COURSE DESCRIPTION (SYLLABUS)

1.	Course: **Biophysics**
2.	Language of instruction: **English**
3.	Faculty: **Faculty of Biotechnology**
4.	Course/module code: **29-BT-S1-E4-EnBph**
5.	Course/module type (*mandatory* or *elective*): **mandatory**
6.	Programme: **Biotechnology**
7.	Study cycle (*1st/2nd*): **1st cycle**
8.	Year: **2nd**
9.	Semester *(autumn* or *spring):* **spring**
10.	Form of tuition and number of hours Lecture: **30 h**
11.	Coordinator(s): **Mr. Maciej WIKTOR, PhD**
12.	Initial requirements (knowledge, skills, social competences) **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.**
13.	Objectives: **Acquiring general knowledge in the interdisciplinary field of biophysics.** **Understanding physical underpinnings of basic biological phenomena and processes.**
14.	Content: **Physical quantities, units and prefixes; periodic table and properties of elements; orbital hybridization and chemical bonding; elements of living 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. **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, cerebrosides, 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. **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 retinalophototrophy; 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 b_6f, 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.**	
15.	Learning outcomes: **Student:** • **makes a qualitative and quantitative description of the basic biological phenomena and processes;** • **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**	Outcome symbols: **K1_W01** **K1_W05** **K1_W06** **K1_U03**

	biophysics in English; • **takes advantage of the online resources and literature to obtain information on biophysics;** • **understands the need for continuing education throughout the whole life, including broadening knowledge in biophysics.**	 **K1_U04** **K1_K01**

16.	Recommended literature: • **Biochemistry, 8th Edition. Berg, Jeremy M., Tymoczko, John L., Gatto, Gregory J., Stryer** • **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**
17.	Methods of verification of the assumed learning outcomes: **written exam**
18.	Conditions of earning credits: **positive exam result, active participation in the lectures**

19.	Student's workload:	
	Activity	Number of hours for the activity
	Hours of instruction (as stipulated in study programme): • lecture: **30 h** • consultations: **5 h**	35 h
	Student's own work: • reading the literature • preparation for the exam	35 h
	Total number of hours:	**70 h**
	Number of ECTS:	**3 ECTS**