POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Systems Approaches in Biomedical Research [S2Bioinf2>PSBB]

Course

Field of study
Bioinformatics

Year/Semester
2/3

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
15

Laboratory classes
20

Other
0

Tutorials
10

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

A student undertaking the second-cycle studies of Bioinformatics should have achieved assumed learning objectives from the first-cycle studies (these effects are available on the department's website www.cat.put.poznan.pl). A student starting this module should have basic knowledge of molecular biology, systems biology, functional and structural genomics. Should have the abilities to solve basic biological and bioinformatics problems, use biological databases, modelling the structure of biomolecules and biological processes. Moreover, in terms of social competencies, a student must present attitudes such as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. Providing basic knowledge of the practical use of systems approaches in biomedical research, including applications of genomics, transcriptomics, and proteomics in medicine. 2. Developing the ability to analyze data and modelling on the basis of selected examples from systems medicine. 3. Acquaintance with the basic strategies of biomarker search, identification of therapeutic targets, potential drugs, as well as statistical analysis of biomedical research. 4. Acquaintance with the basic strategies of searching and learning about the mechanisms of disease processes. 5. Developing the ability to plan research and formulate basic assumptions of research projects.

Course-related learning outcomes

Knowledge:
1. A student knows the basic strategies and methods used in the process of searching for mechanisms laying in the basis of diseases, biomarkers, new therapeutic targets and drugs.
2. A student has the knowledge necessary to solve tasks related to the analysis of complex biological systems with the use of known bioinformatics tools and databases.
3. A student has the knowledge necessary to implement a project consisting of creating a research plan. This plan should focus on one of the following goals: understanding the mechanism of the diseases process, biomarkers identification, therapeutic targets identification, or potential drugs identification.
4. A student knows the principles of research planning in the field of biomedicine and bioinformatics.

Skills:
1. A student is able to use basic techniques and bioinformatics tools to solve biological problems, and is also able to interpret the obtained results and draw conclusions.
2. Under the supervisor, a student designs research plans with the use of analytical and bioinformatics methods.
3. A student applies appropriate statistical methods and proper tools to describe processes and analyze biomedical data.
4. A student prepares a presentation of research results and discusses the results of work in the scientific community.
5. A student understands systems approaches and is able to apply them in bioinformatics tasks. Student notices not only a technical approach to the problem but also an important biological context.
6. A student formulates and tests hypotheses related to biological, biomedical and bioinformatics problems.

Social competences:
1. A student properly define the priorities for the implementation of the task proposed by himself/herself or others.
2. In the context of various systems approaches, a student is able to identify and resolve ethical dilemmas.
3. A student demonstrates a creative attitude in professional and social life.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative Assessment:
a) Lectures:
Verification of the assumed learning outcomes is achieved through:
- Answering questions about the material covered in previous lectures.
b) Exercises:
Verification of the assumed learning outcomes is achieved through:
- Evaluation of the project developed by the student.
- Multimedia presentation of the project prepared by the student.
- "Defense," i.e., the ability to justify the decisions made and the methodology selected for the project.
- Assessment of the ability to critique and verify the accuracy of research presented in other students' projects.
c) Laboratory:
Verification of the assumed learning outcomes is achieved through:
- Assessment of the student's preparation for each laboratory session and their ability to complete planned tasks.
- Continuous evaluation during each class (oral responses), with an emphasis on skill progression in using the introduced principles and methods.
- The dominant component of formative assessment is the evaluation of reports, prepared partially during and partially after the sessions.
Summative Assessment:
a) Lectures:
Verification of the assumed learning outcomes is achieved through:
- A final test consisting of closed and open questions.

- Additional bonus points can be earned for active participation in lectures.
- Standard percentage thresholds apply: Below 51%: Fail (2.0); 51-60%: Sufficient (3.0); 61-70%: Sufficient Plus (3.5);71-80%: Good (4.0); 81-90%: Good Plus (4.5); 91-100%: Very Good (5.0).

b) Exercises:
Verification of the assumed learning outcomes is achieved through:
- Evaluation of knowledge and skills demonstrated during the project presentation and discussions about various stages of the research project.
- The evaluation will include the student’s justification for: (i) Choosing the object/process/system of their project; (ii) Defining the project's objectives; (iii) Utilizing existing databases and available literature; (iv) Selecting the research methodology and data analysis techniques, (v) Proposing solutions to the problem; (vi) Choosing methods for validating solutions or verifying possible results.
- The final grade will be based on points accumulated in four categories: (i) Project description in the form of a report; (ii) Multimedia presentation of the project; (iii) Ability to verify, discuss, and critique other students’ projects; (iv) Ability to defend proposed solutions and research methodology.
- The final grade is a weighted average across all four categories. To pass, students must achieve at least 51% in both the project description and project presentation.
- Standard percentage thresholds apply: Below 51%: Fail (2.0); 51-60%: Sufficient (3.0); 61-70%: Sufficient Plus (3.5);71-80%: Good (4.0); 81-90%: Good Plus (4.5); 91-100%: Very Good (5.0).

c) Laboratory:
Verification of the assumed learning outcomes is achieved through:
- Evaluation of reports prepared for each laboratory session. Each set of tasks is graded, and students must achieve more than 50% of the points for each session to pass. All laboratory sessions reports must be passed to receive a positive final grade for the course.
- The final grade for the laboratory component is based on the total points earned across all sessions.
- Additional points can be earned for active participation, particularly for: (i) Discussing additional aspects of the topic; (ii) Effectively applying knowledge to solve assigned problems; (iii) Using creative and innovative solutions to complete planned tasks.
- Standard percentage thresholds apply: Below 51%: Fail (2.0); 51-60%: Sufficient (3.0); 61-70%: Sufficient Plus (3.5);71-80%: Good (4.0); 81-90%: Good Plus (4.5); 91-100%: Very Good (5.0).

Programme content

The lecture program covers topics related to the application of fundamental methods in systems biology and systems medicine for the exploration and identification of mechanisms underlying disease processes, potential biomarkers for pathological states, therapeutic targets, and drugs.
During the exercises, students address bioinformatics problems theoretically and practically, aligning with the themes of the lectures and laboratory sessions.
In the laboratory sessions, students acquire practical skills related to the analysis of biomedical systems, the use of advanced statistical methods, and the application of machine learning techniques for the analysis and processing of biomedical datasets.

Course topics

Lecture:
1. Introduction to Systems Research in Medicine
2. Advanced Statistics in Medical Research
3. Dimensionality Reduction
4. Genome-Wide Association Studies
5. Precision Oncology
6. Biomarker Identification
7. Screening Studies
8. Causal Inference in Biomedical Research and Clinical Trials
9. Generalized Linear Models in Medicine
10. Applications of Artificial Intelligence Techniques in Medicine and Biology

Exercises:
During the exercises, students discuss and present their own system-oriented research projects.

Laboratory:
1. Statistics in Medical Research
2. Dimensionality Reduction
3. Genome-Wide Association Studies

4. Pharmacogenomics
5. Causal Inference in Biomedical Research and Clinical Trials
6. Generalized Linear Models in Medicine
7. Automation of Knowledge Extraction and Analysis of Biomedical Systems Using Artificial Intelligence Methods
8. Identification and Validation of Disease Biomarkers

Teaching methods

Lecture: Multimedia presentations supplemented with examples illustrated on the board.
Exercises:
- Project presentation.
- Discussion and critique of projects.
- Developing the project into a formal report.
- Teamwork.
- Guiding students and supervising the process of designing system-based research, from the initial idea to a concrete research plan.

Laboratory:
- Performing practical tasks (including data analysis, statistics, and machine learning).
- Preparing results in the form of reports.
- Engaging in discussions.

Bibliography

Basic:
1. Statystyka medyczna w zarysie, J. Moczko, Wydawnictwo Lekarskie PZWL (2006).
2. Exploratory multivariate analysis by example using R, F. Husson, S. Lê, J. Pagès, CRC press (2017).
3. Biologia molekularna w medycynie. Elementy genetyki klinicznej, Jerzy Bal (Wydawnictwo Naukowe PWN)
4. Genetyka medyczna. Podręcznik dla studentów, G. Drewa, oprac. T. Ferenc (Elsevier Urban & Partner)
5. The Handbook of Biomarkers, J. Kewal (Humana Press-Springer)
6. Biomarkers in Drug Development: A Handbook of Practice, Application, and Strategy, M. R. Bleavins, C. Carini, M. Jurima-Romet, R. Rahbari (John Wiley & Sons)

Additional:
1. Systems Biology, E. Klipp, W. Liebermeister, C. Wierling, A. Kowald, H. Lehrach,R. Herwig (Wiley-Blackwell)
2. Bioinformatics for Systems Biology, Krawetz, Stephen. Humana Press
3. Immunologia, Jakub Gołąb, Marek Jakóbisiak, Witold Lasek, Tomasz Stokłosa Wydanie: 7, 2020 Wydawnictwo Naukowe PWN

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00