis II: Methods for Discrete Population Genetic Data. Sinauer Associates, Inc. Publishers, Sunderland.

Name of the course: Cell Organisation And Function 151753
Course teachers: Professor Višnja Besendorfer, PhD; Faculty of Science, University of Zagreb Professor Biljana Balen, PhD; Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Biology, Cellular and Molecular Biology
Type of instructions: Lectures – 10 hours; Seminars – 10 hours
Credit value (ECTS): 7
Expected learning outcomes: Introduce new findings about cell structure and function from the molecular and evolutionary aspect based on relevant scientific literature Encourage students to critically read, analyse, summarise and interpret findings of relevant scientific literature
Course objectives: Organization (architecture) of the interphase nucleus, regulation of gene expression and chromatin remodelling, cell-cytoplasm interactions, organization and functionalisation of chromosomes. Biomembranes – organisation and function; membrane models; protein targeting and transmembrane transport. Mitochondria – overview of mitochondria and their functions; mitochondrial proteome; protein transport pathways into mitochondria; mitochondrial organizing network; nuclear-mitochondrial dual localization of proteins; PTMs of mitochondrial proteins. Chloroplasts – overview of cytosolic events for the targeting of proteins with a transit peptide into chloroplasts; chaperone involvement in the cytosol during protein transport to chloroplasts; chaperone involvement in the stroma during chloroplast protein import; PTMs of chloroplast proteins. Endoplasmic reticulum - ER translocation machineries; SRP-dependent pathway; GET (yeast) and WRB/CAML (mammals) pathway; possible fates of ER-translocated proteins Peroxisomes – overview of peroxisomes and their functions; peroxisome proteins; peroxisome biogenesis; peroxisomal matrix and membrane protein import; ER-derived route of peroxisome biogenesis.
Students activities and evaluation of student work over the course of instruction: Active participation in lectures; prepared seminar based on the selected relevant scientific paper(s); oral presentation of seminar
Methods of monitoring quality that ensure acquisition of exit competences: Quality of the prepared seminar and its oral presentation as well as interpretation and analyses of the findings from the selected literature.
Required literature: Alberts B, Bray D, Sewis J, Raff M, Roberts K, Watson JD, Molecular Biology of the Cell. Garland Publishing, Inc. New York, London, 1994 ili novije izdanje. Cooper G.DM. The cell, a molecular approach, ASM Press, Sinauer Associates, Inc. Sunderland, Massachusetts. Varki A, Cummings RD, Esko JD, Freeze HH, Stanley P, Bertozzi CR, Hart GW, Etzler ME, Essentials of Glycobiology, Cold Spring Harbor (NY): Cold Spring Harbor Laboratory Press; 2009.
Optional literature: Relevant scientific papers

Name of the course: Molecular Evolution 151754
Course: Dr. sc. Đurđica Ugarković, Dr. sc. Branka Bruvo Mađarić, Dr. sc. Martina Podnar Lešić
Doctoral study: Biology
Research field associated with the course programme: Biology: evolution and genetics
Type of instructions: lectures and seminars, 20 h (15 + 5)
Credit value (ECTS): 7
Expected learning outcomes: Getting novel insights into current knowledge about the evolution and organisation of eukaryotic genome, as well as about the methods of their investigation and analyses.
Course objectives: Lectures: - Types of genomic sequences and their organisation in the eukaryotic genome; - Evolutionary mechanisms which shape the eukaryotic genome; - Evolution of non-coding DNA; - Evolution of coding DNA (protein-coding and regulatory regions); - Molecular phylogeny and phylogeography, theory and methods of data analyses; - Bioinformatic analysis of the genome, comparative genomics. Seminars: Through the preparation and presentation of seminars, students get additional insight in various relevant topics in the field of molecular evolution and phylogenetics, such as: - Evolution of the genome and chromosomes; - Horizontal gene transfer; - "Junk DNA": transposons, highly repetitive DNA, SINE, LINE, microsatellites, pseudogenes, NUMTs, etc.; - Epigenetic mechanisms of gene regulation; - Evolution of tumor genome; - "Orphan genes"; - Phylostratigraphy; - Molecular clock.
Students activities and evaluation of student work over the course of instruction: Attending lectures, preparation and presentation of seminar topics.
Methods of monitoring quality that ensure acquisition of exit competences: Preparation and presentation of seminars, oral examination.
Required literature: M. Nei, S. Kumar (2000) Molecular evolution and phylogenetics. Oxford University Press, USA; 1st edition W-H. Li (2006) Molecular Evolution, Sinauer Associates. B.G. Hall (2011) Phylogenetic trees made easy: A how-to manual. Sinauer Associates, Inc.; 4th edition
Optional literature: J. Felsenstein (2003) Inferring phylogenies. Sinauer Associates; 2nd edition; J.C. Avise (2004) Molecular markers, natural history, and evolution. Sinauer Associates; 2nd edition; J.C. Avise (2006) Evolutionary pathways in nature: A phylogenetic approach. Cambridge University Press; 1st edition; Thalman et al. (2007) MBE; Harrison & Langdale (2006) Plant J; Keeling (2008) Nat Rev Gene; Khalturin et al. (2009) Trends Genet.; Domazet-Lošo et al. (2007) Trends Genet; Lanfear et al. (2010) TIEE; Kramerov (2011) Heredity; Tollervey & Lunyak (2012) Epigenetics ; Huang et al. (2012) Annu Rev Genet.

1. COURSE DESCRIPTION – GENERAL INFORMATION			
1.1. Course teacher	Dijana Škorić	1.6. Year and semester of study	1st year
1.2. Name of the course	Molecular Diversity of Viruses and Subviral Pathogens 151755	1.7. Credit value (ECTS)	7
1.3. Associate teachers		1.8. Type of instruction (number of hours L+S+E+e-learning)	15+5+0+0
1.4. Study programme (undergraduate, graduate, integrated)	Doctoral studies	1.9. Expected enrolment in the course	10
1.5. Status of the course	Elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1, 0%
2. COURSE DESCRIPTION			
2.1. Course objectives	Shifting the paradigm of viruses as pathogens and introducing new concepts of virosphere as a source of genetic diversity important in evolution of the living world, driving and regulating ecosystems including prokaryotic and eukaryotic systems in which they may act not only as pathogens but also as contributors to normal functioning of the host. Introducing students to the types of subviral pathogens and concepts related to them, noncoding genomes and prions as pathogenic proteins encoding information, diseases of subviral aetiology and importance of subviral and RNA world for the development of evolution and general biological concepts.		
2.2. Enrolment requirements and required entry competences for the course	Basic knowledge of molecular and cell biology, virology, genetics and population genetics. Good critical reading skills, basic molecular laboratory skills.		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Acquiring basic molecular concepts on biological entities smaller and simpler than viruses. Recognizing breakthrough findings in biology and microbiology. Changing the paradigm of viruses as pathogens. Realizing the impact of the noncoding RNAs and subviral agents on evolution and biological systems. Improving critical thinking, interpretation of published research and short oral presentations in English.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Getting informed on new concepts in virology and microbiology. Understanding the impact of viruses and subviral RNAs on the evolution of the living world. Grasping the vast diversity of viral and subviral pathogens. Understanding the biology of small RNA molecules and subviral pathogens.		

	<p>Understanding the principles underlying evolution of viruses and subviral pathogens. Introducing new trends in virology and related fields. Developing the skills of scientific results interpretation of and their public presentation.</p>					
2.5. Course content broken down in detail by weekly class schedule (syllabus)	<ol style="list-style-type: none"> 1. Viruses as pathogens and parasites, diversity of viral genomes and forms 2. Viruses as symbionts, horizontal gene transfer agents and ecosystem regulators 3. Definition of subviral pathogens, types of subviral pathogens (HDV, satellite viruses, satellite RNAs, viroids, prions) 4. Hypotheses on virus origins and evolution of life, the advent of giant viruses 5. Mechanisms underlying viral evolution (mutations, recombinations, rearrangements, antigenic shift and drift) 6. Genetics of viral populations, quasispecies concept, viral fitness 7. Evolutionary dynamics, selection pressure types 8. Host-virus coevolution, emerging viruses 9. Diversity of satellite RNAs and viroids as RNA pathogens and symbionts, relics of RNA-world 10. Origin and evolution of Hepatitis D agent 11. Noncoding RNA diversity and biology 12. Diversity and evolution of viral and subviral pathogens and their role in developing new antiviral therapies 13, 14, 15. Students seminars on a chosen topic. 					
12.1. Type of instruction	<input checked="" type="checkbox"/> lectures <input checked="" type="checkbox"/> seminars and workshops <input type="checkbox"/> exercises <input type="checkbox"/> online in entirety <input type="checkbox"/> mixed e-learning <input type="checkbox"/> field work	T	<input checked="" type="checkbox"/> independent study <input checked="" type="checkbox"/> multimedia and the internet <input type="checkbox"/> laboratory work with the mentor <input type="checkbox"/> (other)	12.2. C	Comments: Guidelines are provided by lectures and recommended literature given by the teacher. The doctoral students are expected to research additional literature online themselves and prepare a short oral presentation for the seminar.	
12.3. Student responsibilities	S					
12.4. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course):	Class attendance	required	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	40%	(Other--describe)	
	Tests		Oral exam	60%	(Other—describe)	
	Written exam		Project		(Other—describe)	
2.1. Grading and evaluation of student work over the course of instruction and at a final exam	Lecture attendance is required. Seminar oral presentation is graded excellent if full understanding of the topic is achieved, presentation well timed and conceptually correct and readiness to discuss the topic with reasonably solid confidence is shown. Oral exam entails understanding of the main concepts given throughout the lectures and seminars including the seminars of fellow students. If full understanding is achieved with clarity in impact and applications, it is graded as excellent.					
2.2. Required literature	Title		Number of		Availability	

(available at the library and via other media)		copies at the library	via other media
	J. Carter & W. Saunders, Virology-Principles and applications. J. Wiley & Sons, Ltd, England, 2nd edition, 2013.	1	Yes
	Viroids and Satellites. Eds: A. Hadidi, R. Flores, J. Randles, P. Palukaitis. Academic Press, 2017.	2	Yes
	Review and original research articles recommended by the teacher mainly available as pdfs via open access online.	0	Yes
2.12. Optional literature (at the time of the submission of the study programme proposal)	Origin and evolution of viruses (2nd Edition). Eds. E. Domingo, C. R. Parrish, J. J. Holland, Elsevier, 2008. The RNA World (3rd Edition). Eds: R. F. Gesteland, T. R. Check & J. F. Atkins, Cold Spring Harbor Laboratory Press, 2006.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Internal teacher evaluation survey.		

Name of the course: Integrative Physiology 151756
Course teacher: Prof. Zoran Tadić, associate professor, University of Zagreb, Croatia
Doctoral study: Biology
Research field associated with the course programme: Ecophysiology, Animal behaviour
Type of instructions: 5 lectures (3 hours each) + seminars (5 hours)
Credit value (ECTS): 7
Expected learning outcomes: After the course, the students will be able to understand the integrative functions of human/animal body exposed to the extreme terrestrial/extraterrestrial environments. The seminar encompasses current topics in extreme physiology/ecophysiology.
Course objectives: Understanding integrative function of human and animal bodies at the extreme of their performance in special environments.
Students activities and evaluation of student work over the course of instruction: The students will actively participate in seminar discussions. Every student has to present a seminar, based on contemporary paper from the field.
Methods of monitoring quality that ensure acquisition of exit competences: Seminars, active discussions.
Required literature: H.-C. Gunga: "Human Physiology in Extreme Environments", Academic Press/Elsevier, 2014, ISBN 9780123869470 (https://www.elsevier.com/books/human-physiology-in-extreme-environments/gunga/978-0-12-386947-0 - accessed on July 14, 2019) R. W. Hill, G. A. Wyse, M. Anderson: "Animal Physiology, 4 th ed.", Oxford University Press, 2017, ISBN 9781605357379 (chapter 15) (https://global.oup.com/ukhe/product/animal-physiology-9781605357379? – accessed on July 14, 2019) W. L. Kenney, J. Wilmore, D. Costill: "Physiology of Sport and Exercise, 7 th ed.", Human Kinetics, 2019, ISBN 9781492572299 (https://uk.humankinetics.com/products/physiology-of-sport-and-exercise-7th-edition-with-web-study-guide?_pos=7&_sid=fe69ab446&_ss=r – accessed on July 14, 2019.) S. C. Stearns, R. Medzhitov: "Evolutionary Medicine", Sinauer/Oxford University Press, 2015, ISBN 9781605352602 (http://global.oup.com/ukhe/product/evolutionary-medicine-9781605352602? – accessed on July 14, 2019.)

Name of the course: Mechanisms of cell regulation 194739
Course teacher: Assoc. Prof. Maja Matulić, Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: molecular biology
Type of instructions: lectures 10, seminars 5
Credit value (ECTS): 7
Expected learning outcomes: 1. to understand the principles of information transduction in the cell and signalling 2. to explain the mechanisms of transcriptional regulation 3. to explain the mechanisms of regulation on the level of translation and posttranslational modifications of proteins 4. to understand the principles of regulation of cellular programs during differentiation
Course objectives: Lectures: 1. Basic principles of signal transduction in the cell and types of signalling molecules; logics of signalization (1 h) 2. Transcription regulation: promoter structure, the role of chromatin, signal transduction to transcription factors, mechanisms of feed-back loops (2 h) 3. Regulation on the level of translation and posttranslational modifications, regulation by microRNA (1 h) 4. Regulation of the cell cycle and proliferation (2 h) 5. Regulation of cellular functions and structures by signalling: regulation of cytoskeleton and metabolic functions (2 h) 6. Cellular programs and their changes during differentiation (2 h) Seminars: Each student should have a seminar about some specific system of regulation in the cell (i. e. signalling pathways, mechanisms of differentiation of specific cell types).
Students activities and evaluation of student work over the course of instruction attending lectures and seminars, to hold a seminar on chosen topic
Methods of monitoring quality that ensure acquisition of exit competences: oral exam, seminar successfully held
Required literature: materials obtained on the lecture articles from scientific journals
Optional literature: Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A, Scott MP: Molecular Cell biology, Macmillan higher education, 7. ed, W. H. Freeman and Company, New York, 2013. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P: Molecular Biology of the Cell, Garland Science, 6. ed. Taylor & Francis Inc, 2014.

Name of the course: <u>Plant Embryogenesis</u> 151759
Course teacher: Prof. dr. sc. Dunja Leljak-Levanic, Faculty of Science, Zagreb Dr. sc. Snjezana Mihaljevic, Senior Research Associate, Ruder Boskovic Institute, Zagreb
Doctoral study: Biology
Research field associated with the course programme: Plant Developmental Biology
Type of instructions: lectures (5 hrs), seminars (4 hrs), lab practice (6 hrs), consultations (by appointment).
Credit value (ECTS): 6
Expected learning outcomes: Experimental approaches to study hard to reach cells of female and male gametophytes, fertilization with genetic and epigenetic background will be discussed. Zygotic embryogenesis, somatic embryogenesis and apomixis will be compared.
Course objectives: <ol style="list-style-type: none"> 1. Morphology of male and female gametophyte 2. Polarity and cell identity 3. Signaling between male and female gametophyte 4. Double fertilization 5. Embryogenesis and apomixes 6. Genetic and epigenetic regulatory mechanisms
Students activities and evaluation of student work over the course of instruction: Regular attendance of lectures, exercises and seminars, assessment during the semester by means of seminar papers and consultations.
Methods of monitoring quality that ensure acquisition of exit competences: Written exam (oral exam if necessary), oral presentation of seminars.
Required literature: During the course, all students will receive a CD with the relevant required literature.
Optional literature: During the course, all students will receive a CD with the relevant required literature.

Name of the course: Phenols in plant defense response 151760
Course teacher. Full Professor Gordana Rusak, Faculty of Science University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Biology (Molecular Biology of Plants)
Type of instructions: 8 hours of seminars, 7 hours of practical courses
Credit value (ECTS): 6
Expected learning outcomes: Defense response of pathogen attack activates signal pathways in invaded plant. These signal pathways include immediate responses of invaded cells, local and systemic responses as well as activation of related genes connected with local and systemic responses of invaded plant. The aim of this course is understanding of recent knowledge about molecular mechanisms of plant defense to pathogen attack.
Course objectives: Immediate responses of invaded cells (generation of ROS, nitric oxide synthesis, opening of ion channels, protein phosphorylation/dephosphorylation, hypersensitive reaction, gene induction) Local responses and gene activation (alterations in secondary metabolic pathways, cessation of cell cycle, synthesis of pathogenesis-related proteins, accumulation of benzoic and salicylic acid, production of ethylene and jasmonic acid, fortification of cell walls) Systemic responses and gene activation (systemically acquired resistance- SAR, synthesis of pathogen related proteins – glucanases, chitinases, peroxidases.
Students activities and evaluation of student work over the course of instruction Condensed practical courses include virus infection of test plants as well as monitoring of quantitative and qualitative changes in content of secondary metabolites (phenolics) as a consequence of infection. Spectrophotometric and HPLC (high performance liquid chromatography) analyses will be carried out. Seminars and project assignment based on practical courses are obligatory and they will be evaluated.
Methods of monitoring quality that ensure acquisition of exit competences: Project assignment will be connected with the results obtained in practical courses. Based on these results student should prepare report, including discussion and conclusion.
Required literature: Biochemistry&Molecular Biology of Plants, B.B. Buchanan, W. Gruissem, R.L Jones (Eds.), Wiley Blackwell, 2016.

Name of the course: MECHANISMS OF PLANT RESPONSES TO STRESS 151761
Course teacher Assoc. prof. Sandra Radić Brkanac, Ph.D., Faculty of Science, University of Zagreb Assoc. prof. Željka Vidaković-Cifrek, Ph.D., Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: BIOLOGY; Botany / Biochemistry and Molecular Biology
Type of instructions: 8 hours seminars, 7 hours laboratory work
Credit value (ECTS): 6
Expected learning outcomes: -to explain mechanisms of plant responses to stress conditions through seminars and laboratory work -to gain experience in techniques applied in laboratory work -to apply obtained knowledge in planning and realisation of laboratory work, collection and interpretation of obtained results
Course objectives EFFECT OF STRESS CONDITIONS ON PHYSIOLOGICAL PROCESSES IN PLANTS – abiotic stress conditions (water deficit, osmotic stress, salinity, hypoxia and anoxia in rhizosphere, heat stress, chilling and freezing, light and UV-stress, heavy metals' effect, xenobiotics); biotic stress; changes on whole plant level (growth, development, reproduction); plant defence and repair mechanisms. MODEL PLANTS IN STRESS PHYSIOLOGY – characteristics of model plants Mesembryanthemum crystallinum, Lemna minor, Arabidopsis thaliana and application in stress physiology OXYDATIVE STRESS – induction of reactive oxygen species under stress conditions and antioxidative response (antioxidative enzymes and nonenzymatic antioxidants) METHODS OF EVALUATION OF PLANT RESPONSES TO STRESS – measurements of products of lipid peroxidation, products of protein oxidation, H ₂ O ₂ content, activity of antioxydative enzymes (guaiacol-, pyrogallol- and ascorbate peroxidase, catalase, superoxide dismutase), metabolites induced by stress (proline, ascorbate, glutathione) EFFECT OF STRESS CONDITIONS ON PHOTOSYNTHESIS AND RESPIRATION – determination of respiration and photosynthetic rate by Clark oxygen electrode, chlorophyll fluorescence analysis by saturation pulse method
Students activities and evaluation of student work over the course of instruction Attendance and active participation on seminars and experimental work; seminar in oral form, planning of the laboratory work, work in the laboratory
Methods of monitoring quality that ensure acquisition of exit competences: Seminars, reports on laboratory work
Required literature: Buchanan, B., Gruissem, W., Jones, R. L. (2015): Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists. Wiley Blackwell. Taiz, L., Zeiger, E. (2010): Plant Physiology. Sinauer Associates, Inc., Sunderland, Massachusetts.
Optional literature: Inzé, D., van Montagu, M. (2002): Oxidative Stress in Plants. Taylor & Francis Inc, London, New York. Prasad, M. N. V. (2004): Heavy Metal Stress in Plants. From Biomolecules to Ecosystems. Second Edition. Springer-Verlag Berlin Heidelberg. Scientific publications

Name of the course: Biological and hormonal control of plant diseases 151762
Course teacher: Mirna Ćurković Perica, Full Prof, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: microbiology and plant biology
Type of instructions: practicals (8), seminar (7)
Credit value (ECTS): 6
Expected learning outcomes: The aim of the course is to familiarize students with the application of biological control and plant growth regulators in the suppression of certain plant diseases. Students will gain insight into the connection between basic biological research with applied research in agriculture and forestry. During the practicum, students will learn how to cultivate some plant pathogens <i>in vitro</i> and detect them on the molecular level. Students will learn to design and perform an experiment or research, and present their results.
<p>Course objectives: (<i>razraditi ih što preciznije, po mogućnosti prema nastavnim tjednima</i>):</p> <ul style="list-style-type: none"> • Plant pathogens: fungi, bacteria and viruses • Methods for detection of plant pathogens (serological, ELISA; different versions of PCR, nested RT, real-time PCR) • Phytoplasmas • The effect of plant growth regulators on phytoplasmas • Chestnut blight • Biological control of chestnut cancer hypovirusom • Genetically modified plants resistant to plant pathogens <p>Practicals: Cultivation of virulent and hypovirulent strains of the fungus <i>Cryphonectria parasitica</i> in the laboratory conditions and detection of hypovirus. Alternatively: Cultivation of phytoplasmas in <i>Catharanthus roseus</i> shoots grown <i>in vitro</i>, effect of auxins on phytoplasmas and molecular detection of phytoplasmas.</p>
<p>Students activities and evaluation of student work over the course of instruction:</p> <p>Active participation in practical work in the lab that will include independent tasks and results analysis, and preparation of report.</p>
Methods of monitoring quality that ensure acquisition of exit competences: oral examination
<p>Required literature:</p> <p>Ambriović Ristov A. et al. Metode u molekularnoj biologiji. Institut Ruđer Bošković, 2007. Ausubel F M. et al. Current Protocols in Molecular Biology. John Wiley and Sons, New York 1994. Leljak-Levanić et al. Biochemical and epigenetic changes in phytoplasma-recovered periwinkle after indole-3-butyric acid treatment. Journal of Applied Microbiology. 109 (2010) 2069-2078 Kišpatić J. Opća fitopatologija. Fakultet poljoprivrednih znanosti Sveučilišta u Zagrebu, 1985. Nuss DL. Hypovirulence: Mycoviruses at the fungal-plant interface. Nature Reviews. Microbiology. 3 (2005): 632-642.</p>
<p>Optional literature:</p> <p>Agrios GN. Plant Pathology. Academic Press, San Diego, 1997 (2004). Jelaska S. Kultura biljnih stanica i tkiva. Školska knjiga, Zagreb, 1994. Juretić N. Osnove biljne virologije. Školska knjiga, Zagreb, 2002.</p>

1. COURSE DESCRIPTION – GENERAL INFORMATION			
1.3. Course teacher	Dijana Škorić	1.11. Year and semester of study	2nd year
1.4. Name of the course	Plant-Pathogen Molecular Interactions 151763	1.12. Credit value (ECTS)	6
1.4. Associate teachers	Martina Šeruga Musić	1.13. Type of instruction (number of hours L+S+E+e-learning)	8+3+4+0
1.5. Study programme (undergraduate, graduate, integrated)	Doctoral studies	1.14. Expected enrolment in the course	5
1.6. Status of the course	Elective	1.15. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1, 0%
2. COURSE DESCRIPTION			
12.1. Course objectives	Overview of different plant-pathogen interactions especially with regard to their molecular aspects. Introducing modern concepts and plant-microbe interactions achievements made in the last decade. Stressing the interplay of basic molecular biology aspects and possibilities for solving practical problems in agriculture. Improving skills in interpreting and presenting published research findings, critical thinking, improving knowledge on the principal methods and strategies for research of plant-pathogen molecular interactions.		
12.2. Enrolment requirements and required entry competences for the course	Basic knowledge of molecular and cell biology, virology, bacteriology, genetics. Good critical reading skills, good molecular laboratory skills.		
12.3. Learning outcomes at the level of the study programme to which the course contributes	Exposure to new scientific findings and their implications. Acquiring basic molecular concepts on interactions of microbes and plants. Recognizing breakthrough findings in microbiology. Changing the paradigm of plants as passive microbial hosts. Realizing the impact of bacterial and viral pathogens for development and evolution of biological systems and solving practical agricultural problems. Improving critical thinking, interpretation of published research and short oral presentations in English. Improving project design and writing skills.		
12.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Getting informed on new concepts in molecular basis of bacterial and viral interactions with plants. Understanding the impact of bacteria and viruses on the evolution plants. Grasping the diversity of molecular interaction types and regulation in plants. Understanding the biology of main interaction types. Introducing new trends in molecular plant-microbe interactions. Developing the skills of scientific results interpretation of and their public presentation.		
12.5. Course content broken down in detail by weekly class schedule (syllabus)	<ol style="list-style-type: none"> 1. Plant systems for recognizing pathogens, pathogenesis in plant cell and organism upon infection with subviral, viral, bacterial or fungal pathogen – molecular and evolutionary aspects. 2. Viral and other pathogen type movements within a plant host, innate and acquired immunity or resistance, signal transduction in defence. 		

	<ol style="list-style-type: none"> 3. Conventional plant protection methods and reasons for their inefficiency against viruses, phytoplasmas and fungi, alternative strategies, GMOs. 4. Molecular mechanisms of fungal, bacterial and phytoplasma pathogenicity. 5. Reductive evolution of phytoplasma genomes, parasitism in two kingdoms. 6. Plant-bacterial molecular interactions. Horizontal gene transfer. 7. Molecular mechanisms of plant virus and satellite RNA pathogenesis. 8. Mechanisms underlying viroid pathogenicity. 9. Post-transcriptional gene silencing (PTGS), RNA silencing, RNA interference in plant defence and pathogen counter defence 10. Comparative functional genomics of plants and their pathogens. 11. Interactions of parasite and host genomes and gene products. 12. Parasites in plant genome evolution, selection pressure of plant hosts in plant pathogen evolution (molecular interactions and their biological consequences). 13., 14. Preparation and presentation of projects 						
<p>a. Type of instruction</p>	<input checked="" type="checkbox"/> lectures <input checked="" type="checkbox"/> seminars and workshops <input type="checkbox"/> exercises <input type="checkbox"/> online in entirety <input type="checkbox"/> mixed e-learning <input type="checkbox"/> field work	<input checked="" type="checkbox"/> independent study <input checked="" type="checkbox"/> multimedia and the internet <input type="checkbox"/> laboratory <input type="checkbox"/> work with the mentor <input type="checkbox"/> (other)	<p>b. Comments:</p>			<p>Guidelines are provided by lectures and recommended literature given by the teachers. The doctoral students are expected to research additional literature online themselves and prepare a written research project. A short oral presentation, including a discussion, is given as a seminar to defend their potential research project.</p>	
<p>c. Student responsibilities</p>							
<p>d. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course):</p>	Class attendance	required	Research		Practical training		
	Experimental work		Report				
	Essay		Seminar essay		Oral presentation with a discussion (project defence) (Other--describe)		
	Tests		Oral exam	40%	(Other—describe)		
	Written exam		Project	30%	(Other—describe)		
<p>2.3. Grading and evaluation of student work over</p>	<p>Lecture attendance is required. Written project proposal is graded by teachers before the oral defence. Oral presentation is graded excellent if full</p>						

the course of instruction and at a final exam	understanding of the topic is achieved, good research plan presented with risks and possible solutions as demonstrated by the presentation and discussion. Oral exam entails mastering the concepts presented by teachers.		
2.4. Required literature (available at the library and via other media)	Title	Number of copies at the library	Availability via other media
	Review and original research articles selected by the teachers (mainly as free access pdfs).		yes
	Molecular Plant Pathology. Ed. M. Dickinson, Blackwell, 2000;	1	yes
	Molecular Plant Pathology (Advanced texts). Ed. M. Dickinson, BIOS Scientific Publishers, 2003.	1	yes
	Natural Resistance Mechanisms of Plants to Viruses. Eds. G. Loebenstaein, J. P. Carr, Springer, 2006.	1	yes
2.14. Optional literature (at the time of the submission of the study programme proposal)	Review and original research articles recommended by the teachers.		
2.15. Methods of monitoring quality that ensure acquisition of exit competences	Internal teacher evaluation survey.		

COURSE: 'omics' research: Application in disease detection and analysis. 151764

AUTHOR OF COURSE PROGRAMME:

Dr. sc. Oliver Vugrek, senior scientist; Institut Ruđer Bošković

TEACHING TECHNIQUES:

Lectures and practical course, 15hours (6h lectures, 9h course)

ECTS: 6

COURSE ACHIEVEMENTS:

This course will present and discuss technologies, which use genomic information to address the function of the molecules encoded by the genome, what is commonly referred to as functional genomics, proteomics and metabolomics, or newly termed as 'omics' research. Students will gather insights in approaches to NGS technology, i.e. massive-parallel DNA sequencing (NEXT-GENERATION-SEQUENCING), in both theoretical and practical knowledge of NGS technology in practice examples.

COURSE PROGRAMME:

This course will present methods and techniques using genomic information for the purpose of finding the function of molecules encoded by the genome, an approach commonly referred to as "functional genomics, proteomics and metabolomics, or short" omics' method. Accordingly, a short introduction in the biochemistry of nucleic acids, PCR, RNA-analysis and DNA-sequencing will be given, mutational analysis, recombinant DNA technology, heterologous gene expression, recombinant protein purification and functional analysis, RNA interference, and CrispR-Cas9 technology. Students will gather insights in approaches to NGS technology, i.e. **massive-parallel DNA sequencing** (NEXT-GENERATION-SEQUENCING). The laboratory has two Illumina devices (NextSeq500 and MiniSeq), and will bring participants closer to the theoretical and practical knowledge of NGS technology in practice examples.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Seminars and project tasks; oral and written exam

OBLIGATORY LITERATURE:

1. Barić I, Fumić K, Glenn B, Čuk M, Schulze A, Finkelstein J D, Jill James S, Mejaški-Bošnjak V, Pažanin L, Pogribny I P, Radoš M, Sarnavka V, Šćukanec-Špoljar M, Allen R H, Stabler S, Uzelac L, Vugrek O, Wagner C, Zeisel S, Mudd H: S-adenosylhomocysteine hydrolase deficiency in a human: A genetic disorder of methionine metabolism. Proc. Natl. Acad. Sci. U.S.A. 2004: 101(12), 4234-4239.
2. Buist NRM, Glenn B, Vugrek O, Wagner C, Stabler S, Allen RH et al. S-Adenosylhomocysteine hydrolase deficiency in a 26-year-old man. J Inher Metab Dis 2006; 29: 538-545
3. Belužić R, Čuk M, Pavkov T, Fumić K, Barić I, Mudd SH, Jurak I, Vugrek O: A single mutation at tyrosine 143 of human S-adenosylhomocysteine hydrolase renders the enzyme thermosensitive and effects the oxidation state of bound co-factor NAD. Biochemical J 2006; 400: 245-253.
4. Fumić K, Belužić R, Čuk M, Pavkov T, Kloor D, Barić I, Mijić I, Vugrek O: Functional analysis of human S-adenosylhomocysteine hydrolase isoforms SAHH-2 and SAHH-3. Eur J Hum Gen 2007; 15, 347-351.
5. Beluzic R, Cuk M, Pavkov T, Baric I, and Vugrek O: S-Adenosylhomocysteine hydrolase (AdoHcyase) deficiency: Enzymatic capabilities of human AdoHcyase are highly effected by changes to codon 89 and its surrounding residues. Biochemical and Biophysical Research Communications 2008, 368: 30-36.
6. Vugrek O, Belužić R, Nakić N, Mudd SH: S-Adenosylhomocysteine hydrolase (AHCY) deficiency: Two novel mutations with lethal outcome. Human Mutation, 2009: 30 (4): E555-E565.
7. Honzik T; Magner M; Krijt J; Sokolova J; Vugrek O; Beluzic R; Baric I; Hansikova H; Elleder M; Vesela K; Bauerova L; Ondruskova N; Jesina P; Zeman J; Kozich V: Clinical picture of S-adenosylhomocysteine hydrolase deficiency resembles phosphomannomutase 2 deficiency. Molecular Genetics and Metabolism (2012); 107 (3), 611–613.
8. Strauss KA, Ferreira C, Bottiglieri T, Zhao X, Arning E, Zhang S, Zeisel SH, Escolar ML, Presnick N, Puffenberger EG, Vugrek O, Kovacevic L, Wagner C, Mazariegos GV, Mudd SH, Soltys K. Liver transplantation for treatment of severe S-adenosylhomocysteine hydrolase deficiency. Mol Gen and Metabolism 116 (2015), 44-52.
9. Motzek A, Knežević J, Switzeny OJ, Barić I, Belužić R, Strauss KA, Puffenberger EG, Mudd SH, Vugrek O*, Zechner U (2016). Abnormal hypermethylation at imprinting control regions in patients with S-adenosylhomocysteine hydrolase (AHCY) deficiency, PLoS ONE 11

(3):e0151261.

10. Lepur A, Kovačević K, Belužić R, Vugrek O* (2016). Combining Unique Multiplex Gateway Cloning and Bimolecular Fluorescence Complementation (BiFC) for High-Throughput Screening of Protein–Protein Interactions. *Journal of Biomolecular Screening*, 21 (10), 1100-1111. DOI: 10.1177/1087057116659438
11. Grbeša I, Kalo A, Belužić R, Kovačević L, Lepur A, Hochberg H, Kanter I, Simunović V, Muñoz-Torres PM, Shav-Tal Y, Vugrek O* (2017). Mutations in S-adenosylhomocysteine hydrolase (AHCY) effect its nucleocytoplasmic distribution and capabilities for interaction with S-adenosylhomocysteine hydrolase-like 1 protein. *European Journal of Cell Biology*, 96(6):579-590. doi: 10.1016/j.ejcb.2017.05.002.
12. Belužić, L., Grbeša, I., Belužić, R., Park, J. H., Kong, H. K., Kopjar, N., ... Vugrek, O*. (2018). Knock-down of AHCY and depletion of adenosine induces DNA damage and cell cycle arrest. *Scientific Reports*, 8(1), 14012. <http://doi.org/10.1038/s41598-018-32356-8>

SUPPLEMENTARY LITERATURE:

- De Clercq E: John Montgomery's Legacy: Carbocyclic Adenosine Analogues as SAH Hydrolase Inhibitors with Broad-spectrum Antiviral Activity. *Nucleos Nucleot Nucleic Acids* 2005, 24: 1395-1415.
- Robertson KD: DNA Methylation and human disease. *Nature Rev Gen* 2005, (6): 597-610.

Additional literature based on newest releases at lecture start

Name of the course: <u>IMMUNOREGULATION</u> 151871
Course teacher <u>MODERATOR/LECTURER:</u> Asst. Prof. Alenka Gagro, MD, PhD, Research Adviser, Department of Pediatrics, Pulmology, Allergology, Immunology and Rheumatology Division, Children's Hospital Zagreb, Klaićeva 16, 10000 Zagreb
Doctoral study: Biology
Research field associated with the course programme: FIELD: 3.01; BRANCH: 13: immunology and immunohematology; SCIENTIFIC PROJECT SUPORTED BY MINISTRY OF SCIENCE, EDUCATION AND SPORTS (2006-2014): Modulation of human regulatory T cells function
Type of instructions: lectures: 8 seminars: 4 practicals: 3
Credit value (ECTS): 6
Expected learning outcomes: The course provides the basic principles and mechanisms of regulation of immunity with special emphasis on regulatory T cells. The role of regulatory cells in different experimental animal models as well as human diseases (autoimmune, autoinflammatory, allergy, tumors, infections, graft versus host reactions) will be presented. Upon completing the course, the students will accept basic knowledge of the role of regulatory cells in immunity and will be able to critically follow the recent published papers in this field. Also, the students will accept practical skills to perform laboratory methods used to determine regulatory T cells and their function by flow cytometry and <i>in vitro</i> functional assays.
Course objectives: <u>Lectures:</u> Definitions of immunoregulation, immune tolerance (peripheral and central) and immunosuppression. Types of regulatory cells (natural, induced) and their markers. The role of Th3, Tr1, Th17, Th22 and Th9 lymphocytes in immunoregulation. Animal models for investigation of immunoregulatory mechanisms. Examples of disturbed immunoregulation in human diseases. Possibilities for modulation of regulatory cells. <u>Practicals:</u> Determination of regulatory T cells and immunoregulatory cytokines (IL-10, TGF- β) by multicolor flow cytometry analysis. <i>In vitro</i> methods for examination of regulatory T cell function. <u>Seminars:</u> Cellular therapy with regulatory T cells. Immunotolerance to allergens.
Students activities and evaluation of student work over the course of instruction Active participation in all aspects of the course, including the Journal Club. Taking part in students' discussion groups, completing the seminar with independent literature topic research in the field of immunoregulation and short oral presentation of the results using the Power Point.
Methods of monitoring quality that ensure acquisition of exit competences: Written test or presentation of project proposal in the field of immunoregulation.

Required literature:

Murphy K, Janeway's Immunobiology, 8th edition. New York: Garland Science, Taylor & Francis Group; 2011.

1. Marinic I, Gagro A, Rabatic S. Regulatory T cells. *Acta Med Croatica* 2006;60:447- 56.
2. Ajduk J, Turkalj M, Gagro A. Regulatory T cells in children undergoing rush venom immunotherapy. *Allergy Asthma Proc* 2012;33:525-30.
3. Banchereau J, Pascual V, O'Garra A. From IL-2 to IL-37: the expanding spectrum of anti-inflammatory cytokines. *Nat Immunol* 2012;13:925-31.
4. Yuan X, Malek TR. Cellular and molecular determinants for the development of natural and induced regulatory T cells. *Hum Immunol* 2012;73:773-82.
5. Fujita H, Meyer N, Akdis M, Akdis CA. Mechanisms of immune tolerance to allergens. *Chem Immunol Allergy* 2012;96:30-8.
6. Cretney E, Kallies A, Nutt SL. Differentiation and function of Foxp3(+) effector regulatory T cells. *Trends Immunol* 2013;34:74-80.

Optional literature:

The most recent and relevant scientific papers in the field will be presented and discussed during seminars.

1. Miyara M, Ito Y, Sakaguchi S. TREG-cell therapies for autoimmune rheumatic diseases. *Nat Rev Rheumatol* 2014;10:543-51.
2. Roychoudhuri R, Eil RL, Restifo NP. The interplay of effector and regulatory T cells in cancer. *Curr Opin Immunol*. 2015 Feb 26;33C:101-111. doi: 10.1016/j.coi.2015.02.003. [Epub ahead of print]
3. Li Z, Li D, Tsun A, Li B. FOXP3+ regulatory T cells and their functional regulation. *Cell Mol Immunol* 2015; doi: 10.1038/cmi.2015.10. [Epub ahead of print]

Name of the course: MOLECULAR BIOLOGY OF NEURODEGENERATIVE DISORDERS 151765
Course teacher: Senior Scientist, Silva Katušić Hećimović, Ruđer Bošković Institute
Doctoral study: Biology
Research field associated with the course programme: Life sciences, neuroscience, neurobiology
Type of instructions: I SATI NASTAVE: Lectures (10h), seminars (5h) – in total 15h
Credit value (ECTS): 6
<p>Expected learning outcomes: In this course students will gain knowledge on molecular details of neurodegenerative diseases, including the most common disorders such as Alzheimer's disease and Parkinson's disease and rare inherited disorders such as Huntington's disease and a lysosomal storage disorder Niemann-Pick type C. The course will cover genetic aspects of inherited and „sporadic“ forms of neurodegenerative diseases, protein biology and molecular mechanism(s) of these disorders. Additionally, the course will illuminate some of the novel animal and cellular models, novel treatment strategies and the biomarker discovery programmes aiming for an early and accurate diagnosis of neurodegenerative disorders.</p>
<p>Course objectives: This course will fulfil the following objectives: 1) To gain knowledge on clinical and pathological features of several neurodegenerative disorders, such as Alzheimer's disease, Parkinson's disease, Huntington's disease and a rare lysosomal storage disorder Niemann-Pick type C. Discuss their similarities and their differences in respect to brain pathology, morphological changes of the brain and the proposed mechanisms. 2) To learn about genetics of neurodegenerative disorders. Describe genetic aspects of inherited and „sporadic“ forms of neurodegenerative disorders, monogenic and complex diseases and methods used to identify new genes/genetic risk factors of complex traits. 3) To gain knowledge about molecular and cellular biology of neurodegenerative disorders. Using the proposed hypothesis and current knowledge describe the mechanisms of several neurodegenerative disorders, (dys)function of some of the key proteins leading to protein accumulation and aggregation in the brain and neuronal loss and degeneration. 4) To learn about new animal and cellular models used to study molecular detail of neurodegenerative diseases and to test novel therapies. The course will describe some of the new animal and cellular models of neurodegenerative disorders and how well they replicate human diseases. Induced pluripotent stem cell technology (iPSC) will be discussed as a tool to model human neurons. 5) To gain knowledge on biomarker discovery programmes, their benefit in respect of early and accurate diagnosis, monitoring the disease progression and/or the efficacy of the therapy.</p>
<p>Students activities and evaluation of student work over the course of instruction: Students are obliged to attend lectures and after the each course objective they will present a seminar work.</p>
<p>Methods of monitoring quality that ensure acquisition of exit competences: Oral examination and presentation of the seminar work.</p>

Name of the course: Cell Response to Genotoxic Agents 151766
Course teacher Ph. D. Anamaria Brozović, Senior Scientist
Doctoral study: Biology
Research field associated with the course programme: Biology, Molecular biology
Type of instructions (in hours) 7 lectures , 4 seminars, 4 training
Credit value (ECTS): 6
Expected learning outcomes: The knowledge about signaling pathways and molecular mechanisms that are activated following the cell treatment with genotoxic and non-genotoxic agents will be obtained. Also, the knowledge about molecular mechanisms involved in drug resistance of tumor, along with the molecular biology methods which helped to resolve these mechanisms will be obtained.
Course objectives: Cell exposure to cytotoxic compounds can cause diverse harmful effects. As maintenance of genomic stability is essential for the survival of organisms, during the evolution the cells have developed numerous strictly regulated pathways to minimize these effects. The events that influence cell response can be principally divided in two groups: those that occur upstream of DNA damage, or downstream of it. Generally, the first group involves cell adhesion, activation of membrane transporters, glutathione (as the protective molecule, as well as the central molecule for redox state regulation, and modification of signalling pathways). Cells survival is supported by two signalling cascades, PI-3K/PKB and NF-kappaB cascades. In cell response to genotoxic agents DNA repair has an important role. If the cells cannot repair the damage, cell death will occur (necrosis, apoptosis, autophagy). The activity of the key molecules involved in cell death (p53 family proteins, Bcl-2 family proteins, caspases, their inhibitors, inhibitors of caspases inhibitors, cathepsins etc.) is very precisely regulated. The final outcome of cell exposure to certain genotoxic agent is a complex process that depends on the cell-type and cell status, as well as on the agent itself. Very similar processes are involved in cell defense against non-genotoxic agents. Briefly, in this course the cascades of events that are activated following the cell treatment with genotoxic and non-genotoxic agents will be presented that may influence the final outcome: cell adhesion, activity of cell transporters, activity of Rho GTPases, glutathione, DNA damage repair, and the activation of cells death, signalling pathways that are involved in these processes and their interaction, as well as the molecular mechanisms that are involved in drug-resistance. In addition, the obtained knowledge will be used to understand the personalized medicine approach to each patient.
Students activities and evaluation of student work over the course of instruction Lectures attendance, participation in training, seminar work
Methods of monitoring quality that ensure acquisition of exit competences Written and oral exam
Required literature: 1. Köberle B., Tomicic M., Usanova S., Kaina B. (2010) Cisplatin resistance: Preclinical findings and clinical implications- Review. Biochem. Biophys. Acta, 1806:172-182. 2. Roos W.P., Bernd K. (2013) DNA damage-induced cell death: From specific DNA lesions to the DNA damage response and apoptosis. Mini-review. Cancer Lett. 332:237-48. 3. Dey A., Lane D.P. , Verma C.S. (2010) Modulating the p53 pathway- Review. Sem. Cancer Biol. 20: 3–9. 4. Rodriguez-Nieto S., Zhivotovsky B.(2006) Role of Alterations in the Apoptotic Machinery in Sensitivity of Cancer Cells to Treatment Current Pharmaceutical Design, 2006, 12, 4411-4425. 5. Kelly G., Andreas Strasser (2011) The essential role of evasion from cell death in cancer. Adv. Cancer Res. 111: 39–96. 6. Circu M.L., Aw T.Y. (2010) Reactive oxygen species, cellular redox system and apoptosis. Free Radic. Biol. Med. 48: 749–762.
Optional literature: 1. Hanahan D., Weinberg R.A. (2011) Hallmarks of cancer: The next generation. Cell 144: 646-674. 2. Brozović, A., Majhen, D., Roje, V., Mikac, N., Jakopec, S., Fritz, G., Osmak, M., Ambriovic

Ristov,A.: $\alpha V\beta 3$ integrin mediated drug resistance in human laryngeal carcinoma cells is caused by glutathione dependent elimination of drug induced reactive oxidative species. *Mol. Pharmacol.* 74 (2008) 1-9, 2008.

3. Čimborá-Zovko T., Fritz G., Mikac N., Osmak M.: Downregulation of RhoB GTPase confers resistance to cisplatin. *Cancer Lett.*, 295 (2010) 182-190.

Name of the course: Glycobiology 151767
Course teacher: Olga Gornik, Associate Professor, Faculty of Pharmacy and Biochemistry Sanja Dabelić, Associate Professor, Faculty of Pharmacy and Biochemistry Toma Keser, Research and Teaching Assistant
Doctoral study: Biology
Research field associated with the course programme: Biology, Biochemistry and Molecular Biology
Type of instructions: 6 lectures, 3 seminars, 6 practicals
Credit value (ECTS): 6
Expected learning outcomes: Students will receive an insight into the process of glycosylation of biomolecules as well as learn about the role of glycans in physiological and pathological processes.
Course objectives: Over the past decade glycobiology has developed into the one of the most progressive and the most propulsive scientific disciplines. Glycosylation is essential for numerous physiological and pathophysiological processes, from embryonic development and intercellular recognition, to inflammatory processes and tumor metastasis. A recent information showed that only 0.7% of simple membrane proteins are not glycosylated or in complex with another glycoprotein. Unfortunately, despite the undoubted importance of glycosylation, as the most widespread and diverse post-translational modification, during undergraduate studies students learn very little about it at the Faculty of Science, Pharmacy and Biochemistry and the School of Medicine. This course is designed as a short recap of the basic mechanisms and roles of glycosylation in the normal organism, with emphasis on changes in glycosylation that occur in different diseases. The desire is to give students an insight into the latest findings and their application in diagnostics.
Objectives: Lecture 1 and 2: To get an insight into: <ul style="list-style-type: none"> • glycoconjugates and their distribution in the body • information capacity glycoconjugates, recognizing sugar-protein and sugar-sugar • biosynthesis of glycoconjugates (N- and O-glycosylated proteins, glycolipids) Lecture 3 and 4: To learn about: <ul style="list-style-type: none"> • key role of glycosylation during embryonic development • physiologically normal differences in glycosylation (blood types, polymorphism of glycoforms) • role of glycosylation in inflammatory processes (selectins, acute phase proteins, etc.). • glycosylation of immunoglobulins and its importance in the development of disease (rheumatoid arthritis, allergy) Lecture 5 and 6: <ul style="list-style-type: none"> • diagnostic significance of glycosylation • glycoconjugates as tumor markers • the impact of glycosylation on the pharmacokinetics of recombinant drugs • methods of analysis of glycosylation (HPAEC, HPLC, MS, lectins) The newest insights about mentioned topics will also be discussed during seminars and the analytical methods will be covered by practical courses.
Students activities and evaluation of student work over the course of instruction
Beside attending lectures and practicals, students will prepare (write and orally present) seminars on

the different topics from the field of glycobiology. These seminars will be evaluated.

Methods of monitoring quality that ensure acquisition of exit competences: The final grade will be formed on the basis of seminar and oral exam.

Required literature:

Essentials of Glycobiology. 3rd edition.

Varki A, Cummings RD, Esko JD, et al., editors.

Cold Spring Harbor (NY): Cold Spring Harbor Laboratory Press; 2015-2017.

This book has free online access at:

<https://www.ncbi.nlm.nih.gov/books/NBK310274/>

Optional literature: Scientific papers in the field (students can get these in print or electronic version from lecturers)

Name of the course: Molecular basis of behavioral disorders 151768
Course teacher Dubravka Hranilović, professor, University of Zagreb, Faculty of Science
Doctoral study: Biology
Research field associated with the course programme: neuroscience
Type of instructions: : lectures (6 hrs), seminars (5 hrs), laboratory work (4 hrs)
Credit value (ECTS): 6
<p>Expected learning outcomes:</p> <ul style="list-style-type: none"> - to understand how molecular changes can lead to behavioral alterations - to integrate animal model approach and population-based approach in studies of behavioral disorders - to present the selected topic in a form of a short oral presentation - to operate with basic molecular, statistical and behavioral methods in psychiatric genetics - to interpret the obtained experimental results
<p>Course objectives: (five 3-period teaching units):</p> <p>1st teaching unit: Lecture: Alterations in brain development and neural transmission as basis for behavioral disorders <ul style="list-style-type: none"> - electrical and chemical neurotransmission and their disorders - development of nervous system and its alterations </p> <p>2nd teaching unit: Lecture: Methods for studying genetics of complex disorders studies in human population: classic genetic studies, molecular genetic studies <ul style="list-style-type: none"> - studies on animal models: candidate gene based approach, linkage analyses </p> <p>3rd teaching unit: Seminar: genotypization Laboratory work: polymerase chain reaction, enzymatic digestion of the PCR product</p> <p>4th teaching unit: Laboratory work: electrophoresis and data analyses Seminar: statistical problems and possible solutions</p> <p>5th teaching unit: Student seminars: Based on the recent papers in the field, students will prepare and report on the latest discoveries, controversies or dilemmas within the scope of the course</p>
<p>Students activities and evaluation of student work over the course of instruction</p> <ul style="list-style-type: none"> - students must prepare and present a seminar, engage in discussions, and perform practical work in the lab
<p>Methods of monitoring quality that ensure acquisition of exit competences:</p> <ul style="list-style-type: none"> - good quality of seminar, contribution to discussions following each seminar, and results of practical work will demonstrate acquisition of exit competences
<p>Required literature: written material handed out before each lecture</p>
<p>Optional literature: papers on genetics and epigenetics of behavioral disorders.</p>

<p>Name of the course: EXPERIMENTAL AND MOLECULAR NEUROPHARMACOLOGY 151769</p>
<p>Course teacher: Dubravka Svob Strac, PhD, Senior Research Associate, Laboratory for Molecular Neuropharmacology, Division for Molecular Medicine, Ruder Boskovic Institute</p>
<p>Doctoral study: Biology</p>
<p>Research field associated with the course programme: Basic medical sciences: Neuroscience</p>
<p>Type of instructions: Lectures (4 hours), Practicals (5 hours), Seminars (6 hours)</p>
<p>Credit value (ECTS): 6</p>
<p>Expected learning outcomes: The aim of the course is to explain to students, how by using different neuropsychotropic drugs, and by studying their effects and mechanisms of action, they can get valuable information about normal as well as disturbed brain neurotransmission. During the course different ways in which neuropsychotropic drugs can "repair" existing disturbances in the transmission of nerve signals will be explained. Moreover, selected experimental models and methodological approaches used in the study of neuropsychotropic drugs will be demonstrated. The examples how these medications can be used as a useful "tool" in neurobiological research will be presented.</p>
<p>Course objectives:</p> <p>Lectures:</p> <ul style="list-style-type: none"> • Action of neuropsychotropic drugs used in the treatment of various neurotransmission disorders, which can lead to a variety of neurological and psychiatric diseases • Different CNS levels and ways in which neuropsychotropic drugs can "repair" specific neurotransmission disorder, and how the application of neuropsychotropic drugs has enabled certain important discoveries in neurobiology (examples of selected diseases and drugs) • How by using neuropsychotropic drugs in various experimental approaches in vitro and in vivo, numerous structural, morphological, functional, biochemical, molecular, developmental, and any other information on CNS could be obtained • The use of pharmacological manipulation to cause and/or distinguish different behaviors • Various pharmacological models of neuropsychiatric and neurodegenerative diseases (schizophrenia, depression, anxiety, addiction, Parkinson's and Alzheimer's disease, epilepsy, etc.), and their use in order to elucidate biochemical/molecular mechanisms associated with a specific behaviors, development and etiology of different disorders, as well as to test potential new drugs <p>Seminars:</p> <p>Each student will present some of the latest scientific paper from this area</p> <p>Practicals:</p> <ul style="list-style-type: none"> • work with selected cell models in neurobiology (culture of neurons, recombinant receptors), treatment of cells with drugs, monitoring changes following in vitro administration of drugs (e.g. morphology and cell proliferation, expression of messenger RNA and proteins, etc.) • in vivo application of neuropsychotropic drugs and presentation of certain behavioral tests used to determine different drug effects (locomotor activity, rota-rod, Porsolt test, Marble test, etc.) • radioligand binding method which by using radiolabeled drugs can obtain much information on neurotransmitter receptors (number, affinity, function, etc.) in the brain
<p>Students activities and evaluation of student work over the course of instruction: Regular class attendance, preparation and presentation of seminar work, practicals attendance, active participation in discussions</p>

Methods of monitoring quality that ensure acquisition of exit competences:

Seminar work and oral exam

Required literature:

Working material which will be distributed to students before each lecture

Optional literature:

Lackovic Z. Neurotransmitori u zdravlju i bolesti. Medicinski fakultet Sveucilišta u Zagrebu, Zagreb, 1994.

Katzung BG. Temeljna i klinicka farmakologija. Medicinska naklada, Zagreb, 11. izdanje, 2011. (Katzung's - Basic and Clinical Pharmacology 12th edition (2012))

Selected review papers from the latest scientific literature

Name of the course: **Human cell cultivation techniques in diagnostics of chromosomal and genetic diseases** 151750

Course teacher

Feodora Stipoljev, B.Sc. Molecular Biology, Assoc. Prof.
Department of Medical biology and Genetics
Faculty of Medicine, University of Osijek, Croatia

Doctoral study: Biology

Research field associated with the course programme:

biomedical sciences: biomedicine and healthcare
scientific field: basic medical sciences
branch: genomics and proteomics

Type of instructions: lectures (5 hours), practicals (5 hours), seminars (5 hours)

Credit value (ECTS): 6

Expected learning outcomes: Aim of this course is to get introduce to students with the general principles and commonly used cultivation techniques of human cells for diagnostic purposes. Techniques of classical and molecular cytogenetics, and the recent information about of new progress in use of cultivation techniques in clinical praxis will be explained. This course is mainly planned as a practical work of students, where they will obtain basic skills of using techniques of prenatal and postnatal diagnosis in routine work. Students are engaged to critically analyze fundamental postulates of cytogenetics.

Course objectives:

Lectures:

Diagnostic possibilities of using different fetal cells in prenatal diagnosis (2P)

Postnatal diagnosis of chromosomal disorders: detection of microdeletion, and microduplication syndromes; the use of molecular cytogenetics in diagnostic protocols for infertility problems (2P)

Diagnostic cultivation techniques in multifetal pregnancies (1P)

Seminars:

Cultivation protocols for peripheral blood, amniotic fluid and spontaneous abortions (2S)

Preimplantation diagnostics and the isolation of fetal DNA from maternal blood (1S)

Preparation of seminar work: students will prepare seminar work on the requested theme and present as the oral power point presentation (2S)

Practicals:

Estimation of risk of having a child with chromosomal and genetic disease, types and mechanisms of inheritance (2V)

Introduction to the work of the cytogenetic laboratory , the techniques of cell cultivation, preparation of karyotype, and the interpretation of results (3V)

Students activities and evaluation of student work over the course of instruction

attendance to lectures, seminars, and practicals is prerequisite for the exam, active participation in practicals

Methods of monitoring quality that ensure acquisition of exit competences:

oral presentation of the requested seminar work

Required literature:

1. Michael Connor, Malcolm Ferguson-Smith. Essential medical genetics. Blackwell Science 2011 (6th edition).
2. R.J. McKinlay Gardner, Grant R. Sutherland. Chromosome abnormalities and genetic counseling. Oxford University Press 2011 (4th edition).

Optional literature:

O:J. Miller, E. Therman. Human chromosomes. Springer-Verlag New York 2001 (4th edition).

Name of the course: T lymphocyte differentiation 151774
Course teacher: Prof. Mariastefania Antica, Rudjer Boskovic Institute
Doctoral study: Biology
Research field associated with the course programme: Immunology hematology
Type of instructions: Oral presentations and seminars. 15 hours
Credit value (ECTS): 6
Expected learning outcomes: Extended knowledge on T lymphocyte differentiation from hematopoietic stem cells
Course objectives: The course T lymphocyte differentiation will introduce the features of the adult stem cells on the example of the best known adults stem cells – the hematopoietic precursors and their development towards immunocompetent mature T cells; Molecular aspects of development and commitment; Transcription factors important for the selection process and for the T cell maturation and commitment; Apoptosis and thymus selection, Thymic epithelial stem cells and methods for lymphocyte cultivation and study.
Students activities and evaluation of student work over the course of instruction: Seminar preparation on the topic from recent publications in the field.
Methods of monitoring quality that ensure acquisition of exit competences: Evaluation of the work through the final test.
Required literature: Immunobiology: The Immune System in Health and Disease, Izdavač: Garland publishing 2018 Autori: CharlesJaneway, Paul Travers, Mark Walport, Mark Shlomchik

Name of the course: IMMUNOBIOLOGY OF STRESS 151775
Course teacher Course coordinators: Katja Gotovac, PhD, research scientist, Genera, Zagreb; Anđelko Vidović, MD, PhD, research scientist, University Hospital Dubrava, Zagreb Associates: Andrea Jambrošić- Sakoman, MD, University Hospital Dubrava, Zagreb; Ela Kosor Krnić, PhD, Hospira, Zagreb; Krešo Bendelja, PhD, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Field: basic medical sciences, Branch: immunology
Type of instructions: lectures (6), seminars (5), practicals (2)
Credit value (ECTS): 6
Expected learning outcomes: Understanding the role of immune system in homeostasis maintenance through functional interactions with nervous and endocrine systems. Understanding stress-related neuroendocrine-immune interactions.
Course objectives: Concepts of the immune system (danger and integrity models); Molecular aspects of stress (cellular stress, "heat shock" proteins, modulation of the immune response); Types of stressors (physical, psychosocial, acute, chronic) and stress response; Physiological mechanisms of the stress response: the effect of stress on the immune system (recirculation of immune cells, Th1/Th2 balance, effector functions – phagocytosis, cytotoxicity, humoral and cell-mediated immune responses to vaccination, platelet activation), the effect of stress on the autonomic nervous system (heart rate, blood pressure, skin conductance, respiratory rate, body temperature), the effect of stress on the central nervous system (sickness behavior, the role of cytokines); The concept of allostasis and allostatic load: reactivity of the stress response, pathological effects of stress (cardiovascular, autoimmune, malignant, and psychiatric diseases)
Students activities and evaluation of student work over the course of instruction Attending lectures and active participation in seminars and practical courses.
Methods of monitoring quality that ensure acquisition of exit competences: Multiple choice-test
Required literature: M. Boranić i sur.: Psihoneuroimunologija, Školska knjiga, Zagreb, 2007.
Optional literature: Psychoneuroimmunology, Volume 1 and 2. Ader R, Felten DL, Cohen N (eds) Third Edition, Academic Press 2001. Sabioncello A, Gotovac K, Vidović A, Gagro A, Markotić A, Rabatić S, Dekaris D: The immune system under stress. Period biol 106:317-323, 2004. Other selected most recent reviews.

Name of the course: Ecology and taxonomy of marine phytoplankton 151776
Course teacher: dr. sc. Zrinka Ljubešić, associate professor, University of Zagreb, Faculty of Science
Doctoral study: Biology
Research field associated with the course programme: Biology, Ecology
Type of instructions: Lectures, seminars, exercise (7+8+0)
Credit value (ECTS): 6
Expected learning outcomes: <ol style="list-style-type: none"> 1. Associate the structure of organisms, their evolutionary course of development, and the systematic affiliation with their physiological functions and the flow of energy in the sea. 2. Apply scientific methods according to the set hypotheses and conceived experimental design for resolving problems in oceanography 3. Analyze the position and role of phytoplankton in the biosphere and their role in processes of cycling of biogenic elements. 4. Use various devices, measurement instruments and optical aids in research methods in biology when planning and implementing routine analyses, experiments, research and projects.
<p>Course objectives:</p> <p>Biology, anatomy and taxonomy of phytoplankton.</p> <p>Methods and tools in taxonomy.</p> <p>Phytoplankton community structure, spatial and temporal distribution of phytoplankton.</p> <p>Methods in the field work, planning and setting up hypotheses.</p> <p>The role of phytoplankton in trophic, regeneration and biogeochemical interactions in the environment. The role of phytoplankton in production of organic matter, microbiological loop.</p> <p>Abundance, biomass, primary production.</p> <p>Analytical methods and ecological interpretation. Graphical and statistical tools in data management.</p> <p>Environmental parameters (physical, chemical and biological) controlling phytoplankton ecology and taxonomy phytoplankton. Phytoplankton and eutrophication</p> <p>Case studies</p>
Students activities and evaluation of student work over the course of instruction: Actively involved in lectures and seminars, homework, practical exercise.
Methods of monitoring quality that ensure acquisition of exit competences: oral exam, written report
Required literature: Kirchman, D.L., 2000: Microbial ecology of the oceans. Wiley-Liss, New York. Livingston, R.J., 2001: Eutrophication processes in coastal systems. Origin and succession of plankton. Viličić, D. 2014: Ecology and composition of phytoplankton in the Adriatic Sea., Koeltz Scientific Books, Koenigstein, Germany.
Optional literature: Recent scientific papers

Name of the course: Biological classification of freshwaters, distribution and functional organization of communities 151777

Course teacher: Associate Professor; Ines Radanović, PhD, Associate Professor; Renata Matoničkin Kepčija, PhD, Professor, Maria Špoljar, PhD Faculty of Science, University of Zagreb

Doctoral study: Biology

Research field associated with the course programme: Biology, Ecology

Type of instructions: Seminar and practicum (5+10)

Credit value (ECTS): 6

Expected learning outcomes: Acquiring knowledge on freshwater communities, their diversity, ecology and functional organization. Applying methods for determination of functional feeding structure and their horizontal and vertical changes in lotic and lentic freshwaters.

Course objectives: Geological, hydrological and climatic parameters in evolution of biodiversity in the aquatic ecosystems. The origin of freshwater animals. Number of species in European limnofauna. Permanent and temporal fauna of freshwaters. Primary, secondary and tertiary ecological parameters influencing spatial distribution and seasonal fluctuations in qualitative and quantitative composition of the aquatic communities. The complexity of functional organization of communities and ecological determination of their spatial and temporal changes in running and stagnant waters. The gradient of spatial changes of physical, chemical and biocenological parameters in running and stagnant waters. Alochtonous and autochtonous food resources. Functional feeding groups of primary consumers; herbivorous and detritivorous in running waters: shredders, scrapers and collectors; in stagnant waters: detritivores, bacterivores, filterers of different size fractions of nanophytoplankton and net phytoplankton. Predation in plankton and benthos of aquatic ecosystems. Classification systems for the assessment of ecological status according to European water framework. Biological quality elements and metrics used to assess ecological status.

Students activities and evaluation of student work over the course of instruction

Students are expected to attend instructions. They will present elaborates related to problem tasks and submit in written form prior to exam. During the practical work, students will be given different samples for the analysis, upon which they will be expected to discuss the results. Using existing data, students will use software packages to calculate metrics and ecological quality ratios.

Methods of monitoring quality that ensure acquisition of exit competences:

Final evaluation will be a combination of student achievements during the course, their results and final exam.

Required literature:

Dodds, W. K., 2002: Freshwater Ecology. Concepts and Environmental Applications. Academic Press, San Diego.

Hauer, F. R., Lamberti, G. A. 2006: Methods in Stream Ecology, Academic Press, San Diego.

Kalff, J., 2002: Limnology. Inland Water Ecosystems. Prentice Hall, New Jersey.

Lampert, W., Sommer, U., 2007: Limnology: The Ecology of Lakes and Streams. Oxford

Optional literature: Recent scientific articles (depending on seminar themes)

Name of the course: <u>INVASIVE PLANTS</u> 181227
Course teacher: Prof Božena Mitić, PhD; University of Zagreb, Faculty of Science Prof Sven Jelaska, PhD; University of Zagreb, Faculty of Science
Doctoral study: Biology / Ecology
Research field associated with the course programme: Biology, Botany / Ecology
Type of instructions: 8+5+2 8 hours - lectures 5 hours - field work (2 x 2,5 hours) 2 hours – seminars (oral presentations)
Credit value (ECTS): 6
Expected learning outcomes: – to adopt basic knowledge about invasive alien plants; after the course students should be able to find a proper way to get more information about invasive alien plants, their impact, prevention and possible management measures.
Course objectives: to achieve student awareness of the problem and possible impacts of invasive alien plants on global, regional and national scales..
Students activities and evaluation of student work over the course of instruction <ul style="list-style-type: none"> - To attend classes - To hold an oral seminar (ppt presentation)
Methods of monitoring quality that ensure acquisition of exit competences: <ul style="list-style-type: none"> - Written exam - Oral exam
Required literature: Mitić B., Jelaska S: Invasive alien plants. Lectures (On-line). Nikolić T., Mitić B., Boršić I. (2014): Flora Hrvatske – Invazivne biljke. Alfa d.d., Zagreb. Lockwood J.L., Hoopes M.F., Marchetti M.P. (2007): Invasion Ecology. Blackwell Publishing, Oxford. Richardson D.A., ur. (2011): Fifty Years of Invasion Ecology. Wiley-Blackwell, Chichester.
Optional literature: Pyšek, P., Prach, K., Rejmanek, M., Wade, M. (1995): Plant invasions. SPB Academic Publishing, Amsterdam. Rotherham I.D., Lambert R.A., ur. (2013): Invasive and introduced plants and animals. Human perceptions, attitudes and approaches to management. Routledge, New York. http://hirc.botanic.hr/fcd/ http://www.issg.org/database/welcome/ http://www.europe-aliens.org/

Name of the course: ALGAE IN BIOLOGICAL VALORISATION OF FRESHWATER ECOSYSTEMS 151870
Course teacher: Assoc. prof. Marija Gligora Udovič, PhD University of Zagreb, Faculty of Science, Department of Biology
Doctoral study: Biology
Research field associated with the course program: Ecology and taxonomy of phytoplankton, phytobenthos, and periphyton communities in freshwater ecosystems
Type of instructions: Lectures 10 hours, Seminar work 5 hours Lectures: Trophic interactions in freshwaters (2h); Water Framework Directive (1h); Eutrophication (2h); Biomonitoring and Next-generation biomonitoring (1h); Developing new genetic tools for bioassessment of aquatic ecosystems (2h); Integrating (e)DNA metabarcoding in biological assessment of aquatic ecosystems (2h). Seminars: Preparation and organization of fieldwork; Laboratory analyses; Methods of limnological surveys (1h); Morphotaxonomy vs. Metabarcoding; Implementation of WFD (1h); Application of software for results analysis (1h); Eutrophication-causes, mechanisms, consequences and predictability (1h); Setting problem task, processing of samples, statistical analysis, interpretation of results in biological valorization of freshwater (1h).
Credit value (ECTS): 6
Expected learning outcomes: (i) development of new practical skills that represent the foundation for a successful upgrade in future research, (ii) understanding and practical application of intraspecific and interspecies interrelationships of algae and other organisms in different types of freshwaters and understanding of biogeochemical processes, (iii) gaining experience in independent reasoning in the field of ecology, (iv) advancement of scientific thinking and critical appraisal, (v) follow modern concepts in biological valorization of freshwater ecosystems, (vi) rising awareness about the diversity and variability of organisms, (vii) obtaining a broader picture of the structure and dynamics of algae as a response to environmental conditions in aquatic ecosystems, (viii) the independence in the laboratory, experience in planning and execution of research with experience in interaction in scientifically complex environment.
Course objectives: Scientific and professional education of highly educated students for: their independent mastery, modern principles of taxonomic classification and identification of freshwater algae, understanding and interpretation of the spatial and temporal distribution, the importance of the algae in the ecosystems, active preparation and active participation in lectures, independent lab and field work, practical knowledge mastery. To develop the student's ability to set up, understand and creatively solve problem tasks, principles and theories, identifying and applicability of measurement principles in practice, independence and creativity in practical and generic skills related to the field of work. Gaining experience in the planning, setting up and performing laboratory experiments, data processing and statistical analysis of the results.
Students activities and evaluation of student work over the course: Minute papers, Problem sets, Cooperative exams, Written and oral assignments
Required literature: 1. Lampert W., Sommer U (2007) Limnoecology - The Ecology of Lakes and Streams (2nd Edition). Oxford University Press. 2. Wetzel R.G. (2001) Limnology, Third Edition: Lake and River Ecosystems, Academic Press 3. Allan J. D. i Castillo M.M. (2007) Stream Ecology Structure and function of running waters Second Edition, The University of Michigan, Ann Arbor, MI, U.S.A. 4. Taberlet P., Bonin A., Zinger L. and Coissac L. (2018) Environmental DNA: For Biodiversity Research and Monitoring Oxford Univ Pr, UK

Name of the course: <u>Invertebrate Ecology of Aquatic Ecotones</u> 151778
Course teacher Prof. Sanja Gottstein, Faculty of Science, University of Zagreb Prof. Ivančica Ternjej, Faculty of Science, University of Zagreb Prof. Zlatko Mihaljević, Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Ecology
Type of instructions: seminars - 9 hours, practice course - 6 hours (total hours: 15)
Credit value (ECTS): 6
Expected learning outcomes: <ol style="list-style-type: none"> 1. understanding theoretical concepts important for invertebrate ecology of aquatic ecotone research; 2. applying framework necessary for evaluation of particular aquatic ecotonal habitat type and their communities; 3. determining and explaining the relationship between aquatic wildlife resources and the physical environment in aquatic ecotones; 4. enabling to critically evaluation of endangerment level of various aquatic ecotones; 5. assesing approaches and tools available for addressing questions in protection and/or revitalization of aquatic ecotones; 6. organizing and leading protection of aquatic ecotonal landscape
Course objectives: (<i>razraditi ih što preciznije, po mogućnosti prema nastavnim tjednima</i>): The main objective of the course is to acquire specific knowledge on various aquatic ecotones as significant transitional ecosystems. The aims of the course are: (1) to determine spatial and temporal structure of various aquatic ecotones, (2) to recognize properties of aquatic ecotones and controlling factors which regulate them, (3) to describe specific methods and techniques to objectively define and identify specific aquatic ecotones, and (4) to qualify and quantify animal community characteristics. It will contribute to the acquisition of theoretical and practical knowledge as well as general principles and concepts of aquatic invertebrate ecology in various aquatic ecotones. Seminars (9 hours): <ol style="list-style-type: none"> 1. Concepts of ecotones using the example of various aquatic ecotones 2. Ecological interactions of groundwater and surface water- anchialine caves 3. Ecological interactions of groundwater and surface water - Freshwater copepods and cladocerans: ecology, evolution, research methods 4. Ecological interactions of groundwater and surface water - Water flies: ecology and biology, research methods 5. Littoral lake zone as transitional zone: macroinvertebrate ecotonal community structure 6. Molecular phylogenetic relationships of species in aquatic ecotones 7. Biogeography of aquatic invertebrates in ecotones - taxonomy, biodiversity, zoogeography and conservation strategy in copepods and cladocerans 8. Crenobiocoenosis and hyporeos as a groundwater dependent ecoton communities 9. Concept and principles for the protection of aquatic ecotones Practice: <ol style="list-style-type: none"> 1. Field research methodology of aquatic ecotonal communities 2. Laboratory research methodology of aquatic invertebrates in ecotones (taxonomic problems, molecular phylogenetic studies, phylogeography) 3. Organisms and physical environmental conditions – quantifying ecotone pattern and determine the optimal habitat configuration to maximize total abundance of species (ecological simulations)

4. The application of ecological software in assessment of similarity and diversity of freshwater ecotone communities (Primer)
5. Life history traits of aquatic invertebrates in ecotones
6. Endangered species monitoring and environmental assessments of aquatic ecotones

Students activities and evaluation of student work over the course of instruction:

Each student must take one seminar theme and prepare it in the form of original scientific paper on at least 15 pages and defence in the form of oral presentation. The students give a 10 minute Powerpoint presentation + 5 minute discussion.

Each student must be on at least one field work and related laboratory practice which should be finalized in the form of PRIMER worksheet.

The *PhD projects* aims to analyze the consequences of aquatic ecotonal landscape dynamics and community structure in Microsoft Excel. The students will complete lab report in Word.

Methods of monitoring quality that ensure acquisition of exit competences: Successfully finished projects (30 %), fieldwork practice and laboratory analyses (20 %), seminar papers and oral presentation (30 %), final written exam (20%)

Required literature:

Cunningham-Minnick, M. J., Meyer, T. B., Thomas O. C. 2019 Shifts in dragonfly community structure across aquatic ecotones, *International Journal of Odonatology*, DOI: 10.1080/13887890.2019.1615006

Gibert, J., J. Mathieu and F. Fournier, 2009. Groundwater/Surface Water Ecotones: Biological and Hydrological Interactions and Management Options. *International Hydrology Series*. Cambridge University Press, str. 1-246.

Samways, M. J., Stewart, A. B. 1997. An aquatic ecotone and its significance in conservation. *Biodiversity and Conservation*, 6: 1429-1444.

Thorp, J. H. 2015. Chapter 4. Functional Relationships of Freshwater Invertebrates. In: J. H. Thorp, D. Ch. Rogers (eds) *Thorp and Covich's Freshwater Invertebrates (Fourth Edition)*. Academic Press, p. 65-82.

Yarrow, M. M., Salthe, S. N. 2008. Ecological boundaries in the context of hierarchy theory. *BioSystems*, 92: 233-244.

Optional literature:

Bohonak A.J. & D.G. Jenkins, 2003. Ecological and evolutionary significance of dispersal by freshwater invertebrates. *Ecology Letters*, 6: 783–796.

Čmlec, K., Ivković, M., Šemnički, P. & Z. Mihaljević, 2013. Emergence phenology and microhabitat distribution of aquatic Diptera community at the outlets of barrage lakes: effect of temperature, substrate and current velocity. *Polish Journal of Ecology*, 61 (1): 1-30.

Dole-Olivier M. J., D.M.P.Galassi, P.Marmonier & M. Creuzed Des Chatelliers, 2000. The biology and ecology of lotic microcrustaceans. *Freshwater Biology*, 44: 63-91.

Forbes, A.G., Yerkes, K. 2008. Ecotone: Nutrient Dynamics and the Emergent Behaviour of Ecological Agents. *Associations for the Advancement of Artificial Intelligence*, 1-5 (www.aaai.org).

Gosz, J.R. 1993. Ecotone hierarchies. *Ecological Applications* 3: 369-376.

Gottstein Matočec, S. (ur.), Bakran-Petricioli, T., Bedek, J., Bukovec, D., Buzjak, S., Franičević, M., Jalžić, B., Kerovec, M., Kletečki, E., Kralj, J., Kružić, P., Kučinić, M., Kuhta, M., Matočec, N., Ozimec, R., Rađa, T., Štamol, V., Ternjej, I. & N. Tvrčković 2002. An overview of the cave and interstitial biota of Croatia. *Natura Croatica* 11 (Suppl. 1): 1-112.

Gottstein Matočec, S. (ur.), Ozimec, R., Jalžić, B., Kerovec, M., Bakran-Petricioli, T. 2002. Raznolikost i ugroženost podzemne faune Hrvatske. *Ministarstvo zaštite okoliša i prostornog uređenja*, Zagreb, str. 1-82.

Gottstein, S. 2010. Priručnik za određivanje podzemnih staništa u Hrvatskoj prema direktivi o staništima EU. *Državni zavod za zaštitu prirode*, Zagreb, str. 1-99.

Gottstein, S., Ivković, M., Ternjej, I., Jalžić, B., Kerovec, M. 2007. Environmental features and crustacean community of anchihaline hypogean waters on the Kornati islands, Croatia. *Marine Ecology*, 28 (Suppl. 1): 24-30.

Havel J.E. & J. B. Shurin, 2004. Mechanisms, effects, and scales of dispersal in freshwater zooplankton. *Limnology & Oceanography*, 49 (4, 2): 1229–1238.

- Moseley, M. 2010. Are all caves ecotones? *Cave and karst science* 36 (2), 2009: 53-58.
- Resh V.H. & Rosenberg D.M. 1984. *The ecology of aquatic insects*. Praeger, New York, str. 1-624.
- Risser P.G. 1995. The status of the science examining ecotones. *BioScience*, 45: 318-325.
- Santer, B. 1998. Life cycle strategies of free-living copepods in fresh waters. *Journal of Marine Systems* 15: 327–336.
- Šemnički, P., Previšić, A., Ivković, M., Čmrlec, K. & Z. Mihaljević, 2012. Tufa Barriers from a Caddisfly's Point of View: Streams or Lake Outlets? *Internat. Rev. Hydrobiol.* 97(6): 465-484.
- Wilkins, H., Culver, D. C., Humphreys, W. F. (ur.) 2000. *Subterranean Ecosystems*. *Ecosystems of the World* 30. Elsevier, Amsterdam, str. 1-791.

COURSE: Invasive species of freshwater invertebrates 151779

AUTHORS OF COURSE PROGRAMME:

Associate Professor Jasna Lajtner, PhD, Department of Biology, Faculty of Science, University of Zagreb

Professor Ivana Maguire, PhD, Department of Biology, Faculty of Science, University of Zagreb

FIELD:

Biology, Ecology, Zoology

TEACHING TECHNIQUES:

Lectures: 0

Exercises: 10

Seminar: 5

COURSE AIMS:

Aim of the course is to enable students to gain knowledge on freshwater invasive invertebrates as well as get acquainted with invasive species ecological and socio-economic impacts.

Through conducting a small assignment students will learn how to plan and perform a project independently, and afterwards will present results and conclusions of their research to other attendees of the course through seminar/workshop.

COURSE PROGRAMME:

Autochthonous species, allochthonous species, invasive species, cryptic species. Historical overview. Spreading vectors. Ecological impacts. Socio-economic impacts. Invasive species of molluscs. Invasive species of freshwater crayfish. Invasive species of other invertebrates. The invasive species control and management methods. Law regulations.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Regular attending, conducting a small assignment and writing a seminar.

Students will be evaluated on the base of mean value of grades of written exam, seminar and project assignment. Oral exam would be carried out if candidates would like to improve their final grade.

OBLIGATORY LITERATURE:

- Leppäkoski, E., Gollasch S., Olenin, S. (2003): Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer Academic Publishers. Dordrecht, 583 str.

SUPPLEMENTARY LITERATURE:

- Lockwood, J., Hoopes, M., Marchetti, M. (2006): Invasion Ecology. Blackwell Publishing Limited, London. 304 str.
- [Mooney](#), H. A., [Mack](#) R. N., [McNeely](#), J. A. [Neville](#), L. E., [Schei](#), P. J., [Waage](#), J. K., (2005): Invasive Alien Species: A New Synthesis. Island Press, Washington D.C., 368 str.
- [Ruiz](#), G. M., [Carlton](#), J. (2005): Invasive Species: Vectors And Management Strategies. Island Press. Washington D.C., 484 str.
- [Sax](#), D.F., [Stachowicz](#), J.J., [Gaines](#) S.D. (2005): Species Invasions: Insights into Ecology, Evolution, and Biogeography. Sinauer Associates Inc. Sunderland, 495 str.
- Elton, C. (2000): The Ecology of Invasions by Animals and Plants. University of Chicago Press, Chicago, 196 str.
- [Mooney](#), H., [Richard J. Hobbs](#), R. J. (2000): Invasive Species in a Changing World. Island Press. Washington D.C., 384 str.
- Internet pages:
 - <http://www.issg.org/>
 - <http://nas.er.usgs.gov/>
 - <http://www.zin.ru/rbic/>
 - <http://www.daisie.ceh.ac.uk/>

Name of the course: <u>ECOLOGY AND SYSTEMATICS OF FISHES</u> 151780
Course teacher: assoc. prof. Perica Mustafić, PhD, Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: ecology, ichthyology
Type of instructions: Lectures and seminars (10+3 hours); practical course (2 hours)
Credit value (ECTS): 6
Expected learning outcomes: The aim of the course is to introduce students with methods and research techniques in modern ichthyology as well as the techniques of scientific work. The emphasis is placed on the ecological characteristics of fish and fish communities in the fresh waters of Croatia.
<p>Course objectives:</p> <p>The topics to be covered in this course are as follows:</p> <ol style="list-style-type: none"> 1. The science of ichthyology 2. Diversity of freshwater fish of Europe and freshwater ichthyofauna of Croatia 3. Molecular methods in taxonomy and ichthyology 4. Swimming and habitat preferences 5. Reproduction and life histories 6. Food and feeding behavior of fishes 7. Fish migration 8. Structure and dynamics of ichthyocenosis 9. Fishes in the ecosystem 10. Extinction and biodiversity loss 11. Methods of conservation of fish communities
<p>Students activities and evaluation of student work over the course of instruction</p> <p>Students activities include active participation in lectures and the preparation of seminar papers related to a particular thematic unit; participation in field work; laboratory work related to lectures and field work.</p>
<p>Methods of monitoring quality that ensure acquisition of exit competences:</p> <p>Evaluation of seminar papers, participation on the exercises and field work will make 50% of the final grade while the oral exam will be the next 50%.</p>
<p>Required literature:</p> <ol style="list-style-type: none"> 1. Čaleta, M., Buj, I., Mrakovčić, M., Mustafić, P., Zanella, D., Marčić, Z., Duplić, A., Mihinjač, T., Katavić, I. (2015) Endemic fishes of Croatia. AZO, Zagreb. 2. Mrakovčić M., Brigić A., Buj I., Čaleta M., Mustafić P. Zanella D. (2006) Crvena knjiga slatkovodnih riba Hrvatske. Ministarstvo kulture Hrvatske, Državni zavod za zaštitu prirode, Zagreb. 3. Kottelat, M. & Freyhof J. (2007) Handbook of European freshwater fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany. 4. Vuković T. i Ivanović B. (1971): Slatkovodne ribe Jugoslavije. Zemaljski muzej BiH, Sarajevo 5. Helfman, G.S., Collete, B.B., Facey, D.E., Bowen, B.W. (2009) The Diversity of Fishes, 2nd. ed. Wiley-Blackwell, Oxford
<p>Optional literature:</p> <ol style="list-style-type: none"> 1. Bone, Q. & Moore, R.H. (2008) Biology of fishes, 3rd.ed. Taylor & Francis, NY. 2. Moyle, P.B. & Cech, J.J. (2004) Fishes: An Introduction to Ichthyology, 5th.ed. Pearsons, London.

Name of the course: Biological wastewater treatment 151781
Course teacher: Prof. Dr. Jasna Hrenović, University of Zagreb Faculty of Science
Doctoral study: Biology
Research field associated with the course programme: microbiology
Type of instructions: Lecture and seminar (5+10)
Credit value (ECTS): 6
Expected learning outcomes: have insight into the existence of different kinds of wastewater and the need for their treatment; identify wastewater that can be biologically treated; recognize the role of microorganisms in the wastewater treatment; handle the important factors that could disrupt the process of biological wastewater treatment.
Course objectives: Types of biological wastewater treatment. The causes of the fall of the effectiveness of biological wastewater treatment. Removal of nutrients in biological wastewater treatment plants. Bioaugmentation.
Students activities and evaluation of student work over the course of instruction: Attending lectures and seminar work.
Methods of monitoring quality that ensure acquisition of exit competences: Rating of the seminar and oral exam.
Required literature: Henze M., van Loosdrecht M.C.M., Ekama G.A., Brdjanovic D. (2008): Biological wastewater treatment. IWA Publishing, London. Tedeschi S. (1997): Zaštita voda. HDGI, Zagreb.
Optional literature: Articles from professional and scientific journals. Bitton G. (2005): Wastewater microbiology. John Wiley & Sons, Inc., New Jersey. Ramadori R. (1987): Biological phosphate removal from wastewaters. Pergamon Press, Oxford. Seviour R, Nielsen P.H. (2010): Microbial ecology of activated sludge. IWA Publishing, London. Wong T.W. (2009): Handbook of Zeolites: Structure, Properties and Applications. Nova Science Publishers, Inc, Hauppauge NY, SAD.

Name of the course: Marine Microbial Ecology 194740
Course teacher(s): Sunčica Bosak, PhD, Assistant Professor, Department of Biology, Faculty of Science, University of Zagreb; Zrinka Ljubešić, PhD, Associate Professor, Department of Biology, Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field associated with the course programme: Natural Sciences, Biology
Lecture type: (formal lectures, practical, seminar) and hours: Lectures 10 hours; seminar 5 hours
Credit value (ECTS): 6
<p>Course objectives and expected learning outcomes:</p> <p>During the course of Marine Microbial Ecology students will be introduced to the challenges of the research and the applications of state of the art methods and technologies used in the investigation of marine microorganisms, the most abundant yet unexplored biotic component of Earth ecosystem. Lectures will present examples of well-established research practices, experimental approach and field and laboratory research designs. Wide range of detection and identification methods used for the marine microorganisms with a particular emphasis on the development of the novel technologies will be presented. Students will learn to interpret ecological marine ecosystem data using novel molecular methods, satellite remote sensing and different automated methods of enumeration and identification of marine microorganisms. During seminars, they will enhance their team-work skills and critical thinking while participating in diverse specific assignments and solving scientific problems.</p> <p>Specific learning outcomes:</p> <ul style="list-style-type: none"> ● Describe most important heterotrophic and autotrophic microorganisms and their ecological role in marine ecosystems ● Discuss the influence of novel molecular methods and approaches (metagenomics, metatranscriptomics, metaproteomics etc.) within the framework of marine microbial ecology research ● Interpret the comparison of classical taxonomical and molecular detection methods with remote sensing technology ● Learn about a wide range of field and laboratory methods that may be applied in diverse research fields ● Recognise scientific problem and appropriate research question/hypothesis in original scientific articles on the topic of marine microbiology ● Evaluate the quality of the research article from the field of marine microbiology regarding the basic principles of the scientific writing ● Apply the correct way of citation of the scientific literature and web sources in the team seminar presentations and summaries ● Compose a short summary of the results obtained from the teamwork exercise in accordance with the most important elements of a scientific report
<p>Course contents:</p> <ol style="list-style-type: none"> 1. Introduction: scope, syllabus, requirements, historical overview of the research in the field of marine microbial ecology; identification and taxonomy of microorganisms, quantitative methods in microbial ecology: epifluorescent microscopy, flow cytometry, chemotaxonomic analyses using HPLC, methods of automated image analysis 2. Molecular methods of identification in microbial ecology (16s RNA, PCR, DNA fingerprinting techniques, FISH). Metagenomics and taxonomy; overview of large scale projects and datasets (Human microbiome, Sargasso Sea, Global Ocean Survey, TARA Oceans, Malaspina, Ocean sampling day) 3. Remote sensing technologies used for the marine surveys: satellite observations, automated vehicles and lasers; integration of ocean colour data with a diversity of the microbial

communities and trophic status; chemotaxonomy

4. Ecological interactions of the marine microorganisms (intraspecific and interspecific interactions), predation, microbial food web, bacterial communication (quorum sensing), biofilms, primary production and respiration, symbiotic and commensal relationships with multicellular organisms, holobiont/hologenome concept
5. Climate change and their influence on microorganisms and food web in marine ecosystems: ocean acidification, global warming, changes in the biogeochemical cycles

Students activities and evaluation of student work over the course of instruction

Lecture attendance; project assignments and final report

Methods of monitoring quality that ensure the acquisition of exit competencies:

The evaluation of the project report, oral exam

Required literature:

Kirchman, D.L., 2000: Microbial ecology of the oceans. Wiley-Liss, New York.

Šolić, M., Krstulović, N., 2000: Ekologija morskog bakterioplanktona. Institut za oceanografiju i ribarstvo, Split.

Šolić, M., Krstulović, N., 2006: Mikrobiologija mora. Institut za oceanografiju i ribarstvo, Split.

Optional literature:

Munn, C.B., 2004: Marine microbiology. Ecology and applications. BIOS Scientific Publishers, London

Viličić, D., 2003: Fitoplankton u ekološkom sustavu mora. Školska knjiga, Zagreb.

Molecular Evolution: A phylogenetic Approach, Roderick D. M Page, Edward C. Holmes, 1998, Wiley Blackwell, ISBN: 978-0-86542-889-8

Phylogenetics: Theory and Practice of Phylogenetic Systematics, 2nd Edition, E.O. Wiley, Bruce S. Liebermann, Wiley-Blackwell, 2011, ISBN: 978-0-470-90596-8

Thomas, T., Gilbert, J., & Meyer, F. (2012). Metagenomics - a guide from sampling to data analysis. Microbial Informatics and Experimentation, 2, 3.

Recent original research articles and reviews

Name of the course: Symbioses 151783
Course teacher: prof. dr. sc. Goran Kovačević, Faculty of Science, Zagreb
Doctoral study: Biology
Research field associated with the course programme: Biology, Evolution, Symbioses
Type of instructions: lectures (10 hs), seminars (5 hs)
Credit value (ECTS): 6
Expected learning outcomes: To acquaint students with the meaning of the term symbiosis and importance of symbiosis in modern biological science. To acquaint students with basic principles and mechanisms of symbiosis. To understand the importance of symbiosis in evolution. To explain the role of symbiosis in biodiversity. To give an overview of historical and modern research in the field of symbiosis. To recognize the symbiosis subject in biological science.
Course objectives: Definitions of symbiosis. Forms of symbiosis. Role of symbiosis in speciation. Importance of symbiosis in biodiversity. Models of symbiosis in plants and animals. Mechanisms of symbiosis. Endosymbiosis. Principles and possibilities of symbiosis. Evolutionary reversal. Molecular phylogeny of endosymbionts and hosts. It is scheduled that one lecture would be given by an endosymbiosis expert.
Students activities and evaluation of student work over the course of instruction Regular attendance of the course, written and oral seminars, colloquia
Methods of monitoring quality that ensure acquisition of exit competences: Oral final exam
Required literature: Intracellular Niches of Microbes-A Pathogens Guide through the Host Cell (2009) Schaible, U. E., Haas, A. (ur.), Wiley-VHC Verlag GmbH & Co. KGaA, Weinheim Douglas AE (1994) Symbiotic Interactions. Oxford University Press Inc, Oxford and New York Margulis L, Sagan D (2002) Acquiring Genomes: A Theory of the Origin of Species, Basic Books, New York

COURSE: ANTHROPOLOGY - HUMAN BIOLOGICAL VARIATION 151785
INSTRUCTORS: Tatjana Škarić-Jurić, PhD, Scientific Adviser (tenure position) Assistant Professor Natalija Novokmet
DOCTORAL STUDY: Biology
MAIN SCIENTIFIC FIELD AND SUB-FIELD: Anthropology, Biological Anthropology
COURSE FORMAT: 4 hours of lectures, 11 hours of seminars
ECTS POINTS: 6
COURSE DESCRIPTION: The course reviews anthropological approaches to the study of human biological variation. Emphasis is placed on understanding the principles of research into genetic and environmental origins of human phenotypic variation throughout the life cycle. Selected research examples, typical for complex phenotypes' analyses, are highlighted, which gives students an overview of analytical techniques that are the most appropriate for analyses of complex biological traits. Dilemmas in interpretation of novel scientific anthropological information and the need for holistic analytical approach as the most successful in contemporary anthropology are discussed.
COURSE CONTENT: <ol style="list-style-type: none"> 1. Biological anthropology. Holistic analytical approach in anthropology; the aim of contemporary study of biological variation among human populations: possibilities and limitations. 2. Growth and development. Evolution of human life cycle; principles of human growth; stages in the life cycle; growth and development variation in living human populations; population differences in rate of growth; differences in growth between boys and girls; population variation in skeletal, dental, and sexual maturation. 3. Human Aging. Aging theories; aging and evolution; aging as the consequence of natural selection; life expectancy and demographic structure of populations; difference between biological and chronological age; genetic basis of aging; lifestyle and aging; definition of health and disease; aging or disease; definition and selection of phenotype in genetic research. 4. Biocultural interactions in contemporary populations. Biological and biocultural traits and their inter-population diversity; genetic, environmental and cultural interactions in population differences; body proportions, adaptive value of body size and secular trends in human populations. 5. Environmental factors influencing human phenotypic variation. Human adaptation, plasticity and variation: adaptability – biological and behavioral adaptations; acclimatization; nutrition, altitude, climate, migration and urbanization; socio-economic status; men-environment interaction. 6. Human genetic variability. Quantitative vs. qualitative traits; quantitative phenotype variability; 'ecolabile' and 'ecostabile' traits; evolutionary aspect of human quantitative variation; genetic determination of quantitative (complex) phenotypes; population studies (isolates, population stratification), family studies; gene-environment correlation and interaction; epistasis and pleiotropy.
STUDENT'S OBLIGATIONS Attendance at lectures and active participation at seminars, preparation of a seminar at the assigned topic
EXAMINATION Class presentation of a seminar at the assigned topic

REQUIRED TEXTS

1. Relethford, J. (2006) *The Human Species – An Introduction to Biological Anthropology*. Mayfield Publ. Comp., Mountain View, California.
2. Rudan, P. (2004) *Human Population Biology (Introduction to Anthropology)*, supplementary material to the lectures, Croatian Anthropological Society – internal edition, Zagreb.
3. Bogin, B. (1999) *Patterns of Human Growth*. Cambridge University Press, Cambridge, UK
4. Hartl, D.L. (2000) *A Primer of Population Genetics*. Sinauer Associates Inc., Sunderland, Massachusetts.
5. Frisancho, R.F. (2007) *Human adaptation and Accomodation*. The University of Michigan Press, Ann Arbor, USA.

SUPPLEMENTARY TEXTS

1. Selected scientific articles related to the topics of interest
2. Selected book chapters

Name of the course: DNA sequencing and sequence analysis 151786
Course teacher: Helena Četković, PhD, scientific adviser, Ruđer Bošković Institute, Zagreb Prof. Kristian Vlahoviček, PhD, full professor with tenure, University of Zagreb, Faculty of Science Robert Belužić, PhD, research associate, Ruđer Bošković Institute, Zagreb (associate)
Doctoral study: Biology
Research field associated with the course programme: Field: Molecular biology
Type of instructions: Lectures 4 hours, 8 hours of practical work and 3 hours of seminars
Credit value (ECTS): 6
Expected learning outcomes: Introducing students to the DNA sequencing methods, as well as to computer programs and data bases, which allow numerous analyses of the given nucleotide sequences. The main aim is to enable students in managing with the increasing amount of available data, using achieved knowledge.
Course objectives: Lectures: 1) DNA sequencing methods and 2) Introduction to the bioinformatics tools for sequence analysis Seminars: Next generation sequencing and sequence analysis using different bioinformatics tools Practical work: Sample preparation for sequencing, sequencing reactions and sequence analysis using different bioinformatics tools
Students activities and evaluation of student work over the course of instruction: Besides attending obligatory lectures, as well as obligatory participation at practice, this course will also include seminary paper or project task. This way students will have the opportunity to show how much they have acquired from both DNA sequencing methods and analysis of the given results, using computer programs.
Methods of monitoring quality that ensure acquisition of exit competences: Students' achievements will be tested in the form of exam and seminary paper/project task, through which students will be able to show implementation of the achieved skills and

Name of the course: Non-coding DNA sequences in eukaryotic genomes 151787
Course teacher: Prof. Dr.Sc. Miroslav Plohl, senior scientist with tenure; Ruđer Bošković Institute Dr.Sc. Nevenka Meštrović, senior research associate; Ruđer Bošković Institute Dr.Sc. Brankica Mravinac, senior research associate; Ruđer Bošković Institute
Doctoral study: Biology
Research field associated with the course programme: Biology, Molecular biology
Type of instructions: Lectures: 6; Seminar 6; Training 3
Credit value (ECTS): 6
Expected learning outcomes: Principles of structural organization of eukaryotic genomes and functional consequences of the organizational complexity. Categories, significance and possible roles of non-coding DNA sequences in complex genomes. Particular emphasis will be given to the composition and organizational patterns of repetitive DNA elements in functionally important chromosomal regions, centromeres and telomeres. Evolutionary dynamics and significance of repetitive DNA elements in centromeres and telomeres for genomic evolution and speciation. Epigenetic markers important for molecular interactions between protein components and DNA sequences in chromatin of these regions.
Course objectives: 1. Brief overview of genome projects, their objectives, experimental approaches, achievements and limitations. Non-coding DNA sequences will be categorized according to the basic features and genomic abundance. Principal characteristics of genome organization of several model organisms will be presented. 2. Structure and organization of non-coding DNA sequences and genome compartments, euchromatin and heterochromatin will be explained. Particular emphasis will be given to each type of repetitive DNA sequences (satellite DNAs, mini- and microsatellites, transposable elements). 3. Evolutionary dynamics of non-coding repetitive DNA sequences will be presented. We will clarify processes and molecular mechanisms involved in non-Mendelian evolution of DNA sequences repeated in tandem, which lead to the concerted evolution of tandem repeats within a genome and in a population. We will explain dynamics of nucleotide sequence and copy number changes in satellite DNAs, as well as the library model in evolution of genomic profiles of satellite DNAs and a phenomenon of concomitant plasticity and stability of satellite DNA sequences. 4. Composition and features of DNA sequences in centromeric and telomeric genomic regions will be analyzed, as well as chromatin structure of these regions. Molecular structure of centromeric chromatin (centrochromatin) will be explained. Relations between repetitive DNA sequences, heterochromatin structure and gene expression will be given. 5. Epigenetic aspects of inheritance will be focused on non-coding repetitive DNA sequences and their interactions with proteins, as well as on significance of different chemical modifications that act as epigenetic marks in these interactions. 6. Significance and potential roles of repetitive DNA sequence dynamics on genome evolution, organization and function will be explained. Impact of mobile element spread on genomic evolution, and links between mobile elements and satellite DNAs will be presented. The role of non-coding DNA

Name of the course: Genetic recombination and DNA repair 151788
Course teacher: Dr. Davor Zahradka, Senior Research Associate, Ruđer Bošković Institute, Zagreb Dr. Ksenija Zahradka, Senior Research Associate, Ruđer Bošković Institute, Zagreb Dr. Ivana Ivančić Baće, Associate Professor, Faculty of Science, Zagreb
Doctoral study: Biology
Research field associated with the course programme: Field: Biology, Molecular biology
Type and duration of instructions: 15 hours of teaching (lectures – 3 hours; experimental work – 6 hours; seminars – 6 hours)
Credit value (ECTS): 6
Expected learning outcomes: To acquaint students with the latest insights in the field of genetic recombination and DNA repair. To deepen the basic knowledge about these processes that students have acquired during their undergraduate studies. Teach students detailed molecular mechanisms and pathways of recombination as well as functions of a range of recombination proteins and their complex interactions. Students will be presented the importance and universality of recombination processes in the living world.
Course objectives: Special focus will be given on homologous recombination and its role in essential biological processes such as horizontal gene transfer, repair of double-stranded breaks and single-stranded gaps in DNA and repair and restoration of collapsed replication forks. New insights about different pathways of recombinational repair (homologous and non-homologous recombination) in bacteria and in eukaryotes. An overview of diseases and pathological conditions associated with defects in DNA recombination and repair in humans.
Students activities and evaluation of student work over the course of instruction: Seminar. Each student will have to prepare a seminar – give a short oral presentation of a recent scientific article within the scope of the course. Students are expected to be active in discussions about the given topic during the presentation of the article. Practical course. Experimental work for students will take place at the Laboratory of Molecular Microbiology at the Department of Molecular Biology, Ruđer Bošković Institute (4 hours) and at the Laboratory for Molecular Genetics (222) at the Department of Molecular Biology, Faculty of Science (2 hours). Practical course will include the following experiments: 1) gene transfer in <i>E. coli</i> by P1 phage-transduction; 2) following DNA repair and bacterial survival (<i>E. coli</i> and <i>D. radiodurans</i>) after UV irradiation; 3) monitoring the reconstitution of the <i>D. radiodurans</i> genome after gamma irradiation using the PFGE method; 4) determination of the interplay between the CRISPR-Cas system and DNA repair using the PCR method.
Methods of monitoring quality that ensure acquisition of exit competences: Written essay on a chosen topic (seminar) and oral examination
Required literature: The Bacterial Chromosome, 2005, Higgins, N. P. (ed.), ASM Press, American Society for

Microbiology, Washington, D.C.

Friedberg, E. C. et al. 2006. DNA Repair and Mutagenesis. ASM Press, American Society for Microbiology, Washington, D.C.

Review articles:

Ranjha L, Howard SM, Cejka P. Main steps in DNA double-strand break repair: an introduction to homologous recombination and related processes. *Chromosoma*. 2018;127:187-214.

Pannunzio NR, Watanabe G, Lieber MR. Nonhomologous DNA end-joining for repair of DNA double-strand breaks. *J Biol Chem*. 2018;293:10512-10523.

Michel B, Leach D. Homologous Recombination-Enzymes and Pathways. *EcoSal Plus* 2013; doi:10.1128/ecosalplus.7.2.7.

Kowalczykowski SC. An Overview of the Molecular Mechanisms of Recombinational DNA Repair. *Cold Spring Harb Perspect Biol* 2015;7:a016410.

Mehta A, Haber JE. Sources of DNA double-strand breaks and models of recombinational DNA repair. *Cold Spring Harb Perspect Biol* 2014;6:a016428.

Symington LS. Mechanism and regulation of DNA end resection in eukaryotes. *Crit Rev Biochem Mol Biol* 2016;51:195-212.

Cubbon A, Ivančić-Baće I, Bolt EL. CRISPR-Cas immunity, DNA repair and genome stability. *Bioscience Reports* 2018;38:1-10.

Optional literature:

Recent original scientific papers in the field of DNA recombination and repair

Name of the course: ORGANIZATION, FUNCTION AND MECHANISMS OF PLANT GENOME EVOLUTION 151789
Course teacher: Prof.dr.sc. Višnja Besendorfer
Doctoral study: Biology
Research field associated with the course programme: Molecular Genetics, Evolution, Plant Sciences
Type of instructions: Lectures: 2 h Practicals: 8 h Seminars: 5 h
Credit value (ECTS): 6
Expected learning outcomes: Understanding the principles of speciation at molecular and cytogenetic level. Learn how to utilize modern molecular and cytogenetic techniques in the study of plant genome evolution and speciation.
Course objectives: Processes of speciation and adaptation are accompanied with considerable restructuring of plant genomes which can be studied through the changes in structure and function of the genome at the level of DNA sequences and chromosome behaviour. Structural chromosome aberrations (deletions, duplications, translocations, inversions) and changes in chromosome number (aneuploidy, polyploidy) are involved in the speciation, while changes in DNA sequence structure could be connected with processes of adaptation. Ribosomal RNA (rRNA) genes and repetitive DNA (satellite DNA, transposable elements) represent regions on chromosome with high potential for structural rearrangements. Comparative analysis at molecular and cytogenetic level enable monitoring of genome changes that associate with speciation. Processes like homologous recombination and transposon-mediated sequence transposition could lead to dramatic qualitative and quantitative differences in distribution and organization of various DNA sequences in the genome. Therefore, study of position, structure and activity of different genome sequences could give an overview on evolutionary processes that are going on at inter- and intraspecies level. The goal of this course is to introduce to the students a new research approaches in the field of biosystematics. <ol style="list-style-type: none"> 1. Organization of plant genome at chromosome and molecular level – structural chromosome aberrations and changes in chromosome 2. Structure and organization of repetitive DNA (rDNA, satellite DNA, transposon elements) 3. Practical: isolation and cloning of repetitive DNA, sequence analysis, hybridization, florescent in situ hybridization, bioinformatics sequence analysis.
Students activities and evaluation of student work over the course of instruction: The students will be actively involved in the course through writing and oral presentation of research in the field based on the recent scientific papers and practical work.
Methods of monitoring quality that ensure acquisition of exit competences: Seminar presentation – written and oral
Required literature: Levine DA (2002) The role of chromosomal change in plant evolution. Oxford Series in Ecology and Evolution. Oxford University Press, Oxford Leitch IJ 2012. Plant genome diversity. Vol. 1. Springer Leitch IJ 2012. Plant genome diversity. Vol. 2. Springer
Optional literature: Schwarzacher T, Heslop-Harrison JS. (2000). Practical in situ hybridization. Oxford Bios, Oxford Relevantni znanstveni članci.

Name of the course: **Mutagens and antimutagens** 151790

Prof. dr.sc. Nada Oršolić, Faculty of Science, University of Zagreb

Doctoral study: Biology

Research field **Biology**; branch: **Genetic Toxicology**

Type of instructions:

Teaching will include: lectures (7 hours), seminars (4 hours), laboratory work (4 hours), consultation with students. The organization of laboratory work will be carried out depending on the interests of the students and the specifics of their scientific and research work.

Credit value (ECTS): 6

Expected learning outcomes:

To introduce students and researchers in biology, genetics, toxicology and oncology with basic features of physical and chemical mutagens and their effects on cell-levels *in vitro* and *in vivo*. Give an overview of the current knowledge of antimutagenic agents of natural and synthetic origin. To introduce students to the basic methods for assessing the effect of mutagens and antimutagens at the molecular and cellular level and at the level of the whole organism, with special emphasis on biomarkers and risk assessment of occupational and environmental exposure of the population.

Course objectives:

Lectures:

1. Basics and mechanism of action of physical mutagens.
2. The basics and mechanism of action of chemical mutagens.
3. Cell-level changes induced by mutagens and review of methods for their early, specific and sensitive detection in *in vitro* and *in vivo* conditions and the application of molecular-biological and cytogenetic biomarkers to assess the risk of occupational and environmental exposure of populations.
4. An overview of antimutagenic agents of natural and synthetic origin.
5. Planning and implementation of experiments *in vitro* and *in vivo* in the field of genetic toxicology and processing and presentation of research results.

Seminars - an overview of new knowledge about individual entities, depending on student interests and their scientific and research work.

1. Ionizing Radiation
2. Non-ionizing radiation
3. Chemical mutagens applied in medicine
4. Chemical mutagens applied in agriculture
5. Chemical mutagens applied in industry
6. Chemical mutagens from the environment
7. Antimutagens of natural origin
8. Antimutagens of synthetic origin
9. The synergistic effects of mutagenic and antimutagenic agents
10. Exposure of populations to mutagens from the living and working environment

Labor in the lab

The organization of laboratory work will be carried out depending on the interests of the students and their scientific and research work.

Students activities and evaluation of student work over the course of instruction

1. Regular lectures, seminars and exercises.
2. Active monitoring of scientific literature from the course.
3. Creating and presenting seminar work.

Methods of monitoring quality that ensure acquisition of exit competences:

Written exam. The final grade is a summary of the written exam evaluation and the evaluation of the seminar work.

Required literature:

Duraković i sur. Klinička toksikologija, Grafos, Zagreb 2000

Albertini, R. J., Anderson, D., Douglas, G. R., Hagmar, L., Hemminki, K., Merlo, F., Natarajan, A. T., Norppa, H., Shuker, D. E. G., Tice, R., Waters, M. D., Aitio, A. (2000) ICPS guidelines for the monitoring of genotoxic effects of carcinogens in humans. *Mutat. Res.* 463, 111-172.

Colombo P, Gunnarsson K, Iatropoulos M, Brughera M (2001) Toxicological testing of cytotoxic drugs (Review). *Int J Oncol* 19:1021-1028

Collins AR. The comet assay for DNA damage and repair. *Mol. Biotechnol* 2004; 26: 249-61.
Fenech M, Chang WP, Kirsch-Volders M, Holland N, Bonassi S, Zeiger E. HUMN project: detailed description of the scoring criteria for the cytokinesis-block micronucleus assay using isolated human lymphocyte cultures. *Mutat Res* 2003;534:65-75.

Garaj-Vrhovac V, Gajski G, Milković Đ, Ranogajec-Komor M, Miljanić S, Beck N, Knežević Ž, Gerić M. Radiation exposure and protection in conventional pediatric radiology of thorax. U: Balenović D, Štimac E (eds.) *Radiation Exposure: Sources, Impacts and Reduction Strategies*. New York, Nova Publisher, 2012;43-74.

Garaj-Vrhovac V, Gajski G. Comet assay in human biomonitoring as reasonably reliable cancer predictor in epidemiology. U: Kristoff HC (ed.) *Cancer Biomarkers*. New York, Nova Publisher, 2011;165-188.

Pfeiffer, P., Goedecke, W., Obe, G. (2000) Mechanisms of DNA double strand break repair and their potential to induce chromosomal aberrations. *Mutagenesis*. 15(4), 289-302

Singh NP (2000) Microgels for estimation of DNA strand breaks, DNA protein crosslinks and apoptosis. *Mutat Res* 455:111-127

Tice RR, Agurell E, Anderson D, Burlinson B, Hartmann A, Kobayashi H, Miyamae Y, Rojas E, Ryu JC, Sasaki YF (2000) Single cell gel/Comet assay: guidelines for *in vitro* and *in vivo* genetic toxicology testing. *Environ Mol Mutagen* 35:206-221.

Oršolić N, Benković V, Horvat-Knežević A, Bašić I. (2008). Scientific base for using propolis and its polyphenolic / flavonoid compounds as an adjunct to radiation therapy. *Scientific publications on the use of propolis in ehtemic medicine* (Editors: Oršolić N. and Bašić I). *Ethnopharmacology-Review Book*, Transworld Research Network, India, pp. 251-310.

Optional literature:

For the preparation of seminar papers as supplemental literature, recent articles from leading journals that publish articles in the field of genetic and molecular toxicology: *Mutagenesis*, *Mutation Research*, *Environmental and Molecular Mutagenesis*, *Toxicology*, *Toxicology Letters*, *International Journal of Radiation Biology*, *Radiation Research* etc. will be used.

Name of the course: Rodent animal models in experimental oncology 151791
Course teacher: Ranko Stojković, DVM, PhD, Senior Scientist, Ruđer Bošković Institute Zagreb Professor Nada Oršolić Department of Animal Physiology, Division of Biology, Faculty of Science, University of Zagreb Siniša Ivanković, DVM. PhD, Senior Scientist, Ruđer Bošković Institute Zagreb
Doctoral study: Biology
Research field associated with the course programme: 2
Type of instructions: I SATI NASTAVE: Lectures 10 Exercises 3 Seminar 2
Credit value (ECTS): 6
Expected learning outcomes: To acquire knowledge about the role and applications of rodent animal models in experimental oncology; application of acquired knowledge in experimental work
Course objectives: LECTURES 1. Human tumor xenograft and syngeneic animal models in for cancer research. 2. Mutant, transgenic and knockout mouse models - p53 deficient mice as models for cancer research, the use of transgenic mouse models in cancer research 3. Models of metastasis, - lungs, spleen / liver, bones, brain 4. In vivo Experimental methods and experimental end points in cancer research 5. Development of new cytostatics today 6. Mouse models of cancer in preclinical studies - Murine models as the basis for the preclinical studies, examples of preclinical trials. EXERCISES Visit to vivarium on Ruder Bošković Institute and practical work with rodents (examples of certain tumor models). SEMINAR Experimental protocols (in vivo) in experimental oncology through critical analysis of scientific articles in the field of experimental oncology (Journal club).
Students activities and evaluation of student work over the course of instruction Regular attendance and participation in class.
Methods of monitoring quality that ensure acquisition of exit competences: Written and oral exam
Required literature: Marko Radačić, Ivo Bašić, Damir Eljuga (2000) Pokusni modeli u biomedicine; Eric C. Holand Mouse Models of Human Cancer; Beverly A. Teicher Tumor Models in Cancer Research
Optional literature:

Name of the course: Tumor cell biology 151792
Course teacher Maja Herak Bosnar, PhD, senior scientist, Ruđer Bošković Institute, Zagreb; Neda Slade, PhD, senior scientist, Ruđer Bošković Institute, Zagreb; (course associates: Anđela Horvat, PhD, senior asistant, IRB, Zagreb)
Doctoral study: Biology
Research field associated with the course programme: Human genetics, genomics and proteomics, basic medicinal sciences.
Type of instructions: lectures, seminars, practice. HOURS: 8+2+5
Credit value (ECTS): 6
Expected learning outcomes: Through interactive classes introduce the students with the nature of malignant transformation of cells, genetic background of cancer, cancer development and progression together with the treatment options at the molecular level. Within their practical work, participants will learn about some of the methods used in cancer research (depending on the available financial resources practical work will be either individual or demonstrated by the lecturer)
Course objectives: The nature of cancer, multistep cancerogenesis, biological factors in cancer development, cellular oncogenes and growth factors, tumor supressor genes, tumor cell signalling, cell cycle and cell death, angiogenesis, invasion and metastasis, the application of molecular biology techniques in cancer prevention and treatment.
Students activities and evaluation of student work over the course of instruction Students are expected to actively participate in the theoretical and practical part of the course as well as to prepare an oral presentation (seminar) based on a scientific article in the field of tumor biology
Methods of monitoring quality that ensure acquisition of exit competences: Oral presentation (seminar) and written exam.
Required literature: Weinberg R.A., The Biology of Cancer, Garland Science, 2013.
Optional literature: Cooper G.M., Hausman R.E. The Cell: a Molecular Approach, 2015. Pecorino, L: Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, 2016.

Name of the course: Signal Transduction Pathways (Oncogenes and Tumor Suppressors) 151794
<p>Course teacher:</p> <p>Course leader:</p> <p>Assistant Professor / Research Associate, Petar Ozretić, PhD, Division of Molecular Medicine, Ruđer Bošković Institute</p> <p>Course assistants:</p> <p>Assistant Professor / Senior, Research Associate, Vesna Musani, PhD, Division of Molecular Medicine, Ruđer Bošković Institute</p> <p>Assistant Professor / Senior Research Associate, Maja Sabol, PhD, Division of Molecular Medicine, Ruđer Bošković Institute</p> <p>Research Associate, Diana Car, PhD, Division of Molecular Medicine, Ruđer Bošković Institute</p>
Doctoral study: Biology
<p>Research field associated with the course programme:</p> <p>Field: biology / biochemistry and molecular biology; basic medical sciences / genetics, genomics and human proteomics</p>
Type of instructions: <i>8 hrs lectures, 4 hrs practical courses, 2 hrs seminars</i>
Credit value (ECTS): 6
<p>Expected learning outcomes:</p> <p>Knowledge of the molecular-biochemical mechanisms of signal transduction pathways in the cell, especially from the perspective of oncogenes and tumor suppressors and their role in tumorigenesis. Introduction to basic molecular-biochemical methods for DNA, RNA and protein research.</p>
<p>Course objectives:</p> <p>Lectures cover the normal functioning of the cell in a multicellular organism: cell cycle regulation, cell differentiation, signal transduction within and between cells, and apoptosis. Well known human cell signaling pathways will be elaborated, with a special emphasis on Hedgehog-GLI signaling pathway, and the role of oncogenes and tumor suppressor in tumor formation. Various developmental and malignant diseases related to dysregulated signaling pathways will be presented, as well as possibilities of their repair and therapeutic approaches. Lectures will also give an overview of the possibilities of genetic and epigenetic analyzes in the diagnosis of malignant diseases such as hereditary breast cancer, various types of ovarian tumors, etc.</p> <p>Practical courses cover the most important methods of molecular biology and genetics: PCR, qPCR, gene expression analysis by microarrays, DNA sequencing, and various immunochemical methods. Seminars cover topics related to modern genome editing techniques (ZFN, TALEN and CRISPR/Cas9), web resources and bioinformatic research approaches related to course topics, and biostatistical analyses of experimental results.</p>
<p>Students activities and evaluation of student work over the course of instruction:</p> <p>Oral presentation of a scientific paper selected by student on the subject covered in the course.</p>
<p>Methods of monitoring quality that ensure acquisition of exit competences:</p> <p>Oral exam.</p>
<p>Required literature:</p> <p>Alberts et al. (2016) Molecular Biology of the Cell (6th Ed.), W. W. Norton & Company</p>
<p>Optional literature:</p> <p>Hancock, J. T. (2017) Cell signalling (4th Ed.), Oxford University Press</p> <p>Hesketh R. (1997) The Oncogene and Tumor Suppressor Gene Factsbook (2nd Ed.), Academic Press</p>

Weinberg, R. A. (2013) *The Biology of Cancer* (2nd Ed.), W. W. Norton & Company

Vogelstein, B., Kinzler, K. W. (2002) *The Genetic Basis of Human Cancer* (2nd Ed.), McGraw-Hill Professional

Chow, A. Y. (2010) Cell Cycle Control by Oncogenes and Tumor Suppressors: Driving the Transformation of Normal Cells into Cancerous Cells. *Nature Education* 3(9):7

Levanat et al. (2017) Hedgehog Signaling Pathway as Genetic and Epigenetic Target in Ovarian Tumors. *Curr Pharm Des* 23(1):73-94.

Sabol et al. (2018) Role of GLI Transcription Factors in Pathogenesis and Their Potential as New Therapeutic Targets. *M Int J Mol Sci* 9(9). pii: E2562.

Name of the course: Molecular basis of gene therapy 151795
Course: Andreja Ambriović Ristov, PhD, Senior Scientist, Ruđer Bošković Institute; Dragomira Majhen, PhD, Senior Research Associate, Ruđer Bošković Institute
Doctoral study: Biology
Research field associated with the course programme: Natural Sciences, Biology, Biochemistry and Molecular Biology
Type of instructions: 10 hours lectures, 5 hours seminars
Credit value (ECTS): 6
Expected learning outcomes: Students will learn about molecular biology and life cycles of viruses that are used as vectors for gene therapy. They will learn how viral vectors are constructed and which are advantages and disadvantages in their use in gene therapy. They will learn about principles of nonviral gene therapy and its associated advantages and disadvantages. Students will learn types of diseases that might be treatable by gene therapy and will learn about clinical trials in gene therapy.
Course objectives: 1. Introduce students to the molecular biology and life cycles of different types of viruses which are used as vectors in gene therapy. 2. Introducing students to the construction of viral vectors, their advantages and disadvantages in gene therapy. Introduction to non-viral methods of gene transfer, their advantages and disadvantages in gene therapy application. 3. Introduction to gene therapy target diseases and short overview of clinical trials results.
Course content: <u>Lectures:</u> Introduction: Principles of gene therapy. (2 hours) Molecular biology of retroviruses, principles of vector construction. (2 hours) Molecular biology adenoviruses, principles of vector construction. (2 hours) Molecular Biology of adeno - associated and herpes viruses, principles of vector construction. (1 hour) Principles vector vaccination. (1 hour) Principles of tumor gene therapy. (1 hour) Non-viral gene transfer. (1 hour) <u>Seminars:</u> Gene therapy clinical trials using retrovirus, adenovirus and adeno-associated viruses, as well as non-viral gene transfer. Ethics in gene therapy. (5 hours)
Students activities and evaluation of student work over the course of instruction: Attending the course, preparing seminar on selected topic.
Methods of monitoring quality that ensure acquisition of exit competences: Oral exam
Required literature: Majhen D., Ambriović-Ristov A.: Adenoviral vectors - how to use them in cancer gene therapy. <i>Virus Research</i> , 119: 121-133, 2006. Majhen D., Calderon H., Chandra N., Fajardo C.A., Rajan A., Alemany R., Custers J.: Adenovirus-based vaccines for fighting infectious diseases and cancer: progress in the field. <i>Human Gene Therapy</i> , 25(4):301-17, 2014. Wirth T, Ylä-Herttuala S.: "Gene Therapy Used in Cancer Treatment." <i>Biomedicines</i> 2, no. 2: 149-162, 2014. Ambriović Ristov A. Brozović A., Bruvo Mađarić B., Četković H., Herak Bosnar M., Hranilović D., Katusić Hećimović S., Meštrović Radan N., Mihaljević S., Slade N., Vujaklija D (ur.): <i>Metode u molekularnoj biologiji</i> . Institut Ruđer Bošković, 2007. Schultz B.R., Chamberlain J.S.: Recombinant Adeno-associated Virus Transduction and Integration, <i>Molecular Therapy</i> , 16(7): 1189–1199, 2008.

Kotterman M.A., Schaffer D.V.: Engineering adeno-associated viruses for clinical gene therapy. *Nature Reviews Genetics*. 15(7):445-51, 2014.

Yi Y., Noh M.J., Lee K.H.: Current Advances in Retroviral Gene Therapy, *Current Gene Therapy*, 11: 218-228, 2011.

Emeagi P.U., Goyvaerts C., Maenhout S., Pen J., Thielemans K., Breckpot K.: Lentiviral vectors: a versatile tool to fight cancer. *Current Molecular Medicine*. 13(4):602-25, 2013.

Pichon C., Billiet L., Midoux P.: Chemical vectors for gene delivery: uptake and intracellular Trafficking, *Current Opinion in Biotechnology*, 21:640–645, 2010.

Optional literature:

Selection from the latest scientific publications regarding gene therapy field.

Name of the course: Chemoprevention and Biotherapy of tumor 151796
Prof. dr.sc. Nada Oršolić, Faculty of Science, University of Zagreb
Doctoral study: Biology
Research field: Basic medical science , branch: Immunology and Immunogenetics, Tumor immunology, Molecular oncology
Type of instructions: (lectures (9), exercises (0), seminars (6))
Credit value (ECTS): 6
<p>Expected learning outcomes:</p> <p>The aim of the course is to give basic remarks on possible mechanisms of chemoprevention and tumor biotherapy:</p> <ol style="list-style-type: none"> 1 Antimutagenesis/anticancerogenesis (inhibition of the process known as "initiation" and "promotion" of carcinogenesis) 2. Antiproliferation and antiprogession (mechanisms include activation of various physiological processes such as hormone modulation/growth factor factors, inhibition of oncogenic activity, modulation of host immune response, stimulation of apoptosis, etc.). 3. To familiarize students with the potential of tumor chemoprevention, especially emphasize the effect of bee products and their polyphenol flavonoid constituents applied alone and/or in combination with chemotherapists on: <ol style="list-style-type: none"> 1) tumor growth and metastatic ability and anti-leukemic activity; 2) angiogenesis and metastasis process; 3) immunomodulation, importance and role of cell polarization, in particular macrophages; 4) on major signal pathways in cancer formation, particularly on Ras, MAPK PI3K signaling pathway, cell cycle control over MAPK and PI3K pathways, mTOR, tyrosine kinase paths, TP53 network and signal transmission via TGF-beta factor, NF-kappaB times; 5) cell death mechanisms (apoptosis, necrosis, autophagy, mitotic catastrophe, senescence) and expression of apoptotic genes such as bcl-2, survivin and bcl-xL and their contribution to cell resistance to cytostatics; 6) chemotherapy and radiotherapy resistance mutants, MRP1, P-glycoprotein, glutathione and glutathione-associated enzyme expression in susceptible and drug-resistant cell lines; 7) the role of P-glycoprotein in polyphenol-cytostatic interaction; 8) the possibility of use of radiation, chemotherapy, hyperthermia with polyphenolic components; 9) to evaluate their positive and negative effects combined therapy and their possibility to contribute in preventing the proliferation of tumor cells, angiogenesis and metastasis 10) evaluate antioxidative, immunomodulatory, radioprotective, cytotoxic, apoptotic, genetic and epigenetic effects of polyphenol/flavonoid components in tumor and metastasis therapy.
<p>Course objectives:</p> <ol style="list-style-type: none"> 1. The Principles of Tumor Immunobiology, Chemotherapy, Radiotherapy and Hyperthermia 2. Mechanisms of improvement of the immunotherapeutic response with polyphenol/ flavonoid components 3. Targeting strategie to defeat of Immune suppression 4. Effects of polyphenol/flavonoid components on intestinal microbiota and its importance in the inhibition of natural carcinogens, antigenotoxic and immunomodulatory effects 5. The role of polyphenol/flavonoid components on angiogenesis, matrix metalloproteinases 2 and 9 (MMP-2, MMP-9) and macrophage polarization (M1 and M2 tumor-associated macrophage-TAM) 6. The role of polyphenol/flavonoid constituents in epigenetic regulation of tumor growth (DNA methylation, histone modification and RNA interference) 7. Reduction of toxicity of standard tumor therapeutic agens by polyphenol/flavonoid components and the selective effect of polyphenol/flavonoid components on the initiation of

<p>apoptosis/necrosis in tumor cells, inhibition of signal pathways of cell proliferation and survival</p> <ol style="list-style-type: none"> 8. Combined treatment of chemotherapeutic drug and/or natural antioxidant as an adjunct to standard cancer therapy may be one way to overcome the development of resistance 9. Interaction of various forms of tumor therapy with polyphenolic/flavonoid components, estimation of additive, synergistic or antagonistic action
<p>Students activities and evaluation of student work over the course of instruction</p> <ol style="list-style-type: none"> 1. Attendance at lectures 2. Active monitoring of scientific literature from the course. 3. Creating and presenting seminar work.
<p>Methods of monitoring quality that ensure acquisition of exit competences:</p> <p>The student should demonstrate knowledge on written and oral exams, actively participate in the seminar</p>
<p>Required literature:</p> <p>Scientific evidence of the use of propolis in ehtnomedicine” (Editors: Oršolić N. and Bašić I). Ethnopharmacology- Review Book, Transworld Research Network, India, 2008.</p> <p>Oršolić N. and Bašić I. (2007) Cancer chemoprevention by propolis and its polyphenolic compounds in experimental animals. <i>Phytochemistry and Pharmacology III</i>, (Editor: V. K. Singh, J. N. Govil & C. Arunachalam, STUDIUM PRESS, LLC, U.S.A). <i>Recent Progress in Medicinal Plants</i> 17: 55-114.</p> <p>Oršolić N., Benković V., Horvat-Knežević A. and Bašić I. (2007) Natural products and flavonoids as radioprotective agents. “Herbal Drugs: A Twenty First Century Perspective” (Editors: RK Sharma and RajeshArora), Jaypee Brothers Medical Publishers Pvt. Ltd, Delhi, pp 666+).</p> <p>Middleton, E. Jr, C. Kandaswami, T.C. Theoharides._2000. The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease, and cancer. <i>Pharmacol Rev.</i>52(4):673-751. Review.</p> <p>Galati, G., S. Teng, M.Y. Moridani, T.S. Chan, and P.J.O'Brien. 2000. Cancer chemoprevention and apoptosis mechanisms induced by dietary polyphenolics. <i>Drug Metabol Drug Interact</i> 17: 311-349.</p> <p>Abbas, Abul K, Lichtman, Andrew H, Poper, Jordan S (2000): Cellular and molecular immunology.4th ed. W.B. Saunders Company, Philadelphia, USA</p> <p>Kuby J. Immunology. 6th ed. W.H. Freeman and company, New York. (2004) Roitt, Ivan, Brustoff, Jonathan, Male, David (2006): Immunology. 7th ed. Mosby, Edinburgh, UK Allegretti, Nikša, Adreis, Igor, Čulo Filip, Marušić, Marko, Taradi Milan (2004): Imunologija. 6 izdanje. Školska knjiga, Zagreb</p>
<p>Optional literature:</p> <p>For the preparation of seminar papers as supplemental literature, recent articles will be used in leading journals that publish articles from the field of tumor immunology, chemoprevention and tumor and metastasis therapies.</p>

Name of the course: Molecular diagnostics of neoplasms 151797
Course teacher Petra Korać, associate professor, University of Zagreb, Faculty of Science
Doctoral study: Biology
Research field associated with the course programme: biomedicine, tumor biology, molecular pathology
Type of instructions: lectures (5 hrs), seminars (5 hrs), practicals (5 hrs)
Credit value (ECTS): 6
Expected learning outcomes: After completed course, the student will be able to: <ol style="list-style-type: none"> 1) explain mechanisms of neoplasm development 2) use methods that are the most reliable for detection of certain aberrations based on the understanding of disease mechanism 3) discuss ethical issues in specific biomedical fields
Course objectives: Objectives: <ol style="list-style-type: none"> 1) to explain molecular basis of disease development and connect it with terms „diagnostic test“, „biomarker“ and „disease classification“ 2) to explain concepts of molecular pathology studies and application of their results in diagnostics 3) to explain laboratory methods used in everyday practice as a part of diagnostics, prognostics and therapy Lectures <ol style="list-style-type: none"> 1) General mechanisms of neoplasm development with emphasis on haematological malignancies: - genetic and epigenetic aberrations in tumor development, B-cell lymphoma development, lymphoma classification, translational research (2 hrs lectures) 2) Methods in biomedicine: - FISH, FISH, immunohistochemistry, PCR, qRT-PCR, methylation status evaluation, RFLP (1 hr lecture) 3) Concept of neoplasm development research: - detailed classification based on aberrations in tumour cell genomes/detecting key aberrations that are responsible for transformation, biomarker analysis, use of results from basic research in diagnostics (1 hr lecture) 4) Impact of Human Genome Project on diagnostics, ethical considerations, possibility for developing new, earlier diagnostic tests (1 hr lecture) Seminars Each student prepares a seminar about selected topic from the routinely used diagnostic methods based on disease development mechanisms. (5 hrs) Practicals After the lectures all student participate in solving cases making their own protocols for diagnostic procedures, selecting methods and analysing results that are prepared from practice. (5 hrs)
Students activities and evaluation of student work over the course of instruction attending lectures, preparing seminars, solving cases from everyday practice, oral exam
Methods of monitoring quality that ensure acquisition of exit competences: seminars, oral exam, solving cases from everyday practice
Required literature: material given during lectures
Optional literature: Swerdlow S.H., Campo E., Harris N.L., Jaffe E.S, Pileri S.A., Stein H., Thiele J , Vardima J.w. (Eds.), WHO Classification of Tumours of Haematopoietic and Lymphoid Tissues, IARC: Lyon, 2008. Küppers Ralf. Mechanism of B-cell Lymphoma Pathogenesis. Nature Rev. Cancer. 2005: 5:251-262. van Dongen JJ, Langerak AW, Brüggemann M, Evans PA, Hummel M, Lavender FL, Delabesse E, Davi F, Schuurin E, García-Sanz R, van Krieken JH, Droese J, González D, Bastard C, White HE, Spaargaren M, González M, Parreira A, Smith JL, Morgan GJ, Kneba M, Macintyre EA. Design

and standardization of PCR primers and protocols for detection of clonal immunoglobulin and T-cell receptor gene recombinations in suspect lymphoproliferations: report of the BIOMED-2 Concerted Action BMH4-CT98-3936. *Leukemia*. 2003;17(12):2257-317.

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Horn H, Ziepert M, Becher C, Barth TF, Bernd HW, Feller AC, Klapper W, Hummel M, Stein H, Hansmann ML, Schmelter C, Möller P, Cogliatti S, Pfreundschuh M, Schmitz N, Trümper L, Siebert R, Loeffler M, Rosenwald A, Ott G; German High-Grade Non-Hodgkin Lymphoma Study Group. MYC status in concert with BCL2 and BCL6 expression predicts outcome in diffuse large B-cell lymphoma. *Blood*. 2013;121(12):2253-63.

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