

# **Applied Biotechnology**

## **SEMESTER 1 ( summer semester)**

### **1. Clean Technologies – lecture ( 30 h, ECTS 2, written exam)**

Prof. dr hab. Inż. Andrzej Kołtuniewicz (IChIP)

The lecture presents practical methods and new opportunities for the technical implementation of modern production. New technologies of production of pharmaceuticals, food, feed, polymers, and all kinds of chemicals must comply with sustainable development, so as not to pollute and degrade ( in any way ) the natural environment, but thrive in harmony with nature. This is possible by adjusting to the natural cycles of matter and energy on Earth. To do this, give up entirely from fossil fuels and replace them with renewables , which are derived from the so-called . biomass. It is a concept of Biorefineries. At the same time must be reduced to the maximum extent the amount of waste substances and wastewater. All products must be biodegradable, and the components of the manufacturing process, as catalysts, solvents, the media must be kept constantly recycled. During production must apply the principle of so-called Green Chemistry , which proposes an optimization of the production at the molecular level, and all macro-scale processes must be optimized by recycling of substrates, catalysts and energy. An additional method of implementation of clean technologies is to integrate different technologies into a single network, in which the sewage emitted by some are raw materials used by other technologies. The most important methods for the implementation of the recycling materials are modern, efficient methods of separation, and among them the hybrid processes combining in parallel physically different techniques. 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.

#### *Literature:*

1. A.B. Koltuniewicz, Sustainable Process Engineering – Prospects and Opportunities, DE GRUYTER 2013, ISBN 978-3-11-030875-4, <http://www.degruyter.com/view/product/204407>
2. Koltuniewicz, A.B. and Drioli E., Membranes in Clean Technologies - Theory and Practice, vol. 1&2, 890 pages, WILEY 2009, ISBN978-3-527-32007-3 <http://eu.wiley.com/WileyCDA/WileyTitle/productCd-3527320075.html>
3. A.B. Koltuniewicz, Integrated Membrane Operations in various Industrial Sectors, chapter 4.05.1, pp.109-154, ELSEVIER 2010, ISBN978-0-444-53204-6

<http://www.sciencedirect.com/science/article/pii/B9780080932507000293>

in: Comprehensive Membrane Science and Engineering, ed.E.Drioli and L. Giorno,

<http://www.sciencedirect.com/science/referenceworks/9780080932507>

4. A. B. Koltuniewicz, Process Engineering for Sustainability, Chapter 6.34 7.1, in: Encyclopedia of Life Support Systems, Ed. Badran, A., UNESCO 2011, ISBN0 9542989-0-X, <http://www.eolss.net/ebooklib>

## **2. Bioinformatics – lecture (30 h , ECTS 2, written exam)**

dr hab. Dariusz Plewczyński Centre of New Technologies, University of Warsaw

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.

## **3. Data Treatment in Chemical Analysis for Biotechnology - lecture + exercises (30h + 30 h, ECTS 4, written exam)**

Prof. dr hab. inż. Artur Dybko

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.

## **4. Bioethics - lecture ( 30 h, ECTS 2, written exam)**

Mgr Justyna Szatan Wydział Administracji i Nauk Społecznych PW

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 through 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.

1. Giordano J.J., Scientific and Philosophical Perspectives in Neuroethics, Cambridge 2010.
2. Monney C., Bioethics, Lucent Books, 2009.
3. Steinbock B., The Oxford Handbook of Bioethics, Oxford, New York 2010.

**5. Laboratory of Applied Biotechnology- laboratory** ( 60 h, ECTS 5, average of partial marks obtained by the students for each laboratory module)  
dr hab. inż. Michał Chudy Prof. PW, Instytut Biotechnologii, Wydział Chemiczny PW

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.

**6. Analytical Methods in Biotechnology - lecture + laboratory + Project** (15 h+15 h+30 h , ECTS 5, Project 50 %, laboratory 20% and oral presentation 30% of total points)  
dr hab. inż. Katarzyna Pawlak, Prof. PW Katedra Chemii Analitycznej, Wydział Chemiczny PW, dr inż. Mariusz Pietrzak Instytut Biotechnologii, Wydział Chemiczny

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.

*Literature:* Analytical and biotechnological journals from data bases like Elseviere and Springer

**7. Environmental Biotechnology – lecture (30 h, ECTS 3, final test)**

Prof. dr hab. Stanisław Gawroński, Wydział Ogrodnictwa i Architektury Krajobrazu SGGW

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, NO<sub>2</sub>, CO, O<sub>3</sub> 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 (Pb<sup>2+</sup>, Cd<sup>2+</sup> and Cu<sup>2+</sup>) 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 (PM<sub>10</sub> and PM<sub>2,5</sub>) 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.

*Literature:*

1. S.C. McCutcheon, J.L. Schnoor, Phytoremediation- Transformation and Control of contaminants, Wiley –Interscience, New Jersey, USA 2003.
2. S.W. Gawronski, Biotechnologia środowiskowa – Fitoremediacja, rozdział: 7.9 p. 455-461, w: S. Malepszy, Biotechnologia roślin, PWN2001.

**8. Introduction to Bioreactors – lecture (30 h, ECTS 3, written exam)**

Prof. dr hab. inż. Jerzy Bałdyga, Wydział Inżynierii Chemicznej i Procesowej PW

Description:

- 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.

*Literature:*

J. Bałdyga, M. Henczka, W. Podgórska Obliczenia w Inżynierii Bioreaktorów, Oficyna Wydawnicza Politechniki Warszawskiej, 1996

J.E.Bailey, D.F.Ollis Biochemical Engineering Fundamentals 2nd ed., Mc Graw-Hill, 1986  
S.Aiba, A.E.Humphrey, N.F.Mills Inżynieria Biochemiczna, WNT 1977  
W.W.Kafarow, A.J.Winarow, L.S.Gordiejew Modelowanie Reaktorów Biochemicznych, WNT 1983  
T.K.Ghose Bioprocess Computations in Biotechnology, Ellis Horwood Limited 1990  
A.H.Scragg Bioreactors in Biotechnology. A practical approach, Ellis Horwood Limited 1991  
H.J.Rehm, G.Reed Biotechnology. Vol.4. Measuring, Modelling and Control, VCH 1991  
M.L.Shuler, F.Kargi Bioprocess Engineering: Basic Concepts, Prentice Hall 1992 K.van't Riet, J. Tramper Basic Bioreactor Design, Marcel Dekker 1991

**9. Synthetic bio-tools for industrial biotechnology (45 h laboratory, 4 ECTS) (Previous name: Chemical Biotechnology: Biomolecules in synthesis and therapy and laboratory of synthesis and biotransformation- laboratory)**

dr Małgorzata Adamczyk Zakład Technologii i Biotechnologii Środków Leczniczych  
Wydział Chemiczny PW

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.

**Literature:** Laboratory instructions and links to videos and publications will be provided by the tutor

**Additional information:**

There are no separate experimental modules. The practical course is designed as a project, so your presence at each class is obligatory.

Knowledge assessment will be based on your performance during the course (activity), entry test, homework and the final report from your project.

**Teaching method:** flipped classroom

**SEMESTER 2 (winter semestr)**

**1. Economics and Management – lecture ( 30 h, ECTS 2, written exam - test or open questions)**

Prof. nzw. dr hab. Radosław Koszewski, Wydział Administracji i Nauk Społecznych PW

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.

*Literature:* N. Gregory Mankiw, *Principles of Economics*, 6th Edition, Harvard University 2011

<https://financeasim.files.wordpress.com/2014/01/principles-of-macroeconomics-n-gregory-mankiw.pdf>

## **2. Implantable Medical Devices – lecture (30 h, ECTS 3, written exam)**

dr hab. inż. Tomasz Ciach, prof. PW, Wydział Inżynierii Chemicznej i Procesowej PW

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.

### **3. Microbioanalytics – lecture (30 h, ECTS 3, written exam)**

Prof. nzw. dr hab. inż. Michał Chudy, Instytut Biotechnologii, Wydział Chemiczny PW

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.

#### *Literature:*

1. Z. Brzózka, Miniaturyzacja w analityce, Oficyna Wydawnicza PW 2005 (in Polish).
2. Z. Brzózka, Mikrobioanalitka, Oficyna Wydawnicza PW 2009 (in Polish).
3. M. Madou, Fundamentals of Microfabrication, CRC Press, Inc. 2002.
4. A. Manz, N. Pamme, D. Lossifidis, Bioanalytical Chemistry, Imperial College Press, Language: English.
5. A. Van Den Berg, Lab-On-A-Chip: Miniaturized Systems for (Bio)Chemical Analysis and Synthesis, Elsevier Science.

### **4. Seminary of Applied Biotechnology - seminary (15 h, ECTS 1, student's presentation)**

dr hab. inż. Michał Chudy, Prof. PW, Instytut Biotechnologii, Wydział Chemiczny PW

Students will be given scientific 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.

#### *Literature:*

Scientific Journals, Conference Proceedings

### **5. Separation Processes in Biotechnology - lecture + exercises (30 h + 15 h, ECTS 4, exam)**

Prof dr hab. inż. Andrzej Kołtuniewicz, Wydział Inżynierii Chemicznej i Procesowej PW

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

*Literature:*

1. R.G. Harrison et al., Bioseparation Science Engineering, Oxford University Press, Oxford 2003.
2. A. Kołtuniewicz, E. Drioli, Membranes In Clean Technologies, Theory and Practice, WILEY VCH, 2008.

**6. Characterization of Biomaterials (Biocompatibility) - lecture + exercises (15 h + 15 h, ECTS 2, written exam and presentation)**

dr hab. inż. Paweł Parzuchowski , Prof.PW, Katedra Chemii i Technologii Polimerów  
Wydział Chemiczny PW

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.

*Literature:*

1. M. Blicharski, Wstęp do inżynierii materiałowej, WNT, Warszawa 2003.
2. R. Pampuch, Materiały ceramiczne, PWN, 1988.
3. H. Saechtling, Tworzywa sztuczne – poradnik, WNT,1995.
4. D. Żuchowska, Polimery konstrukcyjne, WNT, 2000.
5. B. D. Ratner, A.S. Hoffman, Biomaterials Science, an Introduction to Materials in Medicine, Academic Press, London, 1996.

**SEMESTER 3 (summer semester)**

**1. Sensors and Biosensors - lecture + exercises ( 15 h + 15 h, ECTS 2, written exam and presentations)**

Dr inż. Mariusz Pietrzak, Instytut Biotechnologii, Wydział Chemiczny PW

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.

*Literature:*

1. Z. Brzózka, W. Wróblewski, Sensory chemiczne, Oficyna Wydawnicza Politechniki Warszawskiej, 1998.
2. U.E. Spichiger-Keller, Chemical Sensors and Biosensors for Medical and Biological Applications, Wiley-VCH, 1998.
3. B. Eggins, Biosensors, John Wiley & Sons, 1996.

- 1. Diploma seminar - 15 h**
- 2. Diploma laboratory - 180 h**
- 3. M.Sc. Thesis writting - 150 h**