

SUBJECT/COURSE SYLLABUS

1.	Course name in Polish and English Biophysics and bioenergetics Biofizyka i bioenergetyka
2.	Scientific discipline Medical sciences Biotechnology
3.	Language of instruction English
4.	Unit conducting the course Faculty of Biotechnology
5.	Type of course elective - choice limited to Biophysics and bioenergetics and Medical Biophysics
6.	Field of study Biotechnology
7.	Level of study first-cycle
8.	Year of study 2nd
9.	Semester summer
10.	Course form and number of hours Lecture: 30 h Laboratory: 30 h
11.	Prerequisites in terms of knowledge, skills and social competences for the course: LECTURE: Understanding of fundamentals of biology, chemistry, physics and calculus (natural and decimal logarithms, exponential functions, ordinary and partial differential equations, Leibniz's notation, integrals). Curiosity and desire for individual study at home. LABORATORY: Basic knowledge about photosynthesis and redox reactions.
12.	Learning objectives for the course: LECTURE: Acquiring general knowledge in the interdisciplinary field of biophysics. Understanding physical underpinnings of basic biological phenomena and processes. LABORATORY: To introduce the basics of biochemical preparation and spectrophotometric analysis, redox reactions as well as calculating enzymatic activity.
13.	Curriculum content: LECTURE: <ul style="list-style-type: none"> Physical quantities, units and prefixes; periodic table and properties of elements; orbital hybridization and chemical bonding; elements of living

	<p>matter and what is so special about carbon; structure of biopolymers (amino acids and nucleotides) and properties of peptide bond; hypotheses on the emergence of life on Earth, Miller-Urey experiment and its criticism.</p> <ul style="list-style-type: none"> • Standard model and fundamental forces in nature; Coulomb's inverse-square law, types and properties of electrostatic interactions (ion-ion, ion-dipole, ion-dipole induced, dipole-dipole, dipole-dipole induced, dipole induced-dipole induced); types and strengths of bonds in biology (ionic, hydrogen bond, van der Waals). • Fundamental concepts of thermodynamics (system, boundary, surroundings, state of the system, state variables, state function, equilibrium, steady-state); ideal gas law, the Carnot cycle, p-V and T-S diagrams; macro- and microscopic forms of energy; heat vs. temperature, Maxwell-Boltzmann distribution of particle speeds in idealized gas. • Four laws of thermodynamics; isochoric and isobaric gas expansion; enthalpy of endo- and exothermic processes, Hess' law; reversible vs. irreversible processes; heat capacity; thermodynamic probability and equality of statistical and classical formulations of entropy; Helmholtz and Gibbs free energy, temperature and spontaneity of processes. • Standard Gibbs free energy of reactants and processes; fundamental thermodynamic equations for closed and open systems; various formulations of chemical potential (partial molar internal energy/enthalpy/free energy/free enthalpy); chemical potential for ideal and non-ideal gases and solutions, relation of standard Gibbs free energy and equilibrium constant. • Van't Hoff equation; electrochemical work and potential; chemiosmotic theory and directions of chemiosmotic proton transfers; electrochemical potential gradient, proton-motive force; reduction-oxidation reactions, voltaic cell, standard hydrogen electrode, redox potential; relation of redox potential difference and Gibbs free energy, Nernst equation. • Behavior of amphiphilic molecules in solution, hydrophobic effect (water entropy gain and temperature); classification of lipids based on interaction with water; mesomorphism of lipids, phase transitions and phase diagrams; detergents (classification, examples, structures, properties and applications), critical micelle concentration, aggregation number. • Classification of lipids based on chemical structure (fats/oils, waxes, phospholipids, glycolipids, sulfolipids, cerebroside, ketone bodies, eicosanoids, steroids, carotenoids); fatty acids (saturation, properties and nomenclature); soaps and saponification; chemical structure and properties of membrane lipids, fluid mosaic model of cell membrane by Singer and Nicolson. • Langmuir-Blodgett trough and its applications to study lipid monolayers; sandwich model of the cell membrane by Davson and Danielli; proliferation of membranes; asymmetric distribution of phospholipids; cholesterol (structure and function); lipid rafts; membrane permeability of different solutes; passive (simple diffusion, facilitated diffusion, osmosis) and active (primary and secondary) membrane transport; thermodynamic descriptions of various membrane transport processes.
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	<ul style="list-style-type: none"> Primary nutrition groups, morphology of a mitochondrion, structure and function of mitochondrial respiratory chain (complex I - NADH dehydrogenase, complex II - succinate dehydrogenase, complex III - cytochrome c reductase, complex IV - cytochrome c oxidase), electron transfer cofactors (hemes, iron-sulfur clusters, freely mobile carriers), Q cycle, structure and function of ATP synthase, stoichiometry of ATP synthesis. Chloro- and retinalphototrophy; oxygenic and anoxygenic photosynthesis; morphology of a chloroplast; structures and absorption maxima of chlorophylls and accessory pigments, photosynthetic antenna pigment-protein complexes, Emerson enhancement effect; structures and function of photosynthetic electron transfer chain (photosystem II, cytochrome b₆f, plastocyanin, photosystem I, ferredoxin), changes of redox potential during photosynthesis (Z scheme), cyclic and non-cyclic electron flow. Interaction between radiation and matter, electromagnetic radiation spectrum; visible light and color perception; relation of radiation and energy; classification of spectroscopy; electronic transitions between orbitals ($\sigma \rightarrow \sigma^*$, $n \rightarrow \sigma^*$, $n \rightarrow \pi^*$, $\pi \rightarrow \pi^*$), bond conjugation and electron delocalization; chromophores; auxochromes; batho-, hypso-, hyper-, and hypochromic effects; effect of solvent on absorption properties of solutes; three laws of absorption; Beer's law and its limitations. Constructive and destructive interference of radiation; nuclear spin and magnetic dipole moment; gyromagnetic ratio; behavior of nuclei in magnetic field; structure of an NMR spectrometer; NMR experiment (excitation, Larmour precession, relaxation, data acquisition, Fourier transform); chemical shift, NMR reference compounds; spin-spin coupling and multiplicity of NMR signals; nuclear Overhauser effect; applications of uni- and multidimensional NMR spectroscopy. Diffraction, overview of protein X-ray crystallography, structure of a crystal (symmetry operations, crystal lattice, unit cell, asymmetric unit); thermodynamics and phase diagram of crystallization; methods of obtaining crystals; precipitants; Bragg's law; X-ray data collection, diffraction pattern, real and reciprocal lattice; structure factors and electron density, phase problem and its solutions. <p>LABORATORY:</p> <ul style="list-style-type: none"> Conversion of solar energy to chemical energy. Organelles, biological membranes and membrane and soluble proteins involved in the process of photosynthesis. Detailed description of photosynthetic light and dark phase. Structures of photosynthetic reaction centers and oxygen-evolving center. Application of inhibitors, artificial electron donors and acceptors in the study of photosynthetic electron flow. 	
14.	<p>Description of learning outcomes</p> <p>Student:</p> <ul style="list-style-type: none"> makes a qualitative and quantitative description of the basic biological phenomena and processes; 	<p>Symbols for relevant directional learning outcomes:</p> <p>K1_W01</p>

	<ul style="list-style-type: none"> • have extensive knowledge in the field of biophysics; • knows the basic concepts, terms, techniques used in biophysics; • reads and understands scientific literature in the field biophysics in English; • takes advantage of the online resources and literature to obtain information on biophysics; • is able to perform simple experiments under supervision; • can draw conclusions from experiments; • can critically analyze obtained results; • knows rules of safety work in the lab; • shows responsibility for carrying out experiments; • understands the need for continuing education throughout the whole life, including broadening knowledge in biophysics. 	K1_W04, K1_W05 K1_W06 K1_U03 K1_U04 K1_U01, K1_U05 K1_W10 K1_K03 K1_K01
15.	<p>Mandatory literature:</p> <ul style="list-style-type: none"> • Lab manual; • Biochemistry. Berg, Jeremy M., Tymoczko, John L., Gatto, Gregory J., Stryer (Photosynthesis). <p>Recommended literature:</p> <ul style="list-style-type: none"> • Photosynthesis; Krishna K. Rao, David O. Hall; • Biophysics: An Introduction, 2nd Edition. Roland Glaser; • Fundamentals of Thermodynamics, 8th Edition. Claus Borgnakke and Richard E. Sonntag; • Chemistry for Engineering Students, 2nd Edition. Lawrence S. Brown, Thomas A. Holme; • Bioenergetics, 4th Edition. D. G. Nicholls, S. J. Ferguson; • Energy transduction in biological membranes: a textbook of bioenergetics. W. A. Cramer and D. B. Knaff; • Molecular Biology of the Cell. 6th Edition. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter; • UV-VIS Spectroscopy and Its Applications. Heinz-Helmut Perkampus; • Understanding NMR Spectroscopy. 2nd Edition. James Keeler; • Crystallography Made Crystal Clear. 3rd Edition. Gale Rhodes. 	
16.	<p>Methods of verification of the assumed learning outcomes:</p> <p>LABORATORY:</p> <ul style="list-style-type: none"> • entry test, lab report, final test <p>LECTURE:</p> <ul style="list-style-type: none"> • written exam (the condition for taking the exam is to obtain a positive grade in the laboratory classes) 	

17.	<p>Conditions and form of credit for individual components of the course:</p> <p>LABORATORY:</p> <ul style="list-style-type: none"> • mandatory presence and active participation in the classes; • final test: multiple choice and open questions, 60% required to pass; • entry test: 3-5 questions; • lab report: analysis of results, presenting scientific data in the form of description, tables and figures <p>LECTURE:</p> <ul style="list-style-type: none"> • positive exam result; • active participation in the lectures 	
18.	Student workload expressed in teaching hours and ECTS credits	number of hours allocated for the course of a given type of classes
	<p>classes (according to the study plan) with the instructor:</p> <ul style="list-style-type: none"> • laboratory (including introduction lecture, seminar and discussion sessions) • lecture 	<p>30 h</p> <p>30 h</p>
	<p>student's own work (including participation in group work) e.g.:</p> <ul style="list-style-type: none"> • preparation for the classes • reading the manual and literature indicated • writing a lab report • preparation for the final test • preparation for the exam 	60 h
	Total number of class hours:	120 h
	<p>Number of ECTS credits:</p> <ul style="list-style-type: none"> • laboratory • lecture 	<p>3 ECTS</p> <p>2 ECTS</p>