Biochemistry Laboratory 1

- Purification of proteins - precipitation with salts and organic solvents, dialysis followed by chromatographic purification.
- Chromatographic methods in Biochemistry - separation of proteins using gel chromatography, ionex chromatography, and affinity chromatography.
- DNA isolation and analysis - Isolation of plasmid DNA, chromosomal DNA, measurement of DNA concentration, measurement of DNA concentration in microvolumes, agarose gel electrophoresis of DNA.
- Methods for protein concentration determination - quantification of proteins using the Lowry method, biret method, Bradford method, direct determination of protein concentration, direct determination of protein concentration in microvolumes.
- Enzyme kinetics - kinetic parameters of protein cleavage by trypsin, kinetic parameters of hydrogen peroxide cleavage by catalase, kinetic parameters of peroxidase reaction.
- SDS-PAGE of proteins - electrophoretic separation of proteins in polyacrylamide gels of different concentrations, staining of the separated proteins using the CBB dye.

Biochemistry 1

The course which is composed of lectures and the laboratory exercise aims at introducing of general biochemistry for students of the Biology bachelor programme. The course provides a broad array of fundamental knowledge of structural and functional biochemistry which are essential for understanding of other subjects in Biology curriculum. In the course framework, biochemistry is given as chemistry of non-binding/non-covalent interactions which take place in biological systems on the level of molecules and cells. Structural and functional properties of the components which play a role in the transmission of energy as well as signals are emphasized. In the laboratory exercise stressed to one week block students learn basic methods and techniques which are common in biochemical research.

- Introductory to Biochemistry: The origin of life; Mechanisms of molecular interactions, Metabolism.
- Biomolecules: Amino acids; Peptides; Proteins; Carbohydrates; Lipids; Nucleic acids.
- Enzyme catalysis I: Principles of catalysts and enzyme activity.
- Enzyme catalysis II: Enzyme kinetics; Enzyme properties; Enzyme types.
- Gene expression and proteosynthesis: Mechanisms of DNA replication; Transcription/the synthesis of RNA; Gene regulation in Prokaryotes; Gene regulation in Eukaryotes; Translation/the synthesis of proteins; Posttranslational modification.
- Biological membranes and membrane transport: Composition and structure; fluidity and asymmetry; transport across membranes; Methods in biomembrane research.

Biology of Microorganisms

- An Overview of Microbiology
- Cell Structure: Prokaryotic/Eukaryotic Structure
- Microbial Metabolism: Nutrients, Energy, Regulation
- Culture and growth of Microorganisms
- Microbial Genetics: DNA, Protein Synthesis, Regulation, Genetic Exchange
- Genetic engineering with Microbes Classification and Evolution of Microorganisms
- Survey of Prokaryotes
- Eukaryotic Microorganisms: algae, fungi and protists
- The viruses, Viral Infection of Host Cells

- Microbial Ecology, Environmental Activities of Microorganisms
- Microbial Biotechnology Hosts, Parasites and Normal Flora
- Clinical Diagnostic Microbiology
- Infectious Diseases and Populations: Epidemiology, Infectious
- Diseases and Infectious: Viruses, Bacteria, Fungi
- Immunological Defenses against Microorganisms
- Vaccines; Case Study Discussions

- Contents of laboratories: Practical training of the methods covered by the lecture

Biostatistics

The aim of the course is to introduce the principles of statistical thinking and the use of statistics in science. In addition to this theoretical background, special emphasis is put on practical use of statistical analyses for data processing. After completing the course, the students should be able to process their own data and apply basic statistical methods to test hypotheses related to topics of their bachelor theses

- Introduction to statistics
- Basic descriptive statistics
- Probability and likelihood
- Testing of hypotheses
- Goodness-of-fit test, contingency tables
- t-tests and their non-parametric counterparts
- Analysis of variance and its non-parametric counterparts
- Correlation and linear regression
- Multiple regression and general linear models
- Non-linear regression
- Introduction to multivariate methods

- Practical training is focused on computing of statistical methods theoretical principles of which are covered by the lectures. In addition, graphical presentation of data and analysis results is emphasized. All computations are carried out in R package.

Environmental Chemistry

The subject on environmental analytical chemistry has expanded in recent years into a fully grown scientific field. This course represents introduction into a theoretical basis of the distribution of the chemical compounds between the compartments of the ecosystem and overview of the isolation and concentration of the pollutants from the atmosphere, water and soil, their determination with the modern instrumental techniques with the emphasis on the chromatography and its connection with the spectroscopic techniques.

Environmental Chemistry Laboratory

The subject on environmental analytical chemistry laboratory is to provide students with laboratory skills in determination methods used in environmental chemistry, to introduce them to the basic modern instrumental techniques in the study field.

Molecular Biology and Genetics I

- Introduction to molecular biology: History and application of molecular biology in today's science.
- Molecular structure of genes and chromosome: Molecular definition of a gene, chromosomal organization of genes and noncoding DNA, structural organization of chromosomes.
- Basic molecular genetic mechanisms, Replication of DNA: Understanding the central dogma of molecular biology and overview of basic molecular genetic mechanisms. Basic features of DNA replication in vivo.
- Transcription and RNA processing, Translation and the genetic code: Principles of transcription in Prokaryotes and Eukaryotes, basic regulation of gene expression at transcriptional and postranscriptional level. Principles of translation, genetic code.
- Mutation, DNA repair, and recombination: Molecular basis of mutations, induced mutagenesis, overview of repair mechanisms and principles of recombination.
- Basic techniques of molecular biology: Overview of molecular biology techniques and their use in modern research.
- Recombinant DNA technology, the polymerase chain reaction: Cloning genes, principle of polymerase chain reaction and its applications.
- Molecular analysis of genes and gene products: Use of recombinant DNA technology to identify genes, molecular diagnosis of human diseases.
- Regulation of gene expression in Prokaryotes, Eukaryotes and the genetic control of development: Operon, molecular control of transcription in Eukaryotes, gene expression and chromosome organization, mechanisms of regulation of gene expression during development.
- Cell-to-cell signaling and signal transduction: Receptors, hormones, overview of signaling pathways, interaction and regulation of signaling pathways.
- Cell cycle: Overview of the cell cycle and its control, models for studying cell cycle.
- Cancer: Genetic and molecular basis of cancer, oncogenes and tumor suppressor genes, genetic pathways to cancer and treatment.
- Cytoskeleton: Cell motility and shape, microfilaments and microtubules dynamics and motor proteins, connections to cell division, adhesion and communication.
- Molecular biology of model organisms: Overview of the most used models and model organisms in basic research, their genetics and molecular biology, principles and methods of genetic manipulations.
- Overview molecular biology applications in modern basic and applied science: Summary of the course in context of using molecular biology in modern research.

Biochemistry Laboratory 2

- Comparison of protein separation by SDS-PAGE using different concentrations of acrylamide and in gradient gels.
- Comparison of staining of SDS-PAGE separated proteins using different methods (Ponceau, CBB, silver).
- 2D in the analysis of complex biomacromolecular samples - 2D agarose electrophoresis of plasmid DNA; 2D electrophoresis of proteins - BN-PAGE/SDS-PAGE; 2D electrophoresis of proteins - denaturing PAGE/SDS-PAGE.
- Electroblotting of proteins and its use - immunoblotting, lectinoblotting; sensitivity and specificity of immunoblotting; Schiff staining of glycoproteins.
- Spectrophotometric determination of DNA binding capacity for EtBr, quantification of DNA using the intercalating dyes EtBR, SYBR, and DAPI. Determination of molar extinction coefficient of the SYBR dye in complex with DNA.
- Purification of enzymes (catalase, peroxidase, acidis phosphatase, alkalic phosphatase,

trypsin) and determination of their enzymatic activity. Separation of isoeznymes using PAGE.
- Purification of lectins fromplant material. The use of purified lectins for isolation of glycoproteins. Deglycosylation of glycoproteins.
- Comparison of antibody (IgG, IgM, IgY) binding to protein A, protein G.

Biochemistry 2

- Introductory metabolism and bioenergetics: Metabolism; Thermodynamics of energetic metabolism; Biological oxidation; Coupled reactions; Experimental approach.
- Energetic metabolism I: Carbohydrate metabolism; Compartmentation; Regulation.
- Energetic metabolism II: The Citric acid cycle; Electron transport; Oxidative phosphorylation.
- Energetic metabolism III: Lipid metabolism; Nitrogen utilization; Compartmentation.
- Energetic metabolism IV: Photosynthesis and photosynthetic machinery; Photorespiration; the C4 cycle.
- Biotransformation: Metabolism of xenobiotics; Mechanisms of biotransformation reactions; Enzymes in biotransformation, Compartmentation and physiological features.
- Integration and regulation of energetic metabolism: Compartmentation of metabolic pathways; Functional relationships between pathways; Regulatory actions; Metabolic check points; Experimental approaches in metabolism.

Biology of Animals

Basic course of zoology, mainly for students without intent to specialise on zoology, but rather on either ecology, botany, and nature conservation disciplines, or experimental and biomedicine disciplines. The first, common part explains phylogenetic relationships of major metazoan groups, their diversity and major adaptations. The second part will be taught separately, focused either on ecological and biogeographical distribution and conservation strategies, or on comparative approach to general zoology and an evolutionary approach to the experimental model species of animals.

- Origin and evolution of animals: Cells and tissues of multicellular animals, basic anatomy, epithelial layers, body cavities.
- Animal evolution: "Radiata", basal diversification of Bilateria, Deuterostomia, Platyzoa; Lophotrochozoa, Ecdysozoa; Arthropoda; Chordata: Urochordata, Cephalochordata, aquatic vertebrates; Tetrapoda.
- Ecological part: daptations: movement, food, defence; Vertebrate adaptations: movement, food, defence.
- Animal ecophysiology: cold-warm-blooded animals, respiration, osmoregulation, water balance climatic limits, adaptations, migration; reproduction, reproductive organs, strategies, progeny investment, mate choice.
- Intra- and interspecific relationships, parasitism, symbiosis, mimicry.
- Regional biogeography: historical geography, biomes, zoogeographical regions, conservation; Regional biogeography and ecology - Europe: historical geography, biomes, fauna, introduced species, conservation, Central Europe: fauna (origin, ecology, distribution and its changes), important places, protected areas, conservation (causes of threads, conservation actions, habitat protection, environmental organisations and activities).
- Gametogenesis, fertilisation, embryogenesis, cell differentiation, development of organs in the arthropods and vertebrates; Postembryonic development, types of larvae,

metamorphosis, reproduction, hormonal control of reproduction and growth.
- Evolution of genome, cytogenetics, relationships between genes, evolution and onthogeny (Hox genes, etc.).
- Food intake and digestion; energetic metabolism and its regulation, thermoregulation, ecophysiological adaptations, dormancy.
- Locomotion, skeleton and muscles; respiration, circulation, excretion, osmoregulation;
- Evolution of nervous system and sensory organs, communication, pheromones, vertebrate immunity.
- Model species of the animals for experimental research - what they really say about animal kingdom.

Biology of Plants

Introductory basic course of botany, designed for students non-specialists in botany, but rather on another issues of biology. The first part considers "Plantae" branch of tree of life and explains phylogenetic relationships of major plant lineages, their diversity and key adaptations. The second part will be taught separately, focused on plant ecology, (eco)physiology, biogeography and conservation together with comparative view of general botany issues considered with heavy respect to gene level - including plant anatomy, morphology, physiology and development. This lecture is designed to significantly expand botanical horizonts of overspecialized persons

- Origin and evolution of plant lineage (Archeoplastida): Cyanobacteria origin and diversity, origin of plastids via endosymbiosis, plant cells and tissues, basic anatomy.
- Plant phylogeny: Glaucophytes; Rhodophytes; Chlorobionta: "green algae" lineages, Charophytes; Embryophytes: liverworts, mosses, hornworts, Lycopodiophytes; Moniliformopses: horsetails, whisk ferns, ferns; Spermatopsida: conifers, ginkgos, cycads, Gnetales, Angiospermphytes. (2 lectures)
- Plant ecology: key adaptations and strategies for plant life.
- Intra- and interspecific relationships: parasitism, symbiosis.
- Plant ecophysiology: how plants interact with their environment, water balance, climatic limits, osmoregulation, migration.
- Plant reproduction: reproductive organs, strategies, progeny investment, mate choice.
- Plant biogeography: historical biogeography, biomes, alien species, Central European flora: origin, ecology, pattern and its changes, conservation. (2 lectures)
- Plant life cycle: alternation of generations, gametogenesis, sexual process, embryogenesis, cell differentiation, organ development, plant hormones and growth.
- Evolution of genome, cytogenetics, relationships between genes, evo-devo (Hox genes, etc.).
- Plant nutrition: energetic metabolism and its regulation, respiration, photosynthesis.
- Plant anatomy and morphology: structure and development.
- Human prospects on plants: economic plants, ethnobotany.

Methods in Molecular Biology

- Recombinant DNA, cloning vectors, gene libraries.
- Purification and labeling of nucleic acids, hybridization.
- DNA modifying enzymes, cloning strategies, DNA sequencing.
- PCR applications.
- Analyses of mRNA, S1 mapping and primer extension.
- Analyses of gene expression at the mRNA level: in situ hybridization, RT-PCR, quantitative

RT-PCR, microarray technology.
- Extraction and separation of proteins.
- Design and preparation of recombinant proteins in E. coli, fusion and tagged proteins.
- Antibodies, immunodetection methods.
- Analyses of gene expression at the protein level: western blotting, immunocytochemistry.
- Protein-protein interaction analyses: GST pull-down assay, immunoprecipitation, yeast two-hybrid system.
- Protein-DNA interaction analyses: EMSA, DNase protection assay.
- Analyses of transcriptional regulation in cell transfection systems.
- Analyses of gene expression and function in transgenic eukaryotic models (Drosophila and C. elegans).

WHO/EU Labor. and Regul. Procedures

Students learn laboratory and legal procedures commonly performed by industrial laboratory/research supervisors. The requirements and WHO/EU regulations for registration, testing and authorized analysis of drugs, (bio)chemical products, dietary supplements, food, etc. are given.

- Basic definition of products (food, dietary supplements, chemicals, API´s, drugs, etc.).
- Relevant part of EC, WHO, FAO, FDA, national authority, ets., guidelines, and their mutual relationship. Tracing of a selected example.
- Registration of products.
- Test methods - a state of art. Qualitative and quantitative aspects.
- Review of instrumental methods; principle, availability, cost, and information value.
- Validation of analytical methods.
- Testing of biological activity. Ethical guidelines, laboratory screening, models, and approved methods.
- Origin and importance of impurities. Case examples. Qualification of impurities.