Study Plan
M.Sc. Biotechnology
Specialization: Applied Biotechnology

Faculty of Chemistry

Study plan for reference only; may be subject to change.

Semester 1

Clean Technologies – lecture (30 h, written exam)

Bioinformatics – lecture (30 h, written exam)

Data Treatment in Chemical Analysis for Biotechnology - lecture + exercises (30h + 30 h, written exam)

Bioethics - lecture (30 h, written exam)

Laboratory of Applied Biotechnology- laboratory (60 h)

Analytical Methods in Biotechnology - lecture + laboratory + Project (15 h+15 h+30 h)

Environmental Biotechnology – lecture (30 h, final test)

Introduction to Bioreactors – lecture (30 h, written exam)

Synthetic bio-tools for industrial biotechnology (45 h laboratory)

Semester 2

Economics and Management – lecture (30 h, written exam - test or open questions)

Implantable Medical Devices – lecture (30 h, written exam)

Microbioanalytics – lecture (30 h, written exam)

Seminary of Applied Biotechnology - seminary (15 h, student's presentation)

Separation Processes in Biotechnology - lecture + exercises (30 h + 15 h, exam)

Characterization of Biomaterials (Biocompatibility) - lecture + exercises (15 h + 15 h, written exam and presentation)

Semester 3

Sensors and Biosensors - lecture + exercises (15 h + 15 h, written exam and presentations)

Diploma seminar - 15 h

Diploma laboratory - 180 h

M.Sc. Thesis writing - 150

Description of courses:

Clean Technologies

The lecture will include in its scope the following components : 1. Threats of civilization in our ecosphere (pollution, global warming, acid rain , desertification, soil , monoculture) 2. Sustainable development (story development , principles, inevitability) 3. Green Chemistry (rules) 4. Modern methods of separation (membrane hybrid processes , resolution of enantiomers) 5. The use of biotechnology in the production (photosynthesis , algae , microorganisms, enzymes) 6. Biorefineries (rules , biosurowce , bio , bio-based production) 7. Methods for the production of biofuels (bioethanol , biodiesel, bio - hydrogen) 8. Production of biopolymers (from biomass and crops, wastes) 9. Production of various biochemicals 10. Production of pharmaceuticals 11. Summary: factors driving and impeding the introduction of clean technologies.

Bioinformatics

The lecture will address various databases and algorithms used in bioinformatics, genetics, genomics, molecular biology and biotechnology, and the linkage between types of data. Basic operations on a single and multiple sequences or three-dimensional biomolecular structures will be discussed along with methods allowing pair comparison and searching databases with nucleotide, amino acid sequences and protein structures. During the lecture we will assess the concept of protein families, sequence motifs related to function, cell compartments segregation of signals, comparison of genomes for different organisms, population genetics and system level modeling of a single cell. Advanced methods for finding sequence-level and structural similarity and assessing both sequence and structural variability between proteins, genes and whole genomes will also be presented. The lecture will further describe methods for genome sequencing, distinguishing between coding and noncoding DNA sequences (ab initio methods and homology based methods), genome annotations, and comparative and functional genomics at the genomic level. Finally the lecture will address theories of protein and genome folding, tools exercised by molecular graphics, modeling of protein structures and genomic domains, structure of biopolymers, protein-protein interaction networks, types of biological networks, functional motifs in proteins and genomes, and the analysis of various omics data taken from -omics experiments data, with basic concepts in systems biology.

Data Treatment in Chemical Analysis for Biotechnology

Ability to plan experiments and to process, analyze, plot and present the obtained data. Planning of experiments, treatment and transformation of experimental data, statistical data analysis, modeling of dependencies, presentation of data, elements of chemometrics Exercises: Statistical tests, error analysis, estimation of uncertainty, regression analysis.

Bioethics

Content: 1. Identify ethical issues in medicine, health care and life science. 2. Recognize, compare and contrast the general ways of thinking in bioethics. 3. Approach and analyse bioethical problems in written. The purpose of the course is to introduce students to bioethics as an interdisciplinary subject throught critical thinking. The bioethical thinking is a melding of biology and various moral ideas. Interdisciplinary thinking in bioethics is rooted in the processes of scientific and philosophical thinking.

Laboratory of Applied Biotechnology

Subjects of laboratory modules (e.g. microbial cultures, biosensors, biocompatible materials, bioprocesses) are flexible and they will be collected by the head of the laboratory and presented to the students at the beginning of the classes. Students will work individually or in groups on given biotechnological subjects in laboratory. The subject of the course will be focused on processes, their control and optimization and application of modern laboratory facilities (bioreactors, microscopes, clean technologies) for better understanding and solving of given biotechnological problem.

Analytical Methods in Biotechnology

Project - Students select one of the proposed subjects presented as an analytical problem to solve. They are expected to design analytical procedure (on the basis of literature) in aim to determine or identify chosen compound(s) with the special emphasis on matrix composition. The report containing analytical procedure is obligatory for admission of student to an experimental part. The project will include following problems: - determination of metals, amino acids or other components in biological tissue, - determination of metals, dyes or preservatives in food, - determination of bioactive components in drugs. Laboratory - Experiments will be carried out by students with minimal control of assistant (short training and safety precautions only). Simple instrumental and classic analytical methods will be proposed as optional in frame of the project: - Volumetric analysis - Spectrophotometry - Capillary electrophoresis - Liquid chromatography - Potentiometry - Voltammetry Seminary - As a summary students are required to present the aim of the project, procedure, results and conclusions in the form of oral presentation.

Environmental Biotechnology

Development of discipline and state of art. Definition of bio- and phytoremediation and area of application. Phytoremediation of heavy metals (HM) from the soil. Plant defense mechanism against HM. Phytoremediation of noble metals. Plant species with high phytoremediation capabilities. Bio/phytoremediation of organic pollutants from the soil Mycoremediation of oil spill from the water and soil. Mechanism(s) of detoxification/degradation of organic pollutants by plants organism. Air phytoremediation of gaseous pollutants: benzene, NO2, CO, O3 and particulate matter. Indoors air phytoremediation in houses, offices and public places. Phytoremediation of sites with high salinity, polluted by radionuclides or explosive materials. Actual regulations and arising area of research and application with new pollutants: pharmaceutical, contraceptive, cosmetics. Necessary information and condition for undertaking decision of phytoremediation application. Effect of heavy metals (Pb2+, Cd2+and Cu2+) on germination and growth of mustard and corn. Level of salinity and pH in soil samples collected from sites of de-icing roads in Warsaw, Effect of soil salinity on vegetation. Capacity of Canna × generalis and Coleus blumei plants for degradation of organic pollutants (RBBR dye). Utilization of mushroom Pleurotus ostreatus for bioremediation of oil pollution. Deposition of particulate matters (PM10 and PM2,5) on leaves of several tree species (Quercus rubra, Taxus baccata and Carpinus betulus) or plant samples from students neighborhoods or apartments Amount of waxes on leaves of plants (Hedera helix, Ficus benjamina, Schefflera arboricola) assigned for indoor phytoremediation.

Introduction to Bioreactors

Modelling of Basic types of bioreactors Scaling up Selection of bioreactors Predicting dynamics of bioreactors Course content: The course deals with bioreactor design, based on the kinetics of the microorganism growth, kinetics of biochemical reactions and reactor hydrodynamics. Program contains: discussion of interactions between cell population and medium, characteristics of cell population, models of growth (segregated, structural), design and analysis of ideal bioreactors (chemostat, semibatch bioreactor, plug flow bioreactor, bioreactors with recirculation, systems of bioreactors), mixed microbial populations (classification of pairwise interactions, dynamics of mixed microbial populations), problem of stresses in biotechnology, characteristics of different bioreactors (mixed tank, bubble column, air-lift reactor, packed column), rules of bioreactor selection, scale-up, enzyme-catalyzed reactions, immobilized enzyme kinetics.

Synthetic bio-tools for industrial biotechnology

The aim of the course is to gain experience in microbial protein expression, protein design and engineering, recombinant protein purification, standard protein analysis methods, and activity assays. Student will have ability to independently design and execute informative experiments and interpret results. This course will prepare a student for a position of a protein scientist in R&D sector. Lectures and practical course will focus on troubleshooting. 1) Synthetic systems design and engineering (synthetic biology, molecular biology, promoter types, tag systems, functional domains ect.) 2) Expression (protein stability, secretion machinery) 3) Purification (broaden spectrum of techniques in affinity chromatography) 4) SDS-PAGE and Western-blot (visualization techniques, labelling) 5) EMSA assay (protein-DNA interactions assays in molecular biology and biophysics) Each group of students will be given a different synthetic construct (or will be asked for designing its own). Students will have to recognise the overproduced and purified proteins as well as to perform on them activity tests.

Economics and Management

The course introduces students to the knowledge of basic economic categories and principles of functioning of modern market economy. After the course they shall have the ability to analyze and interpret economic processes and use of economic theory to evaluate the activities of companies and the functioning of the national economy.

The content: • Introduction to economics. • Economic systems. • Market - basic categories; Elasticity of demand and supply. • Fundamentals of the enterprise. • Basic models of the market. • The functioning of the labor and the capital markets. • Money and inflation. • Gross domestic product (GDP); Economic growth; The economic cycle. • Country budget. • The role of international trade in economic development.

Implantable Medical Devices

1. Introduction to biomedical engineering and tissue engineering. Legal and regulatory aspects of testing and marketing of implantable medical devices. Introduction to the human anatomy and physiology. Presentation of main mammalian tissues properties. Cell signalling process and signalling molecules. Biology of the mammalian cell division process and cell ageing phenomenon. 2. Materials applied in implantable medical devices. a) Interaction of cells and foreign body implanted in the organism. Proteins and cells adhesion to various materials and surfaces, biology of the foreign body response process. Blood contacting surfaces, platelet activation process and activation markers. b) Non biodegradable materials: metals, polymers and ceramic. c) Biodegradable natural and synthetic materials applied in implants, biodegradable polymers available on the market. d) Hydrogels, material that mimics properties of the natural tissue. 3. Principles of regenerative medicine. a) Regeneration process, stimulation of the tissue regeneration process. b) Stem cells; their origin and properties. Stem cells harvesting, multiplication and differentiation. c) In situ recruitments of cells. 4. Examples of the existing implantable medical systems. a) Implantable drug delivery systems, particles, pumps and other. b) Bone implants, biodegradable bone implants and non biodegradable bone and joints prosthesis. c) Implantable heart prosthesis and heart pacemakers. d) Vascular grafts and urine ducts. e) Coronary stents. f) Implantable hearing aid. g) Surgical sutures – biodegradable and non biodegradable. h) Dental implants, breast implants. 5. Future of regenerative medicine and artificial organs.

Microbioanalytics

Definition of microbioanalytics and miniaturised analytical systems Ideas of miniaturization (integrated systems vs. modular architecture). Basic sample treatment in microsystems (dosing, pumping, separation, analytical reactions, detection). Technologies for microanalytical systems. Application of miniaturized systems for various bioanalytical procedures (medical diagnostics, genomics and proteomics, food analysis and environmental monitoring and pollution control). Design, fabrication and tests of a simple microanalytical module/system (microdetector, microreactor, heating system etc.). Presentation of the results, discussion and evaluation.

Seminary of Applied Biotechnology

Students will be given scientiffic articles in the field of applied biotechnology (e.g. microbial cultures, biosensors, biocompatible materials, bioprocesses) as a base for the case study and presentation preparation. After given cases studies students in small groups (2-3 person) will prepare the presentation of the given topic.

Separation Processes in Biotechnology

Content: 1. Introduction to separation processes in biotechnology. 2. Mechanical processes of solid particles separation. Motion of solid particles in liquids. Sedimentation. Flocculation and coagulation. Filtration. Centrifugation. 3. Cell disruption. Elements and properties of cell walls of bacteria, yeast, mould, plant cells and mammalian cells. Cell disintegration techniques: mechanical, chemical and biological. 4. Membrane processes. 5. Adsorption. Liquid chromatography. 6. Extraction. Distillation and rectification. 7. Precipitation. Crystallization. Drying of bioproducts. 8. Advanced separation processes 9. Separation in Bioreactors 10. Separation of enantiomers 11. Affinity separation 12. Membrane chromatography 13. Advanced oxidation 14. Hybrid processes

Characterization of Biomaterials (Biocompatibility)

The goal of the course is to provide students with the knowledge of biomedical materials and their properties (physical properties, surface properties, biocompatibility and biodegradability). The lecture covers three main groups of biomedical materials: metals and their alloys, ceramics and their composites and polymers, co-polymers and their composites. The main areas of application and requirements for biomaterials will be given.

Sensors and Biosensors

Lecture: 1. Introduction to (bio)sensors. 2. (Bio)recognition of analytes. 3. Types of recognition layers. 4. Transducers and measurement systems (electrochemical, optical, etc.,). 5. Working parameters and factors affecting response of (bio)sensors. 6. Chemical sensors for bioanalyte determination. 7. Application of (bio)sensors in analytical control of bioprocesses, medical diagnostics, environmental protection, etc. 8. Trends in (bio)sensors developments.

Excercises: excercises will introduce students to construction and utilization of sensors and biosensors with different transducers: optical and electrochemical.