COURSE DESCRIPTION CARD - SYLLABUS

Course name
Bioinspired materials [S2Bioinf2>BIM]

Course

Field of study
Bioinformatics

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

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Prerequisites

The student starting this course should have basic knowledge of general inorganic, organic and physical chemistry in the scope enabling understanding of chemical phenomena and processes (core curriculum of the first and second year of full-time first-cycle studies). The student should also be able to obtain information from recommended literature sources, both in Polish and in English.

Course objective

Understand the principles of biomaterials design and their significance in various applications. Utilize bioinformatics tools for computational modeling and analysis of biomaterials. Apply data mining and machine learning techniques to discover and predict properties of new biomaterials. Design protein structures for biomimetic applications using computational tools. Evaluate the biocompatibility and safety of new materials through bioinformatics analysis.

Course-related learning outcomes

Knowledge:
1. Knows and understands complex biological phenomena and processes, and bases their interpretation in research work and practical activities on a precise and consistent approach using empirical data.
2. Knows and understands complex physicochemical and biochemical processes, including the principles of appropriate selection of materials, raw materials, equipment, and devices for their implementation and product characterization.
3. Knows and understands the methods, techniques, and tools used in solving complex bioinformatics tasks, mainly of an engineering nature.
4. Knows and understands the basics of using biocatalysts and biomaterials in biochemical processes.

Skills:
1. Is proficient in utilizing and integrating information obtained from literature and electronic sources, in both Polish and English, and is capable of evaluating, critically analyzing, synthesizing, and creatively interpreting them.
2. Can draw conclusions, clearly formulate and thoroughly justify opinions based on data from various sources.
3. Is able to plan and perform advanced measurements and laboratory experiments, including computer simulations, and interpret their results.
4. Can apply advanced techniques and IT tools to solve biological problems and assess their usefulness.
5. Can plan and carry out research tasks, including those of an engineering nature, under the supervision of a scientific advisor, using analytical, simulation, and experimental methods.

Social competences:
1. Is prepared to engage in lifelong learning, inspire and organize the learning process of others, including seeking expert opinions, while critically evaluating the collected content.
2. Is prepared to demonstrate a creative attitude in professional and social life and to consciously fulfill the social role of a university graduate, including caring for the public interest.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The skills acquired during classes, both in-person and/or online (using the eKursy platform), are assessed based on an exam.
For in-person format: the exam is conducted by spoken evaluation. Grading criteria: 3 (satisfactory) - 50.1% to 70.0%, 4 (good) - 70.1% to 90.0%, 5 (very good) - from 90.1%.
For online format: the exam is a multiple-choice test using the eKursy platform. Grading criteria: 3 (satisfactory) - 50.1% to 70.0%, 4 (good) - 70.1% to 90.0%, 5 (very good) - from 90.1%.
Additionally, grades are based on the documentation of conducted experiments (laboratory reports).

Programme content

Bioinformatics as an important field in the synthesis of bioinspired materials.

Course topics

Lecture
1. Introduction to Biomaterials and Bioinformatics
Overview of biomaterials and their significance in biotechnology and medicine. Introduction to bioinformatics tools and databases relevant to biomaterials research (e.g., PubChem, Protein Data Bank).
2. Computational Design of Biomaterials
Principles of computational design in biomaterials, including molecular modeling, docking studies, and quantum mechanical calculations. Use of software tools like AutoDock and Rosetta for protein and material design.
3.Bioinformatics in Natural Polymer Characterization
Study the characterization of natural polymers (e.g., silk, chitosan) using sequence alignment and phylogenetic analysisto understand their properties and potential applications in bioinspired materials.
4. Protein Engineering for Biomimetic Applications
Explore techniques in protein engineering and synthetic biology to design proteins that can mimic natural adhesives and structural materials. Use tools for protein structure prediction and modification.

5. Biomimicry of Biological Processes
Investigate biological processes (e.g., biomineralization, photosynthesis) and how bioinformatics can be used to model these processes for the design of novel materials. Focus on systems biology approaches to study complex biological systems.
6. Data Mining for Biomaterial Discovery
Utilize data mining techniques to analyze existing literature and databases for discovering new biomaterials. Explore machine learning approaches to identify patterns and predict material properties based on genomic and proteomic data.
7. DNA Nanotechnology and Origami Design
Learn how bioinformatics plays a role in the design and analysis of DNA nanostructures (DNA origami). Discuss applications of DNA nanotechnology in material science and drug delivery systems.
8. Metabolomics and Biomaterials
Introduction to metabolomics and its application in understanding the interactions between biomaterials and biological systems. Use bioinformatics tools to analyze metabolomic data for biomaterial development.
9. Functionalization of Nanoparticles Using Bioinformatics
Study the methods for functionalizing nanoparticles with biological molecules. Use bioinformatics tools to analyze interactions and predict the behavior of these nanoparticles in biological environments.
10. Biocompatibility and Safety Assessment of Biomaterials
Learn how bioinformatics can help in assessing the biocompatibility and toxicity of new biomaterials. Focus on data analysis and modeling for predicting material interactions with biological systems.
11. Case Studies in Biomimetics and Material Innovations
Analyze case studies of successful biomimetic materials and technologies. Use bioinformatics to investigate the underlying biological principles and how they were translated into material applications.
Laboratories:
Isolation of biomaterials from biominerals and their further controlled remineralization in order to obtain hybrid materials.
Production of bio-inspired materials by the electrospinning technique.

Teaching methods

Lecture: multimedia presentation. Laboratory exercises.

Bibliography

Basic:
1. C. Zhai et al. (2020) Discovery and design of soft polymeric bio-inspired materials with multiscale simulations and artificial intelligence. J. Mater. Chem. B, 8, 6562-6587.
2. A.K. Mandall et al. (2023) A Study of Bio-inspired Computing in Bioinformatics: A State-of-the-art Literature Survey. THE OPEN BIOINFORMATICS JOURNAL.
3. G. Pohl; W. Nachtigall (2015) Biomimetics for Architecture & Design. Springer International Publishing.
4. J.F. Mano (2012) Biomimetic Approaches for Biomaterials Development. Wiley-VCH.
5. A. Suwardi et al. (2021) Machine Learning-Driven Biomaterials Evolution. Adv. Mater. 34, 2102703.
6. S.M. McDonald et al. (2023) Applied machine learning as a driver for polymeric biomaterials design. Nat Commun 14, 4838.
7. J. Kerner et al. (2021) Machine learning and big data provide crucial insight for future biomaterials discovery and research. Acta Biomaterialia 130, 54-65.

Additional:
1. K. Konopka, Wzorce z natury w technice i inżynierii materiałowej. Oficyna Wydawnicza Politechniki Warszawskiej.
2. X.Y. Liu, Bioinspiration: from nano to micro scales. Springer-Verlag New York, 2012.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	65	2,50