The Jagiellonian University Graduate School in Science (JAGSS)
BIOLOGICAL CHEMISTRY
(Faculty of Chemistry Jagiellonian University)

The layout of the Biological Chemistry program

1st year

Course	**Course format**	**Hours/ week**	**Hours/ year**	**Crediting basis**	**Credits**
General School Seminar	seminar	2	30	participation	4
Basic Biochemistry	lecture seminar	2 2	30 30	examination test	3 3
Bioorganic Chemistry	lecture	2	30	examination	3
Application of Spectroscopic Methods in Organic Chemistry	seminar	2	30	test	3
Two-dimensional NMR Spectroscopy	lecture	2	30	test	3
Bioinorganic Chemistry	lecture seminar	2 1	30 15	examination miniproject	3 1.5
Principles of Crystallography	lecture	1	15	test	1.5
Introduction to Protein Crystallography	lecture	1	15	test	1.5
Proteomics	lecture seminar	2	30	test	3
Modern Mass Spectrometry	lecture seminar& demonstrations	2	30	test	3
Structure and Function of Proteins	lecture	2	30	examination	3
Structure of Small Bioactive Molecules	lecture	1	15	test	1.5
Physico-Chemical Methods in Biological Chemistry	laboratory tutorial	8 4	120 60	reports miniproject	12 6
1 optional lecture*)	lecture	2	30	test	6

*) can be chosen from the list of the lectures for other spetializations of JAGSS

2nd year

Course	Course format	Hours/ week	Hours/ year	Credit basis	Credits
General School Seminar	seminar	2	30	participation	4
Photochemistry in Biology and Medicine	lecture	1	15	examination	1.5
Neurobiochemistry	lecture	2	30	test	3
Methods in enzymology	lecture	1	15	test	1.5
Self-Organisation in Chemical and Biological Systems	lecture	2	30	test	3
MSc seminar	seminar	2	30	participation	3
MSc project	laboratory	16	480	Thesis defense	48

GENERAL SCHOOL SEMINAR - with participation of students and tutors of all JAGSS specializations.

Seminar Format: *two hours per week in threer semesters.*

Short description: The Seminar aims at improving interdisciplinary background and integration of the JAGSS students

BASIC BIOCHEMISTRY Prof. Jerzy Silberring

Course format: *two hours of lectures and two hours of seminars per week in the fall semester of the 1st yaer.*

Short description: Basic components of living organisms (nucleic acids, proteins oligosacharides, lipids) - structure, physicochemical properties and structure-function relationship with medical correlations.

BIOORGANIC CHEMISTRY Prof. Krystyna Bogdanowicz-Szwed

Course format: *two hours of lectures in the fall semester of the 1st year.*

Short description: Enzymes as catalysts: the main features of enzymatic reactions, the course of enzymatic Reactions, specificity and regioselectivity. Rate and acceleration of enzymatic reactions. The influence of kinetic agents on the course of enzymatic catalysis: covalent catalysis, general acid-base catalysis. Influence of hydrogen bonds, reaction medium and hydrophobic forces on the rate of reactions. Mechanism and stereochemistry of principal enzymatic reactions: oxidation, reduction, hydroxylation, isomerisation, carboxylation. Chemical models of enzymes: polymers as models of enzymes. Host-guest chemistry. Cyclodextrines, catalytic properties of cyclodextrines. Macrocyclic compounds as synthetic models of enzymes. Biogenetic and biomimetic chemistry. Types of biogenetic processes: formation of carbon-carbon chains; cyclisation processes; transformation of functional groups. Biomimetic models of some enzymatic reactions. Biomimetic models of hemoproteins and biological membranes. Design of biologically active compounds. Drug discovery. Identification of active part of molecules. Establishment of the “leading structure”. Synthesis of new compounds as a source of new “leading structures”. Relationship between structure of compound and biological activity.

APPLICATION OF SPECTROSCOPIC METHODS IN ORGANIC CHEMISTRY
Anna Kolasa, PhD

Course format: *two hours of seminar per week in the fall semesterof the 1st year.*

Short description: *Mass spectrometry:* HRMS – establishing molecular formula; ionisation methods and their influence on spectra; fragmentation pathways for main classes of organic compounds and the methods to prove them; rearrangements; GC/MS. *Infrared spectroscopy:* Bands typical for functional groups and structural units; interpretation of spectra; application of IR in stereochemistry and quantitative analysis. *Nuclear magnetic resonance:* interpretation of spectra with complicated spin patterns; heteronuclear couplings; coupling constants and their application for structure elucidation; application of NMR in stereochemistry, in investigation of dynamic processes, in biology and medicine; decoupling technique; chemical shift reagents; NMR of various nuclei (^{1}H, ^{13}C, ^{19}F, ^{31}P, ^{15}N). *Ultraviolet and visible spectroscopy:* spectra of dienes, enones and aromatic compounds; steric effects and UV-VIS spectra; influence of solvents; application of UV-VIS for: structure elucidation, monitoring of reactions, determination of dissociation constants, investigation of equilibria (tautomerism, complex formation), analysis of mixture composition; UV spectra of biomolecules (aminoacids, peptides, proteins). Chiraloptical methods (ORD, CD).*Electron paramagnetic resonance:* application of EPR in investigation of organic radicals. A range and limitations of methods under consideration.

Complementary usage of all the methods for structure elucidation of complex organic compounds.

TWO-DIMENSIONAL NMR SPECTROSCOPY Barbara Rys PhD, DSc
Course format: *two hours of lectures per week in the fall semester of the 1st year.*
Short description:
Application of COSY, TOCSY, HTCOR, HMQC, HMBC, NOESY, ROESY and INADEQUATE methods to structure elucidation.

BIOINORGANIC CHEMISTRY Prof. Grażyna Stochel.
Course format: *two hours of lectures and one hour of seminars per week in the fall semester of the 1st year*

PRINCIPLES OF CRYSTALLOGRAPHY Katarzyna Stadnicka PhD, DSC
Course format: ***one*** *hour of lectures per week in the fall semester of the 1st year.*

INTRODUCTION TO PROTEIN CRYSTALLOGRAPHY Krzysztof Lewiński PhD, DSc
Course format: *one hour of lectures per week in the fall semeste of the 1st year.*
Short description: Crystallization of proteins. X-ray sources. X-ray diffraction by a crystal. Intensity of reflections. Methods of solution of phase problem: Isomorphous Replacement Method, Molecular Replacement, MAD, heavy-atom method, direct methods. Patterson and Fourier maps. Refinement of protein structure. Accuracy of the structural model

PROTEOMICS Prof. Jerzy Silberring
Course format: *two hours of lecture and classes per week in the fall semester of the 1st year.*
Short description: Basic techniques for proteome identification. Polyacrylamide gel electrophoresis of the cerebrospinal fluid proteins. Preparation of peptide map. Capillary HPLC. Mass spectrometry (MALDI TOF MS and ESI MS^n. Sequencing using mass spectrometry. Desalting and microconcentration techniques. Desorption/ionization *on silico* (without matrix). Microchip technology. Protein arrays. Bioinformatics for data interpretation.

PROTEIN STRUCTURE AND FUNCTION Krzysztof Lewiński PhD, DSc
Course format: *one hour of lectures per week in the spring semester of the 1st year.*
Short description: Conformational restrictions of polypeptide chain. Side-chain conformations. Elements of secondary structure: helices and beta-sheets. Motifs of protein structure. Structural hierarchy of protein structures: examples of alpha, alpha/beta and beta structures. Structure and mechanism of activity of selected molecules: enzymes, immunoglobuline, spherical viruses, DNA-binding proteins, ribosome, chaperones, prions.

MODERN MASS SPECTROMETRY Prof. Leonard Proniewicz and Prof. Jerzy Silberring
Course format: *two hours of lectures, seminars and demonstrations per week in the spring semester of the 1st year.*
Short description: Basics of the modern mass spectrometry (organic, biological, proteomics). Theory (ionization, analyzers, detectors). Tuning and calibration. High resolution mass spectrometry. Hyphenated techniques: GC/MS and LC/MS. Mass spectra interpretation. Applications (structure elucidation, tandem mass spectrometry, peptide sequencing). Internet: software and data bases.

STRUCTURE-ACTIVITY RELATIONSHIP OF SMALL BIOACTIVE MOLECULES
Prof. Barbara Oleksyn
Course format: *one hour of lectures s per week in the spring semester of the 1st year.*
Short description: The role of small molecules in living organisms, endo- and exogenic molecules, drugs. Small molecules and biological membranes: structure and function of selected ionophores. Structure and interaction of small molecules with proteins: substrates and inhibitors of enzymes, stimulators and blockers of protein receptors. Interactions of small molecules with DNA. Fate of drugs in organisms *vs.* their physico-chemical properties. QSAR (Quantitative Structure-Activity Relationship) with regard to the three-dimensional molecular structure. Basic knowledge of biological activity measurements. Application of X-ray structure analysis and theoretical calculations in the studies of interactions between a macromolecule and small bioactive molecule. Selected models of drug interaction with active sites of macromolecules, drug design.

PHYSICO-CHEMICAL METHODS IN BIOLOGICAL CHEMISTRY
Organization: Krzysztof Lewiński, PhD, DSc, Realization: members of the research groups of Faculty of Chemistry
Course format: *eight hours of laboratory and four hours of tutorials per week in the spring semester of the 1st year.*
Short decsription: Students will perform measurements and experiments applying all methods and equipment available in Faculty of Chemistry in order to study methods used in modern biological chemistry. The tutorial will be devoted to a miniproject (topic chosen under supervision of one of the research group members).

PHOTOCHEMISTRY IN BIOLOGY AND MEDICINE Prof. Grażyna Stochel
Course format: *one hour of lectures per week in the fall semester of the 2nd year.*

NEUROBIOCHEMISTRY Prof. Jerzy Silberring
Course format: *two hours of lectures and demostrations per week in the spring semester of the 2nd year.*
Short description Neuropeptides and their physiological functions. Neuropeptide receptors. Maturation and metabolism of neuropeptides. Techniques used for studying neuropeptides and proteins (transgenic animals, antisense technologies, microinjections, behavioral tests).
In-vitro quantitation of neuropeptides and proteins (radioimmunoassay, radioreceptorassay, antibodies, aptamers). Synthetic substrates and inhibitors of peptideses (peptide synthesis, peptidomimetics, combinatorial libraries) and their applications in pharmacology and medicine.
Strategies for the optimal design of peptidase inhibitors. Strategies and techniques for isolation and analysis of neuropeptides and proteins. Laboratory animals. Ethical considerations.

METHODS IN ENZYMOLOGY Barbara Krajewska, PhD
Course format: *one hour of lectures per week in the fall semester of the 2nd year.*
Short description: Structure and functions of enzymes. Isolation and purification of enzymes. Enzyme kinetics. Inhibition and inactivation of enzymes. Enzyme engineering. Techniques of enzyme immobilization. Characterization of immobilized enzymes: immobilized vs. native. Kinetics and performance of enzyme reactors. Applications of immobilized enzymes: analytical (biosensors), biomedical (artificial organs), biotechnological (enzyme reactors), environmental (wastewater treatment), and in synthetic organic chemistry. Future directions of enzyme engineering.

SELF-ORGANISATION IN CHEMICAL AND BIOLOGICAL SYSTEMS
Marek Frankowicz PhD, DSc
Course format: *one hour of lectures per week in the fall semester of the 2nd year*
Short description: Elements of theory of dynamical systems: phase space, phase trajectories, attractors. Bifocations, elements of catastrophe theory. Reduction of fast variables, Tikhonov theorem. Deterministic chaos. Strange attractors. Fractal geometry. Case studies: brusselator, van der Pol oscillator, enzymatic systems, Lorenz model, logistic map. Elements of theory of stochastic processes. Markov processes. Master equation. External noises: Langevin equation. Fokker-Planck equation. Noise-induced phase transitions. Case studies: chemical systems, genetic models.

MSc SEMINAR
Students will present and discuss current results obtained in the course of their MSc project.