Faculty of Chemistry

SUBJECT CARD

Name of subject in English: **Bionanotechnology**
Main field of study (if applicable): **Biotechnology**
Specialization (if applicable): Bioinformatics
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code: BTC024004
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				15
Number of hours of total student workload (CNPS)	90				30
Form of crediting	Examination				crediting with grade
For group of courses mark (X) final course					
Number of ECTS points	3				1
including number of ECTS points for practical (P) classes					1
including number of ECTS points for direct teacher-student contact (BK) classes	1				0,5

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of physical chemistry (1st level)
2. Basic knowledge of biochemistry (1st level)
3. Basic knowledge of molecular dynamics (2nd level)

SUBJECT OBJECTIVES

C1	Principles underlying the functioning of molecular machines in biology
C2	Basic knowledge about methods utilized in bionanotechnology to design, synthesize and analyze bionanomachines
C3	Practical knowledge on how to perform basic molecular dynamics (MD) simulations to solve problems in bionanotechnology
C4	Basic knowledge on the recent achievements in bionanotechnology

SUBJECT EDUCATIONAL EFFECTS

Relating to knowledge:

PEK_W01 – Basic concepts of nanobiotechnology and bionanotechnology
PEK_W02 – Principles of functioning of molecular machines in biology
PEK_W03 – Basic knowledge on experimental methods used in design, synthesis and analysis in bionanotechnology
PEK_W04 – Basic knowledge on experimental methods used in structural investigation in bionanotechnology
PEK_W05 – Basic techniques in designing synthetic bionanomachines
PEK_W06 – Basic principles of functioning of bionanomachines
PEK_W07 – Basic knowledge on molecular modelling tools used in designing bionanomachines
PEK_W08 - Basic knowledge on the recent achievements in modern bionanotechnology

Relating to skills:

PEK_U01 – Practical knowledge on how to prepare input files and how to perform minimization and MD of nanopore
PEK_U02 – Practical knowledge of performing basic MD simulations of DNA within the nanopore
PEK_U03 – Practical knowledge on how to prepare and present a seminar on the last achievements in bionanotechnology

PROGRAMME CONTENT

	Form of classes - lecture	Number of hours
Wy1	**Basic concepts.** Nonotechnology, biotechnology, bionanotechnology, nanobiotechnology. Feynman's idea. Top-down and bottom-up appoaches. Milestone achievements in bionanotechnology. Nanobiotechnology/bionanotechnology in electronics, informatics, energetics, army, agriculture and food technology – examples.	2
Wy2	**How do molecular machines work in biology?:**Properties of particles at macro- and nano-levels. Bionanomolecules in water environment – hydrophobic effect. Proteins as a structural material in bionanotechnology. Limitations of natural bionanomolecules.	2
Wy3	**Methods in bionanotechnology: to design, synthesize and analyze.** Rekombinant DNA technology. DNA clonning. PCR method. Protein synthesis in vitro. Directed mutagenesis. Fusion and chimeric proteins. Monoclonal antibodies.	2
Wy4	**Methods in bionanotechnology: to design, synthesize and analyze – part 2 .** X-ray and NMR methods to investigate structure of biomolecules. Electron spectroscopy methods: TEM, SEM, tomography. AFM method. Molecular modelling as a tool to obtain information on structure and dynamics of biomolecule.	2
Wy5	**Design of nanomachines.** Methods used in bionanomachines design: sequential covalent bond formation, polimeryzation, self-organizatoin and aggregation. Protein folding. Role of chaperones in folding. Proteins stable in high temperatures. How to make a protein more rigid? How to introduce a disorder in a protein? Symmetric and quasi-symmetric complexes.	2

Wy6	**Functional aspects of biomoleculs**. Energy transfer in natural bionanomachines. Electron transfer in natural bionanomachines. Light-driven molecular bionanomachines. Charge transfer in biosystems. How do enzymes work? Methods to control bionanomachines – allosteric regulation and covalent modyfication.	2
Wy7	**Design of bionanomachines.** De novo protein design. Enzyme design based on molecular modelling methods. Design of biosystems having specific spectral properties. PNA (Peptide Nucleic Acid) vs. DNA.	2
Wy8	**Exam**	2
La1	**DNA sequencing using MD – part 1**. Construction of a cystal membrane of Si_3N_4. Synthetic nanopore in Si_3N_4.membrane.	2
La2	**DNA sequencing using MD – part 2**. Calibration of force field to reproduce experimental value of dielectric constant.	2
La3	**DNA sequencing using MD – part 3**. Solvation of a nanopore.	2
La4	**DNA sequencing using MD – part 4**. Energy minimization. Molecular dynamics under constant pressure. Measuring ionic current in nanopores.	2
La5	**DNA sequencing using MD – part 5**. Simulating the process of DNA transport through a nonopore.	2
La6	**DNA sequencing using MD – part 6**. Ionic current in nanopores in the presence of DNA. Comparison of ionic current with/without DNA in the system.	2
La7	**DNA sequencing using MD – part 7**. Transporting DNA through nanopore – MD simulation. Transporting ubiquitin through nanopore – MD simulation.	2
	Total hours	**30**
Form of classes - seminar		Number of hours
Se1-15	Students in the form of oral contribution present and discuss the late achievements and trends in bionanotechnology based on the most recent scientific literature. The list of possible topics is upgraded every year due to the very rapid progress in this field.	15
	Total hours	**15**

TEACHING TOOLS USED	
N1	Lecture with multimedia presentation
N2	Practical usage of software
N3	Preparation of reports
N4	Seminar presentation

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation F – forming (during semester), C – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1 (lecture)	PEK_W01 – PEK_W07	Written exam
F2 (lecture)	PEK_U01 – PEK_U02	Report
P (seminar)	PEK_U03	Seminar presentation

P (lecture) = 3.0 if (F1 + F2) = 50-60% max. no of poins.
3.5 if (F1 + F2) = 61-70% max. no of points.
4.0 if (F1 + F2) = 71-80% max. no of points.
4.5 if (F1 + F2) = 81-90% max. no of points.
5.0 if (F1 + F2) = 91-99% max. no of points.
5.5 if (F1 + F2) = 100% max. no of points.

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] D.S. Goodsell "*Bionanotechnology: Lessons from nature*" Plenty of room for biology at the bottom: An introduction to bionanotechnology", Wiley-Liss, 2004.

SECONDARY LITERATURE:

[1] *Bionanotechnology*: *Proteins to Nanodevices,* Eds. V. Renugopalakrishnan, R.V.Lewis, Springer, 2006.
[2] *Nanobiotechnology: Concepts, Applications and Perspectives*, Eds. C.M.Niemeyer, C.A.Mirkin, Wiley-VCH, 2004.
[3] *Nanobiotechnology II: More Concepts and Applications*, Eds. C.M.Niemeyer, C.A.Mirkin, Wiley-VCH, 2007.
[4] E. Gazit "Plenty of room for biology at the bottom: An introduction to bionanotechnology", Imperial College Press, 2007.

SUBJECT SUPERVISOR
(NAME AND SURNAME, E-MAIL ADDRESS)

dr hab. Tadeusz Andruniów, tadeusz.andruniów@pwr.wroc.pl