MASTER OF SCIENCE IN BIOLOGY

Course title: Biomathematics and biostatistics

Credits: 3

Course description:

Basics of R. Descriptive statiscs and graphics. One-sample tests. Two-sample tests. Regression and correlation. Analysis of variance and nonparametric alternatives. Categorical data. Power analysis, simulations in R. Linear models. Nonlinear models. Maximum likelihood and bootstrap, data modelling. Bayes logic.

The course is designed to survey the most important methods as implemented in R.

Students become able to use R to summarize and graph data, calculate confidence intervals, test hypotheses, assess the goodness-of-fit, and perform analyses of variance and linear regression. They also acquire a basic knowledge of the methodology behind modern data-based modelling (simulations, maximum likelihood, bootstrapping and Bayesian analysis).

Literature:

Dalgaard P: Introductory Statistics with R. 2nd ed., Springer Science+Business Media, LLC, New York, 2008. ISBN: 978-0-387-79053-4

R software documentation (http://www.r-project.org/)

Course title: Bioinformatics

Credits: 2

Course description:

During the first semester, the theoretical background is covered. The topics include an understanding of the connections between molecular evolutionary events, the differences and similarities between related DNA and protein sequences, protein structures and functions, and methods and underlying mathematical models of searches in nucleic acid and protein sequence databases. Computational assembly and the investigation of genomic sequences are also introduced.

The course is designed to provide a thorough understanding of how various biological subjects can be traced back from and correlate with genetic, genomic, structural and other types of data. The material presented needs a prior knowledge of genetics, molecular biology, gene regulation and genome organization and also the basics of protein structure. The course is concerned primarily with prokaryotic sequences with eukaryotic implications where appropriate.

The students become familiar with the various sequence data structures and databases, the most commonly applied data searches and comparisons, the rationale behind sequence comparisons, and the most basic mathematical models, algorithms and computational analyses that relate the molecular structures, the biological function and the digitally archived data. They gain an understanding of how molecular evolution is reflected in the structure and regulation of genes and genomes and the activities of proteins and complexes.

Literature:

Lesk AM: Introduction to Bioinformatics 4th edition. Oxford University Press Inc. New York, 2013. ISBN: 9780199651566

Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A, Martin KC: Molecular Cell Biology, 8th edn., Macmillan, New York, 2016. ISBN: 1-4641-8339-2

Course title: Bioinformatics – laboratory practicals

Credits: 3

Course description:

The practicals cover commonly applied tasks, including database searches, DNA and protein sequence alignments, multiple alignments, assessment of conserved vs. variable sequence elements, sequence assembly, gene finding, gene- and genome annotation, genome alignment, the assessment of RNA and protein secondary structure, and *in silico* investigations of other features.

Literature:

New subjects and principles beyond those covered in the previous semester are not introduced, and reading additional to the printed and online sources listed in the syllabus provided to the students during the course is therefore not requested.

Course title: Intracellular signalization

Credits: 2

Course description:

General characteristics of eukaryotic signal transduction. Cell surface and cytoplasmic receptors. Structural and functional classification of receptors. Characterization of the main intracellular signalization pathways. G protein-coupled receptors. Structure and function of heterotrimeric G proteins. Signalization based on the changing level of intracellular cAMP. Signalization based on phosphoinositide breakdown, the importance of IP3 and DAG. Characterization of eukaryotic protein kinases. MAP kinases. Second messenger-activated protein kinases. Intracellular Ca^{2+} -levels during cell-cell signalization. Calcium-binding proteins. The role of calmodulin in intracellular signalization. Receptors with enzyme activity: TGFβ receptors, receptor tyrosine kinases, cytokine receptors, receptor guanylyl cyclases, receptor phosphotyrosine phosphatases and T-cell receptors. Ion channel receptors. Proteolysis-coupled intracellular signalization: Wnt, Hedgehog, Notch/Delta and NF-κB signalization. Intracellular receptors: NO and nuclear receptors. General characteristics of gene regulatory proteins. Transcriptional and translational regulation of gene expression as a consequence of cell-cell signalization. Characteristics of neuronal gene expression. Modularity of intracellular signalization systems. Signal integration.

A comprehensive treatise is given of the principles of intracellular signalling pathways and their specific functions. The main intracellular signalling pathways and the importance of signal integration are explained in detail. The students acquire an understanding of the characteristics of intracellular signalization processes with special reference to neuronal signal transduction. They become familiar with the sequences of signal transduction and the different molecular mechanisms by which specific intracellular signalization pathways are activated.

Literature:

Berridge MJ (2014): Cell Signalling Biology. doi:10.1042/csb0001001

Selected review articles from PubMed.

Course title: Molecular biology - from genes to genomes

Credits: 2

Course description:

Nucleic acids, structure and discovery. Tools for their study. The genomes of prokaryotes and their viruses. The eukaryotic genome, unique sequences and repeats. Genome size and complexity. Chromatin. Extra-chromosomal genomes, genomes of organelles, plasmids. DNA synthesis in vivo and in vitro. Errors and their repair. Transcription units of prokaryotes. Coding and regulatory regions. Operons. The transcription process. Gene organization in eukaryotes. The primary transcript and mature RNA. Cis-regulatory elements of transcription. Eukaryotic RNA-synthesizing enzymes. The basal transcription machinery. Trans-acting transcription regulators. DNA-binding proteins. Enhancers. The role of chromatin in transcription control. Epigenetics. The organization of the nucleus, long-range interactions. Transcription and cell fate determination, stem cells, differentiation, tumorigenesis.

The course is designed to provide a thorough introduction to the organization and function of the genome. The material is presented at a level suitable for B.Sc. students majoring in life sciences. The course is concerned with both pro- and eukaryotic cells in order to provide an evolutionary view of gene function. Emphasis is placed on animal cells and human implications where appropriate, to highlight direct practical consequences. The lectures are structured to correlate structure and function at all levels of macromolecular organization, and are devoted equally to structural details and molecular functions. By the completion of the course, students have achieved a comprehensive understanding of the architecture and function of genetic material.

Literature:

Alberts B, Johnson A, Julian L, Morgan D, Raff M, Roberts K, Walter P: Molecular Biology of the Cell, 6th edn., Garland Science, New York, 2014. ISBN: 9780815344322

Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A, Martin KC: Molecular Cell Biology, 8th edn., Macmillan, New York, 2016. ISBN: 1-4641-8339-2

Course title: Separation techniques

Credits: 2

Course description:

Introduction, historical background. Basic concepts and theoretical background in separation techniques (plate, kinetic and rate theories). Liquid chromatography: instrumental design, function of components, stationary phases, column types, normal- and reverse-phase features; pH control; isocratic, gradient separations; mobile phases, HILIC. Affinity, ion-exchange, ion-pair and gel chromatography. Gas chromatography: instrumental design, functions of components (injectors, detectors). Stationary and mobile phases; column types. Characterization of chromatographic software and calculations in separation techniques, including performance and validation parameters. Thin-layer and forced-flow thin-layer chromatography. Electromigration techniques. Sample pretreatment: solid and gas samples. Liquid samples and derivatizations. Mass spectrometric instrumental designs. Applications and coupled techniques. Preparative separation techniques. Liquid-liquid chromatography.

The course provides detailed knowledge regarding analytical and preparative separations. The lectures cover various aspects of analytical investigations, including basic and advanced information on TLC, HPLC and GC systems, the related sample pretreatments and derivatization methods. Preparative separations, including conventional solid-liquid applications and novel liquid-liquid techniques, are surveyed. Students achieve a comprehensive understanding of the separation methodology used in life sciences.

The students gain an understanding of the significance of separation science and the use of these methods. They receive an introduction into the theoretical background of separation techniques, and acquire knowledge regarding the basic mechanisms involved in the development of different separations. They become familiar with the hardware and software components of the separation systems and attain an insight into the calculations relating to quality assurance processes and chromatographic performance

Literature:

Dong MW: Modern HPLC for Practicing Scientists, John Wiley & Sons, Inc., Hoboken, 2006.

Foacult AP ed.: Centrifugal Partition Chromatography, Chromatographic Science Series Vol. 68, Marcel Dekker, Inc., New York, 1995.

Hoffman E, Stroobant V: Mass Spectrometry: Principles and Applications, 3rd Edn., John Wiley, Hoboken, 2007.

Jennings W, Mittlefehldt E, Stremple P: Analytical Gas Chromatography, 2nd Edn., Academic Press, San Diego, 1997.

McMaster MC: HPLC: A Practical User's Guide, 2nd Edn., John Wiley & Sons, Inc., Hoboken, 2007.

Moldoveanu SC, David V: Sample Preparation in Chromatography, J. Chromatogr. Library Vol. 65, Elsevier, Amsterdam, 2002.

Niessen WMA: Liquid Chromatography-Mass Spectrometry, 3rd Edn., CRC Press Taylor & Francis Group, Boca Raton, 2006.

Scott RPW: Preparative Chromatography, Chrom-Ed Book Series Book 12, Library4science, LLC, 2003.

Toyo'oka T: Modern Derivatization Methods for Separation Sciences, John Wiley & Sons, Inc., Hoboken, 1998

Course title: Advanced genetics

Credits: 2

Course description:

Introduction. Architecture of eukaryotic chromosomes. Mechanism of eukaryotic gene regulation. Tetrad analysis and gene conversion. Mechanisms of sex determination. Genetics of the immune system. Inheritance of quantitative traits. Genetic control of development. Extranuclear inheritance. Epigenetics.

Cancer genetics. Genomics. Introduction to population genetics.

A comprehensive introduction to heredity at a level suitable for advanced M.Sc. students majoring in life sciences. It is integrative over a broad range of fields, ranging from cytology and cell biology, through physiology and molecular biology to evolution.

The students become familiar with the fundamental processes of gene transmission, variation, expression and regulation, the interpretation of genetic experimental data and the drawing of conclusions concerning the underlying causes, the analysis of genetic processes through the use of numerical relationships, and the formulation of genetic hypotheses in a statistical framework.

Literature:

Snustad DP, Simmons MJ: Principles in Genetics, 4th edn., John Wiley & Sons, Inc., Hoboken, 2006. ISBN: 0470388250

Handouts for the lectures are posted on CooSpace.

Course title: Advanced genetics - laboratory practicals

Credits: 6

Course description:

Blood groups. Drosophila as a model system in genetics, the Drosophila life cycle. An introduction to Drosophila genetics. Flybase, fly informatics. Balancer chromosomes and genetic markers. Sex linkage. Complementation analysis and deletion mapping. Transposable elements and P element as a genetic tool. P-element remobilization and insertional mutagenesis. Fluorescent proteins as cellular markers. Gametogenesis. Courtship behaviour.

Students attain an experimental insight into principles of heredity and practical experience in classical and molecular genetics.

Students develop skills in classical and molecular genetics, including the determination of blood groups, the handling of Drosophila, sex linkage, mapping of lethal genes in Drosophila, the use of transposable elements to induce mutations and to utilize them as a genetic tool, and observation of the behaviour of the fruit fly. Gaining information from publicly available databases.

Literature:

Greenspan RJ: Fly Pushing: The Theory and Practice of Drosophila Genetics, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, 2004. ISBN 978-1621822-33-2

Sullivan W, Ashburner A, Hawley RS eds.: Drosophila Protocols, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, 2000. ISBN 978-087969827-0

Course title: Advanced molecular biology: qualitative and quantitative analysis of macromolecules

Credits: 2

Course description:

Molecular cloning, cloning vectors, enzymes used in molecular biology. Generation and use of genomic DNA and cDNA libraries. Hybridization techniques (colony, Southern, Northern). Labelling and detection of nucleic acids and proteins. Immunohistochemistry, labelling and detection using antibodies. Detection of macromolecules by fluorescent and confocal microscopy. Methods for the quantitative and qualitative analysis of RNA. Gel-based and chromatographic methods of protein purification and analysis. In vitro and in vivo methods of analysis of protein-protein interactions. In vitro and in vivo methods of analysis of interactions of proteins and nucleic acids. Mass-spectrometry and proteomics. Polymerase chain reaction and its applications. DNA sequencing, applications of deep sequencing methods. The tools of genomics and functional genomics.

The course familiarizes students with recombinant DNA technology, the methods of isolation and qualitative and quantitative analysis of macromolecules, and the experimental systems, tools and techniques used in the characterization of the organization and function of macromolecular systems. The main tools and methods that students understand after completion are molecular cloning, labelling and detection of macromolecules, immunochemical methods and microscopy; techniques of RNA and protein purification, separation and analysis; methods of protein-protein and protein-DNA interaction studies; PCR; DNA sequencing; and methods of genomics and proteomics.

The course is designed to help students develop the competence required in molecular biological research. They gain detailed knowledge of the practical application of modern experimental methodologies, and their advantages and disadvantages in answering specific research questions. They learn to break down problems into basic units that can be answered by using experimental approaches. They acquire skills in designing experimental procedures, and using the experimental approach to answer complex biological problems.

Literature:

Wilson K, Walker J: Principles and Techniques of Biochemistry and Molecular Biology, 7th edn., Cambridge University Press, Cambridge, 2010. ISBN 978-0-521-51635-8

Course title: Cell and tissue cultures: theory and practice

Credits: 6

Course description:

Theoretical background: cell and tissue culture techniques (4 x 4 hours, 4 hours per week for 4 weeks)

In vitro maintenance of embryonal and adult cells and tissues. Isolation of cells, maintenance of subcultures, cell passaging. Manipulation and differentiation of cultured cells. Cell transfection, transduction. Cell viability. Utilization of in vitro systems in molecular medicine. Tissue engineering. Major cell lines. Culturing media. Mitogens. Minimal/essential culturing media, supplements. Maintenance of a sterile environment. Major equipment in the cell culturing laboratory (thermostat, laminar flow, microscopes, centrifuge, etc.). Preparation and culturing of adult bone marrow cells and their derivatives. Primary cortical and hippocampal cell cultures (chick and rat). Preparation and maintenance of mixed (neuronal and glial) cultures. Organotypic cell and tissue cultures. Preparation and in vitro maintenance of explant cultures. In vitro phenotyping. Immunocytochemistry, Western blot analysis. Neuronal and glial markers.

Introductory practicals, practising sterile work (2 x 4 hours, 4 hours per week, for 2 weeks): The sterile laboratory environment. Maintaining an aseptic working environment, working with culturing media, without cells. Preparation of bone marrow cells from young adult rats. Removal of bone marrow, purification, centrifugation. Cell counting techniques. Preparation of cell smears. May-Grünwald/Giemsa staining.

Practicals with rat bone marrow cell cultures (2 x 4 hours, 4 hours per week for 2 weeks): Preparation of bone marrow cells from young adult rats. Removal of bone marrow, purification, centrifugation, plating. Treatment with mitogens. Collection of mitogen-treated bone marrow-derived cells (neurospheres, DIV7) for Western blot analysis. Determination of protein content.

Practicals with primary cultures from embryonal chicken forebrain (2 x 4 hours, 4 hours per week for 2 weeks): Preparation of primary cultures from embryonal chicken forebrain (E16-E18). Tissue removal, purification, centrifugation. Cell counting. Plating to petri dishes. AChE histochemistry on chicken forebrain cultures. Digital imaging in light microscopy, making of microphotographs. Trypsin treatment, passage of cultured cells for further culturing.

Practicals with primary cultures from embryonic rat forebrains (3 x 4 hours, 4 hours per week for 3 weeks): Isolation of cerebral cortical tissue samples from E18 rat embryos. Tissue preparation, purification, centrifugation. Cell counting. Plating to petri dishes. Fluorescent immunocytochemical

detection of GFAP in astrocytes in primary cortical cultures (DIV7). Digital microphotography on GFAP-positive astrocytes (2 days).

The course is designed to provide a thorough introduction to the theory and practice of various in vitro techniques used in vertebrate neurosciences. The material is presented at a level suitable for advanced B.Sc. students majoring in life sciences. Adult bone marrow cells are used to differentiate neurospheres, and chicken and rat mixed primary neuronal cultures. Histological staining procedures and fluorescent immunohostochemistry are used to demonstrate the presence of different cell types and astrocytes, respectively.

During this one-semester course, the students not only learn and practise basic laboratory skills (basic cell handling and cell counting methods, the use of automatic pipettes, microscopes, etc.; they receive guidance in the use of a medium-sized centrifuge and different types of light microscopes), but also become able to work in a sterile environment (laminar flow) and to handle sterile media and plated cultured cells. They additionally learn basic histological/immunohistochemical methods (May-Grünwald/Giemsa staining, GFAP fluorescent immunohistochemistry).

Literature:

Davis JM szerk. (2011): Animal Cell Culture: Essential Methods. John Wiley & Sons Ltd. ISBN: 978-0-470-66658-6

Freshney RI szerk. (2017): Culture of Animal Cells A Manual of Basic Technique and Specialized Applications Seventh Edition. Wiley Blackwell. ISBN 978-1-118-87365-6

Selected reviews from PubMed.

Course title: DNA damages and repair pathways

Credits: 2

Course description:

The focus is to overview molecular responses, such as chromatin structural changes, transcription or replication stalling occurring during DNA damages. We will discuss the types of DNA damages affecting the integrity of the DNA, the different repair mechanisms developed by the cells to avoid the errors and the cancerous and non-cancerous outcomes upon these damages. We will discuss the essential steps of the DNA damage recognition and repair pathways. Additionally, we will present recently published articles from the topics and we will speak about the new findings written in each presented article.

The course provides a thorough introduction from the molecular background of formation and repair of DNA damages, including very recent data from the field of DNA repair. The materials will be presented at a level suitable for advanced M.Sc. students majoring in molecular biology. The lectures will introduce the different strategies of the cells to repair the damaged DNA. The students will get detailed review of intrinsic and extrinsic causes of DNA damages, the process of DNA repair mechanisms and the recent and future strategies in cancer treatments. By its completion, students have a comprehensive understanding of the background of tumorigenesis, metastases and cancer treatments.

The students will become familiar with the basics of formation different types of DNA damages. They will possess a basic knowledge of DNA repair mechanisms, cancer formations and possible treatment strategies of the tumors. They have a detailed understanding of the molecular basis of DNA repair formations, including the strategies of different organisms and also the silencing of transcription and replication during the repair process. They will be acquainted with the crucial steps of tumor formations and the molecular basis of traditional and next-generation cancer treatments.

Literature:

Bruce Alberts Molecular Biology of the cell 2014 Garland Science (ISBN: 9780815344322)

Mark R. Kelley and Melissa L. Fishel DNA Repair in Cancer Therapy 2016 Elsevier (ISBN: 9780128035825)

Course title: Gene technology 1

Credits: 2

Course description:

1st block: Overview of nucleic acid structure and function. Genes, genomes, size and composition. Tools and techniques of DNA extraction, purification and manipulation: Enzymes used in DNA research: nucleases, phosphatases, kinases, ligases, polymerase. In vivo and in vitro synthesis of nucleic acids. The basics of recombinant DNA technology – gene cloning in Escherichia coli host. Vector types and introduction of DNA into bacterium cells. Genomic and cDNA library preparations, library screens. The use of polymerase chain reaction in DNA amplification, diagnosis and forensic applications, quantitative transcript analysis, digital PCR. Nucleic acid sequence analysis methods, dideoxy chain termination methods and NGS techniques. Hybridization techniques, DNA chips and their use.

2nd block: Transgenic animals – techniques to make them and their use. Somatic cloning of mammalian species. Manipulations with stem cell, induced stem cell production, gene therapy approaches. Genome engineering techniques and in vitro evolution approaches. Trials and perspective of building synthetic genomes.

The course is designed to provide a thorough introduction to basic techinques in molecular biology: isolation of genomic and plasmid DNA, PCR techniques and two application areas of PCR technology. Assays for protein expression after induction by IPTG or lactose and protein purification and gene regulation in prokaryotic cells by lac operon. The course is suitable for advanced MSc students.

The course will emphasize the most important tools, methods and techniques in molceular biology. The students will have a comprehensive understanding about the various gene technologies.

Literature:

Current literature from PubMed.

Course title: Gene technology 2

Credits: 2

Course description:

3rd block: Genetic manipulation of fungi, recombinant hosts, genetic transformation methods, expression systems. Genetic manipulation of fungi, overexpression of genes, heterologous gene expression, gene silencing in fungi. Metabolic engineering of filamentous fungi, recent developments and applications. Modification and improvement of the secondary metabolism of fungi; manipulation of the biosynthetic pathways. Genetic methods in immunology, recombinant vaccines, stem cells and gene therapy.

4th block: Specificities and history of plant gene technology. Biological and methodologic backgrounds of in vitro plant regeneration. Plant cell and tissue culture techniques. Introducing DNA into plant cells and tissues; direct and indirect gene transfer methods (biolistic transformation, Agrobacterium-mediated gene transfer). Integration of genetic engineering strategies into plant breeding: genetic modifications to improve plant tolerance against abiotic and biotic stresses. Molecular pharming: altering plant metabolism to produce functional and high quality foods, biopharmaceuticals, and to increase biomass production. Environmental and health safety, risk assessmentand regulationof the cultivation and commercialization of genetically modified crops. Economic impacts, public perception, present and future roles.

The course is designed to provide a thorough introduction to basic techinques in molecular biology: isolation of genomic and plasmid DNA, PCR techniques and two application areas of PCR technology. Assays for protein expression after induction by IPTG or lactose and protein purification and gene regulation in prokaryotic cells by lac operon. The course is suitable for advanced MSc students.

The course will emphasize the most important tools, methods and techniques in molceular biology. The students will have a comprehensive understanding about the various gene technologies.

Literature:

Current literature from PubMed

Course title: Macromolecule design and manipulation – laboratory practicals

Credits: 6

Course description:

Preparation of DH5α E. coli competent cells and transformation of pET-Pfu plasmid into these cells. Preparation of pET-Pfu plasmid DNA from DH5 α E. coli cells. Preparation of Rosetta (DE3) competent cells. Transformation of pET-Pfu plasmid into Rosetta (DE3) cells. Induction of Pfu protein expression by lactose or IPTG in Rosetta cells. Isolation of Pfu protein from induced Rosetta cells using a sonication method. PCR testing of the activity of Pfu polymerase. Examination of Pfu protein expression by PAGE assay. Further purification of Pfu protein by salting-out assay. Isolation of proteins from PAGE gels and examination by mass spectrometry. Purification of GST-tagged proteins by affinity chromatography. Applications of PCR technology. Isolation of genomic DNA. Genotyping of ABO(H) blood groups by SNP analysis. Determination of ABO alleles by allele-specific PCR, product analysis by agarose gel electrophoresis. Analysis of regulation of the E. coli lac operon.

The course is designed to provide a thorough introduction to basic techniques in molecular biology: isolation of genomic and plasmid DNA, PCR techniques and two application areas of PCR technology. Assays for protein expression after induction by IPTG or lactose, and protein purification and gene regulation in prokaryotic cells by lac operon. The course is suitable for M.Sc. students. During the course, various techniques for the expression and purification of recombinant proteins in prokaryotic cells are applied. By its completion, students have a comprehensive understanding of macromolecule design and manipulation.

The students become familiar with the various molecular biology methods. They understand the modes of protein expression using the pET system and two purification techniques (salting-out and affinity chromatography) for recombinant proteins. They produce a complete project notebook by the end of the semester, which helps them prepare their thesis. They acquire the ability of self-working from a syllabus. During the course, the students gain practice in manual skills, such as sterile work, pipetting and solution handling and various gel electrophoresis (agarose, PAGE) techniques.

Literature:

Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A, Martin KC: Molecular Cell Biology, 8th edn., Macmillan, New York, 2016. ISBN: 1-4641-8339-2

Voet D, Voet JG: Fundamentals of Biochemistry, 4th edn., Wiley Publishing, Hoboken, 2011.

Course title: Molecular medicine

Credits: 2

Course description:

An introduction to molecular genetic and cell biology methods in clinical practice. Diagnostic methods based on immunological techniques (RIA, ELISA, Western blot analysis, immunocytology, etc.). Diagnostic methods based on nucleic acid hybridization (Northern blot analysis, in situ hybridization, DNA chip technology, etc.). Gene sequencing and analysis, genomic and proteomic techniques, cell and tissue culture methods. Molecular markers in human disorders. Diagnostic methods based on specific endonuclease activity (fragment length polymorphism, pedigree analysis, etc.). Molecular biological methods in clinical practice. Intracellular signalization in pathophysiological processes. Regulation of gene expression. Regulation of neuronal gene expression. Molecular biological aspects of neurologic and psychiatric disorders. Gene therapy, viral vectors, DNA-liposome complexes. Antisense pharmacology. Small interfering RNA. Molecular chaperones. Embryonal and adult stem cells. Neuronal stem cells. The feasibility of stem cell therapies. Cell replacement therapies. In vitro differentiation of stem cells to the desired phenotype. Transfection of stem cells. Regulation of cell cycle and cell differentiation, translation control of gene expression. Telomerase-directed molecular therapy. Immunotherapy. Antitumour immune responses. Introduction to bioinformatics and computer-assisted methods in diagnosis and therapy: functional genomics and proteomics.

This one-semester course is designed to provide an introduction to a number of emerging topics related to molecular biology-based diagnostic and therapeutic approaches. The lectures summarize recent advances in selected fields such as intracellular signalization, regulation of gene expression, (stem) cell replacement technologies, telomerase-based therapies, gene therapies, etc. Recent advances in antitumour therapies and immunotherapies are also discussed. The students become familiar with various immunological and nucleic acid-based diagnostic technologies. They are introduced to cutting-edge diagnostic and therapeutic methodologies based on molecular biological approaches. They gain an understanding of how genetic profiling can help diagnosis, and how stem cell-based approaches can be used for therapeutic purposes.

Literature:

Trent RJ (2012): Molecular Medicine 4th Edition Genomics to Personalized Healthcare, Academic Press, ISBN: 9780123814517

Selected reviews from PubMed.

Course title: Molecular neurobiology

Credits: 2

Course description:

Neurocytology, molecular architecture of neurons. Micro RNAs in neuronal tissue. Alternative splicing in neurons. Mechanisms of local protein synthesis in dendrites and axons. Molecular mechanism of axon guidance. Neocortex development. Cell death in the neurons. New role of astrocytes. Protein aggregation and neurodegeneration. The basis of neuroimmunology. Neuroactive steroids.

The course is designed to present the molecular background of different neuronal functions at a level suitable for advanced M.Sc. students. The course provides information on newly discovered biomolecules such as micro RNAs, intracellular pathways, local protein synthesis in neuronal subdomains, and the molecular background of different neurodegenerative disorders (Alzheimer's disease, Parkinson's disease), with concise knowledge concerning the embryonal development of the neocortex in general, and the molecular events associated with it in particular.

The students receive a broad-spectrum survey of the latest molecular mechanisms and their role in neuronal tissue, which helps them identify their own research interest in molecular neurobiology, and new questions in their own chosen neurobiological research topic. Such knowledge is essential if students wish to develop new methods in the therapy of neurodegenerative diseases like Alzheimer's or Parkinson's disease.

Literature:

Selected reviews from PubMed.

Course title: Tumourbiology

Credits: 2

Course description:

Cells in the body and in culture. Basics of cell-to-cell communications, cell cycle, cell division. Cells in culture, growth characteristics of primary cells and cancer cells. Tumours: types, morphological characteristics, occurrence, tumour and tumour environment, development of tumours, familial and sporadic occurrence of tumours. A brief overview of cancer epidemiology. The role and involvement of RNA and DNA viruses in cancer (biology and research). Cancer-causing retroviruses and DNA viruses: RSV, ALV, HTLV, HPV. Non-biological cancer-causing agents: radiation, chemical mutagenesis, mechanisms guarding genome maintenance and integrity. Tumour promoters. Oncogenes and oncogene activation. Types of oncogenes. The role of proto-oncogenes in normal cells, mechanisms of oncogene activation. Tumour suppressor genes, gatekeepers and caretakers. Rb and p53. Genome integrity, genome alterations, telomere, telomerase. Metabolic features of cancer cells, energy production, metastasis, angiogenesis. The cancer genome, tumour driver and passenger mutations, evolution of cancer cells. Cancer and the immune system. Cancer stem cells. Cancer and epigenetics. Cancer prevention and cancer therapy approaches: surgery, radiation, chemotherapy. Anticancer drugs, drug targets, drug resistance. Targeted (rational) and personalized cancer treatment. Present and future.

The course provides a thorough introduction to the molecular background of tumour formation, including very recent data from tumour biology research. The material is presented at a level suitable for advanced M.Sc. students majoring in molecular biology. The lectures introduce the characteristics of tumour cells. They give a particularly detailed review of intrinsic and extrinsic causes of tumour formation, the progression of metastases and also the available and future cancer treatments. By its completion, students have a comprehensive understanding of the background of tumorigenesis, metastases and cancer treatments.

The students become familiar with the basics of the characteristics of normal and cancer cells. They possess a basic knowledge of tumour types, cancer epidemiology and the importance of the tumour microenvironment. They have a detailed understanding of the molecular basis of tumorigenesis, including the role of DNA and RNA viruses, non-biological cancer-causing agents, oncogenes and tumour suppressors, and the alterations in genome integrations in tumour formation and progression. They are acquainted with the crucial steps of metastases and the molecular basis of traditional and next-generation cancer treatments.

Literature:

Weinberg RA: The Biology of Cancer, 2nd edn., Garland Science, New York, 2013. ISBN:9780815342205

Course title: Advanced immunology

Credits: 2

Course description:

The molecular basis of immune recognition. Molecules (MHC, antigen receptors, co-stimulatory molecules, adhesion molecules). Mediators (cytokines, chemokines, hormones). Cells (T and B lymphocytes, antigen-presenting cells, natural immune cells). Complement system, activation, function and regulation. Antigen processing. The regulation of immune responses. Effector mechanisms. Tumour immunology. T cell development, T cell receptors. T cell populations and their role in infection control (Th1, Th2, Th17, T regs, Tc). Autoimmunity and allergy.

The knowledge of the students relating to recent developments in immunology is extended and their understanding of the key scientific questions and approaches in immunological research is improved. The topics are presented at a level suitable for students with advanced knowledge in immunology. The students acquire a comprehensive understanding of the molecular background of immune defence mechanisms and functions.

The students gain knowledge regarding the molecular basis of the immune response, supplemented with recent developments in immunology. They become familiar with the structural and functional components of the immune system. They acquire an understanding of the molecular background of the immune recognition and pathogen elimination mechanisms in both the innate immune system and the adaptive immune system. A comprehensive understanding of the immune system equips students with the ability to evaluate pathological processes that directly involve the immune system or are associated with other physiological systems. The students become familiar with the role of recognition receptors, the complement system, antigen presentation, immunoglobulins and the adaptive T cell response in the general function of the immune response.

Literature:

Janeway CA, Travers P, Walport M, Shlomchik MJ: Immunobiology. The Immune System in Health and Disease. 5th Edn., Garland Science, London, New York, 2001. ISBN: 0-8153-3642-X

Course title: Cell communication in plants

Credits: 2

Course description:

The module comprises the following topics: A general introduction to communication in biology. The evolution of cell communication: from the bacterial two-component system to G-proteins. Inter-organellar signalling in plants. Cell-to-cell signalling: peptides, non-cell-autonomous proteins, RNAs, hormones, nutrients, sugars, reactive oxygen and nitrogen species, mechanical signals. Communication at the organismal level: the communication of plants with microbes, insects, other plants and animals. How to study the signalling pathways involved in cell communication.

The students become familiar with the basis of communication networks between various kinds of cells in the plant body. A comprehensive treatise is provided on the basic principles of cell communication at different levels (intra- and intercellular and organismal), why it is essential for cells to communicate and what kind of channels they can use to do this. The students receive a strong theoretical background of the various communication pathways, and the similarities and differences between the various pathways employed by plants and their different cells.

The students become familiar with the most important signalling pathways through which cells can send messages to each other. They also receive training in the basic methodology of how to study the various communication pathways in different kinds of cells. This includes relevant techniques of genomics and proteomics.

Literature:

Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor) Biochemistry and Molecular Biology of Plants, 2nd Edition, Wiley 2015 ISBN: 978-0-470-71421-8

Selected reviews from PubMed.

Course title: Molecular plant physiology

Credits: 2

Course description:

The organization of plant nuclear, plastidic and mitochondrial genomes. The expression of plant genes. The main regulatory elements, from chromatin organization and epigenetic regulation to transcription factors and small RNAs. Special features of plant cells, cell elongation and division. Plant specific physiological functions such mineral nutrition, short- and long distance transport, and photosynthesis. Molecular mechanisms and signalling of plant hormones and other signals including novel plant growth regulators and signalling intermediates identified in plants. Photoreceptors and light-regulated genes. Control of flowering and sexual reproduction. Senescence, ripening and programmed cell death. Possibilities and main research directions relating to modifications of plant growth and development.

The course provides an up-to-date overview of the exciting progress achieved in plant biology with the tools and results of molecular and cell biology, genomic analysis, bioinformatics and systems biology. Following the introductory sessions, the lectures furnish comprehensive knowledge of the molecular basis of how plants function, respond to environmental and developmental signals, organize their growth and development, and form flowers, seeds and fruits.

The students become familiar with the plant-specific physiological and molecular events and the structural and functional aspects of plant life in relation to the sessile and autotrophic life strategy of plants. They have a holistic view about plant life. Moreover, they will understand the main topics which are in the forefront of plant biochemistry and molecular biology. The obtained knowledge can provide a good basis to formulate their own research interest.

Literature:

Jones R, Ougham H, Thomas H, Waaland S: The Molecular Life of Plants, Wiley-Blackwell, American Society of Plant Biologists, Hoboken, 2012. ISBN: 978-0-470-87011-2

Taiz L, Zeiger E, Moller IA, Murphy A: Plant Physiology and Development, 6th edn., Sinauer Associates Inc., Publishers, Sunderland, 2016. ISBN: 978-1605353531

Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor) Biochemistry and Molecular Biology of Plants, 2nd Edition, Wiley 2015 ISBN: 978-0-470-71421-8

Course title: Applied molecular biotechnology

Credits: 3

Course description:

Planning of a protein expression project with a generally used *E. coli* expression system. Protein production in a non-conventional bacterial expression system. Gene optimization and expression vector design. Tags and fusion proteins. Cloning in *E. coli*. Protein expression in bacterial strains. Testing of different growth conditions for the optimization of protein production. Purification of recombinant proteins.

In close connection with the Molecular biotechnology course, this practical course introduces the preparation and usage of recombinant protein-producing strains. Students learn how to design expression vectors and identify the expression host and expression strategy best suited for the particular target protein, and they investigate the effects of various growth conditions on the protein production capacities of bacterial expression strains.

Students become able to identify appropriate vector and host cells for the production of particular proteins. They design expression vectors and expression strategies. They use bacterial strains for the expression of recombinant proteins and study the protein-producing capacity. They understand the techniques and strategies through which to improve protein expression levels. They become familiar with the extraction and purification of recombinant proteins, especially fused to tags or proteins.

Literature:

Reece RJ: Analysis of Genes and Genomes. John Wiley & Sons, Inc., Hoboken, 2003. ISBN: 978-0-470-84380-2

Course title: Environmental biotechnology

Credits: 2

Course description:

Biotechnology has serious role in green economy by providing green catalyst for producing novel products or for removing hazardous compounds released by human activities. The course will cover several technologies of biorefinery, the maximal utilization of any (by-)products of agricultural or industrial technologies. Some examples of biomaterials and their production by bioprocesses will be detailed. The development/innovation of alternatives to fossil fuels is particular important part of this lecture set. The existing industrial, agricultural and domestic processes are producing huge amounts of pollutants. The pollutants released to the environment have to be eliminated, various bioremediation technologies applicable to solve the pollution problems are presented.

In the lectures focusing on plant biotechnology, the following topics will be covered. General stress physiology, stress detection and signalling in plants. Abiotic stress factors and plant growth: light, temperature extremes, oxygen deficiency, water deficiency, high salinity. Climate change and plant biotechnology. Response of plants to heavy metals and xenobiotica. Phytoremediation: cleaning the environment from heavy metals and organic pollutants by plants. Engineering plants to improve phytoremediation efficiency. Plants in bioindication and biomonitoring. Photosynthetic responses to abiotic stresses and the measurement of photosynthetic activity in the laboratory and in the polluted areas. The responses of plants to biotic stress factors. Strategies of environmentally-friendly plant protection.

The course is designed to provide a comprehesive introduction into environmental microbial and plant biotechnology. On successful completion of the course, the students will be able to understand and explain the importance of molecular approaches in environmental microbiology and biotechnology. The students will be able to desing biotechnological solutions for environmental issues including pollution, renewable energy and biorefinery processes.

The students will be able to design draft bioprocesses taking notice/account of the cost effective parameters, environmental conditions. The lecture familiarizes the students with the biorefinery processes creating a combination the bioremediation technologies with various bioprocesses. The students will become familiar with abiotic environmental factors that affect microbial and plant life including exposure to xenobiotics, extreme illumination, temperature, water deficiency and heavy metal availability. They will understand the key aspects and common processes underlying responses of organisms to environmental stresses and design experiments that study such processes.

Literature:

Flickinger MC ed.: Upstream Industrial Biotechnology, Vol. 1-2., John Wiley & Sons, Inc., Hoboken, 2013.

Flickinger MC ed.: Downstream Industrial Biotechnology: Recovery and Purification, John Wiley & Sons, Inc., Hoboken, 2013.

Gurevitch J, Scheiner SM, Fox GA: The ecology of plants, Sinauer Associates, Inc., Sunderland, 2002.

Kelly DR ed.: Vol. 8a Biotransformations I. in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Klein J ed.: Vol. 11b Environmental Processes II. – Soil Decontamination in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Klein J, Winter J eds.: Vol. 11c Environmental Processes III. – Solid Waste and Waste Gas Treatment, Drinking Water Preparation in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Lambers H, Chapin FSIII, Pons TL: Plant physiological ecology, Springer Science+Business Media, LLC, New York, 2008.

Peters J ed.: Vol. 8b Biotransformations II. in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Roehr M ed.: Vol. 6 Products of Primary Metabolism in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Sahm H ed.: Vol. 1 Biological Fundamentals in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Schulze E-D, Beck E, Müller-Hohenstein K: Plant ecology, Springer, Berlin/Heidelberg, 2005.

Scragg A: Environmental Biotechnology, 2nd Edn., Oxford University Press Inc., Oxford, 2005.

Stephanopoulos G ed.: Vol. 3 Bioprocessing in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

von Döhren H ed.: Vol. 7 Products of Secondary Metabolism in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Wackett LP, Hershberger CD: Biocatalysis and Biodegradation: Microbial Transformation of Organic Compounds, ASM Press, Washington DC., 2001.

Winter J ed.: Vol. 11a Environmental Processes I. – Wastewater Treatment in: Rehm H-J, Reed G, Pühler A, Stadler PJW series eds.: Biotechnology 2nd Edn., Wiley-VCH, Weinheim, 1999-2000.

Elizabeth Pilon-Smits, Phytoremediation, Annual Review of Plant Biology Vol. 56:15-39, 2005

Kvesitadze, G., Khatisashvili, G., Sadunishvili, T., Ramsden, J.J. Biochemical Mechanisms of Detoxification in Higher Plants: Basis of Phytoremediation. Springer, 2006

Course title: Industrial biotechnology

Credits: 2

Course description:

1) Which microbes perform the most important biotechnological conversions and how do they work? The most important microbial taxa employed in the fermentative biotechnology industry are discussed. The biology and biotechnological applications of the following taxonomic groups are presented in detail: methanogens for biogas generation; methylotrophs for bioremediation; Clostridia and their versatile metabolism; lactic acid bacteria for food preservation; Bacilli the multitask group for exploitation; Pseudomonas strains to communicate and perform diverse tasks for us; yeasts, the multifarious eukaryotic workers; fungi, carrying out specific, but important tasks.

2) What can we do to facilitate their activity in the industrial setting? Process design and control parameters are reviewed and industrial technologies for product formation and recovery are discussed. How to design a biotechnological process: the most important parameters to measure and control in the process, steps to facilitate product formation in microbial fermentation, methods for recovery of the desired products, separation technologies for small and large molecular mass products, process control technologies for optimum production, sensitive and specific measuring devices: biosensors, immobilization techniques and their applications.

3) Processes already employed in the biotechnological fermentation industry and future prospects. Selected technologies to introduce already-existing and emerging biotechnological conversion methods, their benefits and difficulties; generation of renewable bioenergy carriers: biohydrogen, biogas, bioethanol and biodiesel; glycerol production strategies; biotechnological production of organic solvents (acetone, butanol, isopropanol and 2,3-butanediol) on an industrial scale; organic acids produced by microbes: acetate, citric acid, gluconic acid and poly-hydroxy butyrate.

4) Food processing biotechnologies. Microbes participate to a large extent in preparing and preserving our foodstuff. How do they work, how can we improve their performance? Related issues are discussed. Milk preservation and conversion technologies: cheese, butter, sour cream, yoghurt, kefir and similar products, the biotechnology of beer production, how to make good whisky, how to make tasty bread.

The course is designed to provide a thorough introduction to biotechnological methods and applications. The material is presented at a level suitable for MSc students majoring in life sciences. The course is concerned primarily with prokaryotic cells, and emphasis is placed on the practical aspects of fermentation technologies. The lectures are compiled to introduce the basic biochemistry, molecular biology and microbiology behind the various applications. By completion, students have a comprehensive understanding of the frequently applied biotechnological techniques.

The students become familiar with the various strategies exploited for biotechnological utilization. They become acquainted with the most important properties of the microbes and eukaryotes employed in biotechnological processes. The rationale and design strategy of biotechnological processes are thoroughly discussed. A number of selected applications and biotechnological technologies to convert substrates into various products are explained.

Literature:

Rehm H-J, Reed G eds.: Biotechnology, 2nd Completely Revised Edition, VCH GmbH, Weinheim, 1994.

Course title: Molecular biotechnology

Credits: 2

Course description:

Prokaryotic expression systems. Transcription regulation in prokaryotes. mRNA degradation in prokaryotic cells. Translation efficiency-determining elements. Proteolysis. Protein transport in prokaryotic cells. Fusion proteins. Downstream processing of recombinant proteins. Generally used Escherichia coli expression systems. Protein production with Gram-positive bacteria. Protein production with eukaryotic cells. Post-translation modifications, protein maturation and its control, glycosylation, protein secretion in eukaryotic cells. Yeast and fungal expression systems. The insect cell - baculovirus expression system. Protein production with mammalian cell cultures. Applicarions in various branches of biotechnology.

Protein expression is universally used by researchers and the biotechnological industry to produce proteins for laboratory investigations and industrial, diagnostic or therapeutic applications. The cellular processes and the regulation of protein expression are introduced. The course focuses on strategies for optimization of the protein expression in heterologous systems for high-level protein production. The generally used prokaryotic, fungal and mammalian expression systems are introduced.

Students learn about the steps of protein expression in prokaryotic and eukaryotic cells (transcription, translation, protein maturation, degradation and secretion) and the regulation of these processes. They become acquainted with the elements of the protein expression systems (vectors, promoters, selection systems and host cells), the procedure and techniques of the completion of recombinant protein expressing strains and process optimization. They acquire an understanding of the capabilities and challenges of protein expression platforms.

Literature:

Glick BR, Pasternak JJ, Patten CL: Molecular Biotechnology. Principles and Applications of Recombinant DNA. 4th edn., ASM Press, Washington DC, 2010. ISBN: 1555814980

Gellissen G ed.: Production of Recombinant Proteins. Novel Microbial and Eukaryotic Expression Systems. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2005. ISBN: 9783527310364

Reece RJ: Analysis of Genes and Genomes. John Wiley & Sons, Inc., Hoboken, 2003. ISBN: 978-0-470-84380-2

Course title: Advanced microbiology 1

Credits: 2

Course description:

The course focuses on the growth and development of microbial cells and cell populations, and includes the following themes: effects of environmental factors on microbial growth; essential nutrients and energy sources and main metabolic pathways and processes; physical and chemical agents for microbial growth control; principles of microbial cell metabolism; secondary metabolite production; strain improvement, metabolic engineering and phylogenetic and molecular taxonomic methods in mycology. Aspects of public health microbiology and epidemiology and also human-microbe interactions (infection and diseases) are introduced.

Students receive a thorough introduction to microbial physiology, and cell and molecular biology. The clinical, environmental and biotechnological importance of microorganisms is surveyed. The material is presented at a level suitable for advanced M.Sc. students.

The students acquire an understanding of the basics of microbial metabolism, the mechanisms and significance of the main catabolic and anabolic pathways, the effects of environmental factors on microbial growth and development, and the background and significance of microbial secondary metabolites, with an overview of public health microbiology and epidemiology.

Literature:

Selected literature from PubMed.

Course title: Advanced microbiology 2

Credits: 2

Course description:

The course focuses on the following topics: The life cycle and genetics of eukaryotic microorganisms; molecular background of mating and heterokaryon incompatibility in different taxa; the parasexual life cycle; the virulence factor of microscopic fungi and its molecular background; the host-pathogen interaction; extra-chromosomal elements of fungi: mitochondrial DNA, DNA plasmids and mycoviruses; the structure and function of extrachromosomal elements and their transmission; secondary metabolites of fungi and the regulation of their production: mycotoxins, antibiotics, pigments and carotenoids.

The course provides an overview of the life cycle of various fungal and yeast species. The structure and function of fungal extrachromosomal elements are discussed. The students become familiar with secondary metabolites produced by fungi and gain a basic insight into the host-pathogen interaction.

The students acquire a basic insight into the genetics of eukaryotic microorganisms, become familiar with the regulation of secondary metabolite production, and attain the basic techniques for strain improvement and molecular taxonomy in fungi.

Literature:

Selected literature from PubMed.

Course title: Advanced microbiology practicals 1

Credits: 6

Course description:

The following practical aspects are demonstrated: the counting of viable bacterial and fungal cells in soil samples; the counting of psychro-, meso- and thermophilic bacteria in water samples; the selective isolation of Pseudomonas and Bacillus strains from soil; the selective isolation of Trichoderma strains from environmental samples; in vitro testing of the microbial antagonism between bacteria and filamentous fungi; study of the extracellular lipase and esterase secretion of bacterial strains; the detection and measurement of the cellulase, xylanase and phosphatase activity of Trichoderma strains; study of the extracellular amylase, chitinase and protease production of bacterial strains; the isolation of laccase-producing filamentous fungi; determination of the copper tolerance of bacteria and fungi; determination of the susceptibility of Trichoderma strains to fungicides.

This practical course provides an introduction to the techniques most frequently used in environmental microbiology. The material is presented at a level suitable for M.Sc. students in life sciences. Students will achieve the basic methodology with which to isolate bioactive microbes and study their activities.

The students learn methods for the counting of microbes in different environmental samples and for the isolation of strains with different biological activities. They acquire basic techniques for the detection and measurement of extracellular enzyme activities, the examination of microbial antagonism, and the performance of various susceptibility tests.

Literature:

Selected literature from PubMed.

Course title: Advanced microbiology seminar

Credits: 2

Course description:

Papers reporting the most recent and relevant results of the discipline are read, discussed and detailed during the consultations. Students prepare a short presentation based on the treated subject.

Under the guidance of the lecturer, students read and interpret selected scientific papers related to the subjects of the Advanced Microbiology 1 course. They prepare a short presentation based on the reviewed paper. The biological and methodical background of the study and the scientific significance of the results are discussed in detail during the consultations.

Through surveys and discussions of recent microbiology literature, the course offers an insight into the current state and perspectives of microbiology, and training in the understanding and interpretation of scientific reports. Students have the opportunity to practise the preparation, presentation and discussion of their contributions.

Literature:

Selected literature from PubMed.

Course title: Industrial applications of microscopic fungi

Credits: 2

Course description:

Students read and interpret scientific papers connected with one of the following topics: Biotechnologically relevant fungal species. Methods for fungal strain isolation. Culture and maintenance. Screening for biological activities. Production of different primary and secondary metabolites by fungi. Classical and recombinant techniques for strain improvement. Metabolic engineering. Fungi as cell factories. Fungi in the food industry. Environmental applications of fungi.

Papers relevant to the different subjects are read and discussed in detail during the consultations. Students prepare a short presentation based on the treated subject.

The course provides an overview of applied mycology, including industrial applications and methodologies used to discover, improve and exploit the biotechnological potential of fungi. It introduces the most relevant fungal groups and fields of applications. Students read and interpret selected scientific papers in a consultative form, and prepare a short presentation on this basis. The biological and/or methodical background of the subject is discussed in detail during the consultations.

The students acquire an understanding of the significance of fungal biology. They receive an introduction to the learning and interpretation of scientific results and published articles. They also have the opportunity to practise the preparation, presentation and discussion of their contributions.

Literature:

Anke T ed.: Fungal Biotechnology. Chapman & Hall, London,1998.

Arora DK, Bridge PD, Bhatnagar D eds.: Handbook of Fungal Biotechnology 2nd Edn. Marcel Dekker Inc., New York, 2003.

Tkacz JS, Lange L eds.: Advances in Fungal Biotechnology for Industry, Agriculture, and Medicine. Kluwer Academic/Plenum Publishers, New York, 2004. ISBN 978-1-4419-8859-1

Wainwright M: An Introduction to Fungal Biotechnology. Wiley Biotechnology Series, Wiley & Sons, Inc., Chichester, 1992. ISBN: 978-0471934585

Course title: Molecular anthropology and palaeopathology

Credits: 2

Course description:

Methodological aspects of the study of ancient human remains. Basic human osteology and palaeopathology. The beginnings of archaeological DNA (aDNA) work. Methodological aspects of aDNA work. Early difficulties and modern technical solutions. Laboratory requirements. Applications of aDNA data. Tracing human prehistory through genetics. The beginnings of palaeomicrobiology, molecular biological studies of ancient pathogens. Applied palaeomicrobiology: evolutionary studies of mycobacterial diseases.

The students receive a background of new methods applied in human osteoarchaeology, acquire an understanding of the special aspects of aDNA work relative to modern DNA, and know what can be learnt from molecular anthropology data. They receive an introduction to palaeomicrobiology, an emerging field of research at the intersection of microbiology and evolution, history and anthropology.

Students attain an understanding of the importance and technical background of human genetic data and the evolution of human pathogens.

Literature:

Paabo S (2004): Genetic analyses from ancient DNA. Annu. Rev. Genet., 38, 645-679.

Raoult D, Drancourt M eds.: Paleomicrobiology. Past Human Infections. Springer-Verlag, Berlin, Heidelberg, 2008. ISBN 978-3-540-75855-6

Shapiro B, Hofreiter M eds.: Ancient DNA: Methods and Protocols, Series: Methods in Molecular Biology, Vol. 840, Humana Press, New York, 2012. ISBN 978-1-61779-516-9

Willerslev E, Cooper A (2005): Ancient DNA. Proc. Biol. Sci. 272, 3-16.

Course title: Molecular ecology and evolution

Credits: 2

Course description:

Dynamics of genes in populations. Evolutionary change in nucleotide sequences. Adaptive and non-adaptive processes in genome evolution. Rates and patterns of protein evolution. Gene regulatory evolution. Molecular phylogenetics. Genome diversity and evolution. Origin of new genes. Gene duplication. Multigene families. Genome and chromosome duplication. Evolution by transposition. Origin of life.

The course is designed to survey both evolutionary patterns and mechanisms at a molecular level. The most important methods of inference are overviewed.

By the end of the course, students have a picture of the key transitions during the evolution of life and are able to demonstrate evolutionary relationships at the various structural levels and develop critical thinking skills with which to evaluate the knowledge acquired in many other disciplines of biology.

Literature:

Barton NH, Briggs DEG, Eisen JA, Goldstein DB, Patel NH: Evolution, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, 2007. (http://evolution-textbook.org/).

Graur D, Li W-H: Fundamentals of Molecular Evolution, 2nd edn., Sinauer Associates, Sunderland, 2000.

Course title: Scientific literature sources and databases

Credits: 2

Course description:

The sources of the scientific literature. Searching for literature: online databases, journal collections. EISZ databases and beyond. The search process: keywords, logical operators. Searching in online databases: general steps. University library: databases. Web of Science. MedLine. PubMed. Citations: citing and cited. Reference programmes: the RefWorks. How to organize RefWorks records? Scopus. Science Direct. Scientometry: valuation of science by quantitative means. Important numbers: Impact factor, Hirsch index. How to use the references? ISI Citation Index.

The course focuses on the use of online scientific reference databases, and on strategies to find the proper information. A general introduction to RefWorks. At the end of the semester, students prepare a presentation including the references found in online databases.

The students become familiar with the various scientific literature online databases. They learn how to search for references and how to organize them with special programmes, how to use them in publications and some elements of scientometry.

Literature:

Course title: Research project/thesis work in biochemistry/molecular biology 1

Credits: 15

Course description:

This two-semester course gives students a specialized knowledge in their chosen research field. They design and carry out a research project relating to one of the major research interests of the Department of Biochemistry and Molecular Biology. The main fields of interest are:

1) Protein structure and enzyme activity.

2) Oxidative stress and consequences in living systems.

3) Nanomaterials and their interactions with tumour cells.

The students become able to find relevant literature in databases; they understand how to design and carry out scientific experiments, how to collect data, and how to present their data in a scientific publication. Benchwork includes the maintenance of cell cultures, animal experiments, immunocytochemistry, image analysis, and basic and advanced biochemical and molecular biological methods. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the thesis.

Literature:

Current literature will be given to the students who are also encouraged to search databases for further information.

Course title: Research project/thesis work in biochemistry/molecular biology 2

Credits: 15

Course description:

This two-semester course provides students with specialized knowledge in their chosen research field. The students design and carry out a research project relating to one of the major research interests of the Department of Biochemistry and Molecular Biology. The main fields of interest are:

1) DNA damage and repair.

2) Molecular mechanisms of neurological diseases in a fruit fly model.

3) Molecular basis of tumour development and metastasis.

The students become able to find relevant literature in databases; they understand how to design and carry out scientific experiments, how to collect data, and how to present their data in a scientific publication. Benchwork includes the maintenance of cell cultures, DNA, RNA purification PCR, next-generation sequencing, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practicing methods related to the topic of the thesis.

Literature:

Current literature is given to the students, who are also encouraged to search databases for further information.

Course title: Research project/thesis work in biotechnology 1

Credits: 15

Course description:

This two-semester course provides students with specialized knowledge in their chosen research field. They design and carry out a research project relating to one of the major research interests of the Department of Biotechnology. The main fields of interest are: 1) bioremediation of hazardous compounds; 2) mapping of metabolic routes of biodegradation; 3) metabolomics of biofuel production; 4) bacteriophages: phage therapy, functional analysis and other applications; 5) microbial bioenergy production; 6) algal biotechnology; 7) biotechnology of photosynthetic bacteria; 8) protein expression technologies; 9) fermentation; 10) infections of livestocks; 11) waste treatments; 12) fertilizing processes in agriculture. The students become able to find relevant literature in databases, to design and carry out scientific experiments, to collect data, and to present their data in a scientific publication. The benchwork includes the establishment and maintenance of mixed primary and pure cell cultures, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in biotechnology 2

Credits: 15

Course description:

This two-semester course gives students specialized knowledge in their chosen research field. They design and carry out a research project relating to one of the major research interests of the Department of Biotechnology. The main fields of interest are: 1) bioremediation of hazardous compounds; 2) mapping of metabolic routes of biodegradation; 3) metabolomics of biofuel production; 4) bacteriophages: phage therapy, functional analysis and other applications; 5) microbial bioenergy production; 6) algal biotechnology; 7) biotechnology of photosynthetic bacteria; 8) protein expression technologies; 9) fermentation; 10) infections of livestocks; 11) waste treatments; 12) fertilizing processes in agriculture.

The students become able to find relevant literature in databases, to design and carry out scientific experiments, to collect data, and to present their data in a scientific publication. The benchwork includes the establisment and maintenance of mixed primary and pure cell cultures, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in cell biology/neurobiology 1

Credits: 15

Course description:

This two-semester course provides students with specialized knowledge in their chosen research field. The students design and carry out a research project relating to one of the major research interests of the Department of Cell Biology and Molecular Medicine. The main fields of interest are:

1) regulation of neuronal and glial gene expression in physiological, pathophysiological and experimental conditions in vivo and in vitro;

2) in vitro neuronal and glial cell phenotyping;

3) roles of microglial cells in neurodegenerative processes in vivo and in vitro.

The students become able to find relevant literature in databases, to design and carry out scientific experiments, to collect data, and to present their data in a scientific publication. Benchwork includes the establishment and maintenance of mixed primary and pure cell cultures, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in cell biology/neurobiology 2

Credits: 15

Course description:

This two-semester course provides students with specialized knowledge in their chosen research field. The students will design and carry out a research project relating to one of the major research interests of the Department of Cell Biology and Molecular Medicine. The main fields of interest are:

1) regulation of neuronal and glial gene expression in physiological, pathophysiological and experimental conditions in vivo and in vitro;

2) in vitro neuronal and glial cell phenotyping;

3) roles of microglial cells in neurodegenerative processes in vivo and in vitro.

The students become able to find relevant literature in databases, to design and carry out scientific experiments, to collect data, and to present their data in a scientific publication. Benchwork includes the establishment and maintenance of mixed primary and pure cell cultures, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in genetics 1

Credits: 15

Course description:

Students acquire advanced knowledge in their chosen field of interest and valuable, first-hand experience in classical and molecular genetic techniques.

During this two-semester course, students carry out individual thesis work in one of the research groups of the Department of Genetics under the guidance of a supervisor. Some of the research topics offered:

1) Genetic characterization of genes involved in ubiquitin-mediated protein degradation in *Drosophila;* 2) Functional analysis of deubiquitylases in *Drosophila;* 3) Genetic basis of chemosensitivity; 4) Genetic and molecular characterization of mitochondria during spermatogenesis; 5) Membrane organization during spermatogenesis;6) Ancient DNA analysis of ancestral Hungarian populations; 7) Studying ancestral disease organisms with ancient DNA; 8) Molecular genetic analysis of the circadian clock.

The thesis work provides students with knowledge and insight into real research activities such as a literature search, the planning and performance of experiments, and the collection, analysis and presentation of experimental data. They additionally acquire the attributes of team work, and apply their knowledge and skills in the context of a real laboratory. Students must have an interest in genetics, with the capacity to participate in research. They must also demonstrate the skills necessary to accurately observe, record and analyse experimental data, handle research equipment and apply relevant scientific knowledge.

Literature:

Current relevant literature is provided by the supervisor. Students are encouraged to search research library collections and online scientific literature databases.

Course title: Research project/thesis work in genetics 2

Credits: 15

Course description:

Students acquire advanced knowledge in their chosen field of interest and valuable, first-hand experience in classical and molecular genetic techniques.

During this two-semester course, students carry out individual thesis work in one of the research groups of the Department of Genetics under the guidance of a supervisor. Some of the research topics offered:

1) Genetic characterization of genes involved in ubiquitin-mediated protein degradation in *Drosophila;* 2) Functional analysis of deubiquitylases in *Drosophila;* 3) Genetic basis of chemosensitivity; 4) Genetic and molecular characterization of mitochondria during spermatogenesis; 5) Membrane organization during spermatogenesis; 6) Ancient DNA analysis of ancestral Hungarian populations; 7) Studying ancestral disease organisms with ancient DNA; 8) Genetic analysis of circadian clock genes in *Arabidopsis thaliana*.

The thesis work provides students with knowledge and insight into real research activities such as a literature search, the planning and performance of experiments, and the collection, analysis and presentation of experimental data. They additionally acquire the attributes of team work, and apply their knowledge and skills in the context of a real laboratory. Students must have an interest in genetics, with the capacity to participate in research. They must also demonstrate the skills necessary to accurately observe, record and analyse experimental data, handle research equipment and apply relevant scientific knowledge.

Literature:

Current relevant literature is provided by the supervisor. Students are encouraged to search research library collections and online scientific literature databases.

Course title: Research project/thesis work in microbiology 1

Credits: 15

Course description:

The students carry out mini research projects in one of the research groups at the Department of Microbiology. Some potential fields of research: 1) Screening for extracellular enzyme activities; antimicrobial susceptibility; 2) Selection of microbial biocontrol agents; 3) Molecular study of opportunistic pathogenic fungi; 4) Biosynthesis of bioactive microbial metabolites; 5) Purification of selected secondary metabolites using separation methods; 6) Analytical measurement of microbial secondary metabolites.

The students become able to find relevant literature in databases, to understand how to design and carry out scientific experiments, to collect data, and to present their data in a scientific publication. Benchwork includes establishment and maintenance of mixed primary and pure cell cultures, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods related to the topic of the thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in microbiology 2

Credits: 15

Course description:

The students carry out a mini research project in one of the research groups of the Department of Microbiology. Some potential fields of research: 1) Screening for extracellular enzyme activities; antimicrobial susceptibility; 2) Selection of microbial biocontrol agents; 3) Molecular study of opportunistic pathogenic fungi; 4) Biosynthesis of bioactive microbial metabolites; 5) Purification of selected secondary metabolites by using separation methods; 6) Analytical measurement of microbial secondary metabolites.

The students become able to find relevant literature in databases, to understand how to design and carry out scientific experiments, to collect data, and to present their data in a scientific publication. Benchwork includes establishment and maintenance of mixed primary and pure cell cultures, immunocytochemistry and image analysis. Searching PubMed/Medline and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods related to the topic of the thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in plant biology 1

Credits: 15

Course description:

This two-semester course provides students with specialized knowledge in their chosen research field. They design and carry out a research project relating to one of the major research interests at the Department of Plant Biology. The main research interests are:

1) Investigations of plant antioxidant systems at physiological and molecular levels

2) Monitoring of photosynthetic activity in response to environmental stress

3) Polyamine catabolism and non-enzymatic antioxidants in plants

4) Studies of heavy metal-induced nitro-oxidative stress in plants

5) Salicylic acid-induced programmed cell death in tomato plants

6) Glutamine synthetase in plants: activity and isoenzymes

Students become able to find relevant literature in databases; they understand how to design and carry out specific experiments, how to collect data and how to present their data in a scientific publication. Benchwork includes the growth and maintenance of plants, using hydroponics, quantitative PCR, electrophoresis, HPLC, infrared gas analysis, chlorophyll fluorometry, fluorescence microscopy, spectroscopy, elemental analysis, ICP-MS, etc. Searching PubMed and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the research project/thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Research project/thesis work in plant biology 2

Credits: 15

Course description:

This two-semester course provides students with specialized knowledge in their chosen research field. They design and carry out a research project relating to one of the major research interests at the Department of Plant Biology. The main research interests are:

1) Investigations of plant antioxidant systems at physiological and molecular levels

2) Monitoring of photosynthetic activity in response to environmental stress

3) Polyamine catabolism and non-enzymatic antioxidants in plants

4) Studies of heavy metal-induced nitro-oxidative stress in plants

5) Salicylic acid-induced programmed cell death in tomato plants

6) Glutamine synthetase in plants: activity and isoenzymes

Students become able to find relevant literature in databases; they understand how to design and carry out specific experiments, how to collect data and how to present their data in a scientific publication. Benchwork includes the growth and maintenance of plants, using hydroponics, quantitative PCR, electrophoresis, HPLC, infrared gas analysis, chlorophyll fluorometry, fluorescence microscopy, spectroscopy, elemental analysis, ICP-MS, etc. Searching PubMed and other databases; concepts in designing experiments and organizing data; presenting data and preparing research reports; learning and practising methods relating to the topic of the research project/thesis.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Advanced microbiology practicals 2

Credits: 6

Course description:

The following practicals are demonstrated: the transformation of bacteria; the transformation of yeasts and fungi; molecular markers in studies of the biodiversity of fungi: isoenzyme analysis; molecular markers in studies of the biodiversity of fungi: RAPD analysis; molecular markers in studies of the biodiversity of fungi: electrophoretic karyotyping; dimorphism in zygomycetes; the parasexual life cycle in filamentous fungi (heterokaryon formation by anastomosis and protoplast fusion, diploid isolation, haploidization); study of the sexual life cycle of yeasts (conjugation, diploid isolation, spore forming, random spore analysis); the killer phenomenon in yeasts.

This course presents the techniques most frequently used to manipulate microorganisms and basic molecular techniques for study of the biodiversity and life cycle of microbes. The material is presented at a level suitable for M.Sc. students in life sciences. Students acquire the basic methodology with which to manipulate microorganisms and study the genetic background of the biodiversity and life cycle of microorganisms.

The students learn molecular microbial techniques with which to study the genetic background of microbial diversity. They acquire the basic techniques through which to manipulate bacteria, yeast and fungi. They carry out experiments to study the sexual and parasexual life cycles of eukaryotic microorganisms, to manipulate the processes and analyse the progeny.

Literature:

Selected literature from PubMed.

Course title: Biology of human pathogen protist parasites

Credits: 2

Course description:

Characterization of Entamoeba histolytica, life-cycle, molecular pathomechanism, virulence factors, the clinical manifestation of amoebiasis, diagnostics, epidemiology and prevention. Characterization of Giardia lamblia, life-cycle, molecular pathomechanism, virulence factors, the clinical manifestation of giardiasis, diagnostics, epidemiology and prevention. Characterization of Trichomonas vaginalis, life-cycle, molecular pathomechanism, virulence factors, the clinical manifestation of trichomoniasis, diagnostics, epidemiology and prevention. An overview of the cellular characteristic features, the molecular mechanism of host invasion and the intracellular survival strategy of Apicomplexa species. Characterization of Cryptosporidium sp., life-cycle, molecular pathomechanism, virulence factors, the clinical manifestation of cryptosporidiosis, diagnostics, epidemiology and prevention. Characterization of Plasmodium sp., life-cycle, molecular pathomechanism, virulence factors, the clinical manifestation of malaria, diagnostics, epidemiology and prevention. The history of malaria, an overview of human genetic mutations and the related molecular mechanisms that endow humans with the ability to survive malaria. Characterization of Toxoplasma gondii, life-cycle, molecular pathomechanism, virulence factors, the clinical manifestation of toxoplasmosis, diagnostics, epidemiology and prevention. An overview of the cellular characteristic features, life-cycles and survival strategies of extra- and intracellular kinetoplastid parasites. Characterization of Trypanosoma rhodesiense and T. gambiense, life-cycles, molecular pathomechanism, survival strategy in the host, the clinical manifestation of sleeping sickness, diagnostics, epidemiology and prevention. Characterization of Trypanosoma cruzi, life-cycle, molecular pathomechanism, survival strategy in the host cell, the clinical manifestation of Chagas disease, diagnostics, epidemiology and prevention. Characterization of Leishmania sp., life-cycles, molecular pathomechanism, survival strategy in the host cell, the clinical manifestation of leishmaniasis, diagnostics, epidemiology and prevention.

The course provides detailed knowledge of the cellular features, life-cycles, virulence factors and pathology of human protist parasites. The students acquire an understanding of the pathomechanism at a molecular level from the up-to-date results of molecular researches. The lectures cover various areas of cellular and medical microbiology, epidemiology, molecular biology and immunology.

The students become familiar with the cellular features and life-cycles of human parasite protists, the molecular pathomechanisms of parasites and how the clinical manifestations relate to the pathomechanism. They achieve an understanding of the survival strategies of pathogens in the host, epidemiological concepts and prevention strategies.

Literature:

Levinson WE, Jawetz E: Medical Microbiology & Immunology: Examination and Board Review, 8th Edn., Lange Medical Books/McGraw-Hill, New York, 2004. ISBN: 0071431993

Course title: Current aspects of the pathology of the enteric nervous system

Credits: 2

Course description:

After the introductory lectures that deal with the structure and function of the enteric nervous system, the students read and discuss scientific papers connected with the enteric nervous system and diabetes, inflammatory bowel diseases (Crohn's disease and ulcerative colitis). During the course, the students prepare short presentations of their choice relating to the course.

The seminars provide an overview of the organization, function and pathology of the enteric nervous system. The students become aware of its importance and clinical relevance.

The students become familiar with the significance of the enteric nervous system. They receive an introduction to the learning and interpretation of scientific results and papers and have an opportunity to practise the presentation and discussion of scientific results.

Literature:

Furness J: Enteric Nervous System, Blackwell, Oxford, 2006. ISBN: 1-4051-3376-7

Selected scientific papers from PubMed.

Course title: Field practice

Credits: 3

Course description:

The field trip introduces students to typical representatives and vegetal associations of the Hungarian flora and the basics of plant taxonomy. On a one-day trip, the students visit the Botanical Garden of the University of Szeged, where they learn about the indigenous plant species from around Szeged and some exotic species found in the Garden.

During the field trip, the students collect biological specimens/samples to identify species from a variety of aquatic habitats, such as bogs, river flats, sewers and fish-ponds and from terrestrial habitats such as different types of soils, tillage, etc.

By exploring plant associations, nearby fields, riverbanks, a wastewater treatment plant, etc., the students gain an insight into the Hungarian flora and basic knowledge in plant taxonomy, and they learn about different adaptation strategies of plants, and the traditional usage of herbaceous plants. They acquire an understanding of the importance of field work and attain first-hand experience about environmental monitoring, sample collection and preservation, and the testing of microbial samples for different species.

The students learn to identify and categorize a number of plant species on the basis of their characteristic morphological features, they gain basic taxonomical and botanical knowledge, and they become acquainted with several sample collection and testing methods.

Literature:

Harris JG, Harris MW: Plant Identification Terminology: An Illustrated Glossary, 2nd. edn., Spring Lake Publishing, Payson, 2001.

Harrington HD, Durrel LW: How to Identify Plants, Swallow Press, Athens, 1986.

Selected reviews from PubMed.

Course title: Fluorescent methods in plant biology

Credits: 2

Course description:

The module comprises the following topics: A general introduction to fluorescence, physical basics, spectra and how to record them. The advantages of fluorescent dyes over alternative methods in cell biology. A general introduction to the measurement of intracellular ion concentrations. Ca-sensitive dyes. How to measure intracellular pH. How to measure the resting membrane potential. How to detect apoptosis. How to measure cell viability. How to use fluorescent dyes in genomics and proteomics. How to study signal transduction with fluorescent probes. Instruments that are used for fluorescence studies (with practical demonstrations).

The students become familiar with the development and applicability of various fluorescent probes that can be used in molecular biology, cell biology and molecular genetics. A comprehensive treatise is provided on the basic principles of fluorescence, with a short introduction to spectroscopy and various methods used in spectroscopy. The various kinds of spectra are discussed, including absorption, emission and excitation spectra, how to obtain them and how to make use of them. This is followed by the various types of fluorescent dyes and what aspects need to be taken into account when one specific dye is to be selected.

The students acquire an understanding of the calibration of dyes, various aspects of dye sensitivity and other technical problems. Demonstrations provide hands-on experience in using fluorimeters, fluorescence and confocal microscopes, flow cytometers and fluorescence-activated cell sorters. Different aspects of the various methods are discussed, and practical advice is given and the theoretical basics are reinforced.

Literature:

Selected reviews from PubMed.

Course title: Fluorescent methods in plant biology – laboratory practicals

Credits: 3

Course description:

The course comprises the following topics: A general introduction to fluorescence, physical basics, spectra and how to record them. The advantages of fluorescent dyes over alternative methods in cell biology. A general introduction to the measurement of intracellular ion concentrations. Ca-sensitive dyes. How to measure intracellular pH. How to measure the resting membrane potential. How to detect apoptosis. How to measure cell viability. How to use fluorescent dyes in genomics and proteomics. How to study signal transduction with fluorescent probes. Instruments that are used for fluorescence studies (with practical demonstrations).

The students become familiar with the development and applicability of various fluorescent probes that can be used in molecular biology, cell biology and molecular genetics. A comprehensive treatise is provided on the basic principles of fluorescence, with a short introduction to spectroscopy and various methods used in spectroscopy. The various kinds of spectra are discussed, including absorption, emission and excitation spectra, how to obtain them and how to make use of them. This is followed by the various types of fluorescent dyes and what aspects need to be taken into account when one specific dye is to be selected.

The students acquire an understanding of the calibration of dyes, various aspects of dye sensitivity and other technical problems. Demonstrations provide hands-on experience in using fluorimeters, fluorescence and confocal microscopes, flow cytometers and fluorescence-activated cell sorters. Different aspects of the various methods are discussed, and practical advice is given and the theoretical basics are reinforced.

Literature:

Selected reviews from PubMed.

Course title: History of microbiology

Credits: 2

Course description:

Leeuwenhoek: The discovery of bacteria. Spallanzani: The first experimental evidence against the abiogenesis theory. Pasteur: Abiogenesis disproved, studies in the silk and fermentation industries, the introduction of a rabies vaccine. Koch: Postulates to prove the connection between microbes and diseases. Discovery of the causal agents of anthrax and tuberculosis. Roux and Behring: The development of serum therapy agains diphtheria and tetanus. Metchnikoff: The discovery of cellular immunity, the father of probiotics. Ehrlich: Discovery of the first chemotherapeutic agent. Fleming: The discovery of the first antibiotic agent.

Information relating to the discovery of bacteria. The principles and results of experiments providing evidence against the abiogenesis theory. The scientific background of fermentation processes. The germ theory of diseases. The introduction of vaccination against infectious diseases. Koch's postulates to prove the connection between microbes and diseases and their application in the discovery of the causal agents of diseases.

The course broadens the general knowledge of the students concerning the history of biological sciences.

Literature:

de Kruif P: Microbe Hunters, A Harvest/Harcourt Brace Jovanovich Publishers Book, San Diego New York London, 1926.

Maurois A: The Life of Sir Alexander Fleming, Discoverer of Penicillin, E. P. Dutton & Co., Inc. Publishers, New York, 1959.

Course title: Molecular plant physiology – laboratory practicals

Credits: 3

Course description:

Laboratory basics practicing. The preparation of various plant tissue culture media, and the establishment of sterile plant tissue cultures (sterilization of Arabidopsis or tomato seeds, and Saintpaulia leaves). The basic steps of primer design and the use of in silico databases of expressed genes. Utilization of PCR reactions in plant science. Checking of DNA samples with PCR. PCR-based selection of homozygotes in Arabidopsis mutant populations. Mapping of the genetic diversity of different plant populations with molecular markers.

The practicals are designed to provide an experimental insight into the principles of basic plant molecular and biotechnological methods. Students gain practical experience in working with plant tissue cultures under sterile flow, extraction, purification, multiplication and analysis of nucleic acids and the main methods used in the investigation of gene functions.

This course helps students develop skills and become familiar with basic molecular and biotechnological methods used in plant biology. This knowledge provides a good basis for their own research interest.

Literature:

Current literature is given to the students, who are encouraged to search databases for further information.

Course title: Neuroimmunology

Credits: 2

Course description:

Introduction to immunology. Origin of the specific cells of the central nervous system (CNS). Immune functions of CNS cells. The blood-brain barrier. Trafficking of cells into the CNS. Monocytes/macrophages, T cells, B cells. Cytokines, chemokines, metalloproteinases, prostaglandins. Cytokines in pain perception. Neurodegeneration, trauma and neuroinflammation. The roles of astroglia and microglia in neuroinflammatory processes. Immunological effects of neurotransmitters. Neurological stimulation of the immune system. Contribution of immunomediators to the development, plasticity and pathology of the CNS. Neuro-immune-associated learning. Multiple sclerosis. Myasthenia gravis and other autoimmune diseases. Creutzfeld–Jacob disease. HIV. Alzheimer's disease. Tumours in the CNS, immune functions of neuronal tumours.

By completion of this course, the students are able to explain how the immune system and cellular brain components contribute to different neurological diseases, and to describe the types and effector functions of resident and peripheral immune cells in the human brain in health and disease.

The students become familiar with the basic principles of the immunological aspects of brain functions in health and disease. They also understand how immunological phenomena can affect brain functions.

Literature:

Galoyan A, Besedovsky H eds.: Neuroimmunology. In: Lajtha A ed.: Handbook of Neurochemistry and Molecular Neurobiology. 3rd edn., Springer Reference, New York, 2008. ISBN 978-0-387-30358-1

Relevant reviews from PubMed.

Course title: Plant–microbe interactions

Credits: 2

Course description:

1) Plant-microbe interactions. Pathogenic interactions, classification of host-parasite interactions, defence mechanisms of the host plant. Non-pathogenic interactions, the soil and the phylloplane as natural habitats of microorganisms. Symbiotic interactions. Plant-virus interactions: plant pathogenic viruses. Symptoms of viral infections, pathophysiological changes related to viral infections. Virus transfer. Molecular genetics of plant pathogenic viruses. Overview of plant pathogenic viruses. Plant pathogenic viroids. Recognition of viral diseases of plants, identification of the causal agents. Possibilities of protection, resistance.

2) Plant-bacterium interactions: Pathogenicity and virulence factors of plant pathogenic bacteria. Penetration and colonization of the pathogen, compatible and incompatible host-pathogen interactions. Symptoms and pathophysiological changes related to bacterial infections. Genetics of plant pathogenic bacteria. Soil-borne and air-borne plant pathogenic bacteria. Phytoplasmas. Recognition of bacterial diseases of plants, identification of the causal agents. Possibilities of protection, resistance. Plant growth-promoting and deleterious rhizobacteria. Endosymbiotic bacteria and their agricultural importance, mechanism and molecular background of endosymbiotic nitrogen fixation in the soil.

3) Plant-fungus interactions: Pathogenicity and virulence factors of plant pathogenic fungi. Germ development and colonization. Symptoms of fungal infections, pathophysiological changes related to fungal infections. Molecular genetics of plant pathogenic fungi. Overview of the most important soil-borne and air-borne plant pathogenic fungi and postharvest pathogens. Recognition of fungal diseases of plants, identification of the causal agents. Possibilities of protection, resistance. Plant growth-promoting fungi in the soil. Symbiotic fungi and their agricultural importance, mycorrhizal fungi in the soil, types of mycorrhiza (ecto-, ectendo- and endomycorrhiza). Endophytic fungus-plant associations.

The course provides detailed knowledge regarding the biological background and agricultural significance of the various pathogenic and non-pathogenic plant-microbe interactions. Pathogenicity and virulence factors; plant cellular, developmental and defence responses to microbes; recognition of diseases of plants, identification of the microbial agents; the possibilities of protection and resistance and the significance of symbiotic interactions are discussed.

The students acquire an understanding of the practical importance of plant-microbe interactions and their role in plant diseases, plant protection and growth promotion. They also receive an introduction to the genetic and molecular biological backgrounds of these interactions.

Literature:

Selected literature from PubMed.