Cell biology

Educational subject description sheet

Basic information

Field of study Bioinformatics **Speciality** - **Organizational unit** The Faculty of Biology and Animal Science **Study level** First-cycle (engineer) programme **Study form** Full-time **Education profile** General academic	**Education cycle** 2025/26 **Subject code** BD000000BBIS.I1.0336.25 **Lecture languages** english **Mandatory** optional **Block** major subjects (conducted) in foreign languages **Disciplines** Biological sciences **Subject related to scientific research** Yes **Subject shaping practical skills** Nie

Teacher responsible for the subject	Adam Urantówka
Other teachers conducting classes	Adam Urantówka, Aleksandra Kroczak-Zdańkowska

Period Semester 1	**Examination** exam **Activities and hours** lecture: 15 laboratory classes: 30	**Number of ECTS points** 5.0

Goals

C1	Presenting to the students the detailed description of the most popular theories of the origin of life and cells.
C2	Providing students with the knowledge about the model organisms representative for particular groups of living organisms.
C3	Explaining to students the most important differences between pro- and eukariotic cells as well as between plant and animal cells.
C4	Presenting to students the mechanisms of the gene expression regulation underlying the diversity of cells of the same organism.
C5	Providing students with the knowledge about mitochondria and chloroplasts in the context of cellurar respiration and photosynthesis.
C6	Explaining to students the structure of biological membranes and biosynthesis of it's components, intracellular compartments and transport through membranes (endoplasmic reticulum soft and rough, Golgi apparatus, endosomes, lisosomes).
C7	Providing students with a knowledge about the structure of the cell nucleus, especially nuclear envelope, nuclear pore complex and protein transport into nucleus.
C8	Explaining to students the protein biosynthesis and mechanisms of protein transport and modification depending on their destination.

Subject's learning outcomes

Code	Outcomes in terms of	Effects	Examination methods
Knowledge – Student knows and understands:			
W1	the molecular basis of the functioning of organisms, structure of subcellular organella, their functions and communication.	BI_P6S_WG03, BI_P6S_WG04, BI_P6S_WG05, BI_P6S_WG06, BI_P6S_WK10	written exam, active participation
W2	the physiological processes occurring in cells of plants and animals.	BI_P6S_WG02, BI_P6S_WG03, BI_P6S_WG04, BI_P6S_WG05, BI_P6S_WG06, BI_P6S_WK10	written exam, active participation
W3	the theories explaining the origin of organic molecules (biopolymers) and evolution of cells.	BI_P6S_WG02, BI_P6S_WG03, BI_P6S_WG04, BI_P6S_WG06, BI_P6S_WK10	written exam, active participation
Skills – Student can:			
U1	correctly preserve and store biological material.	BI_P6S_UK14, BI_P6S_UO12, BI_P6S_UW02, BI_P6S_UW05	observation of student’s work, test
U2	properly perform simple DNA isolation, set-up PCR samples and interprete the results of this reaction visualized via agarose gel electrophoresis.	BI_P6S_UK14, BI_P6S_UO12, BI_P6S_UW02, BI_P6S_UW05	observation of student’s work, test
Social competences – Student is ready to:			

Code	Outcomes in terms of	Effects	Examination methods
K1	systematically update of knowledge in the field of cell biology.	BI_P6S_KK01, BI_P6S_KO02	written exam, observation of student's work, active participation
K2	critically evaluate news related to the field of biology and given in mass-media.	BI_P6S_KK01	written exam, observation of student's work, active participation

Balance of ECTS points

Activity form	Activity hours*	
lecture	15	
laboratory classes	30	
exam / credit preparation	45	
exam participation	2	
consultations	2	
lesson preparation	20	
class preparation	12	
Student workload	**Hours** 126	**ECTS** 5.0
Workload involving teacher	**Hours** 49	**ECTS** 1.9
Practical workload	**Hours** 30	**ECTS** 1.0

* hour means 45 minutes

Study content

No.	Course content	Activities
1.	• Understanding the hypothesis of panspermia, hydrothermal vent theory, Oparin's theory, primordial soup theory, Miller's experiment, RNA world hypothesis, progenote concept, competing theories on the evolution of prokaryotes and eukaryotes, and the endosymbiotic theory • Understanding the concept of model organisms and their role in scientific research, particularly organisms such as Escherichia coli, Saccharomyces cerevisiae, Dictyostelium discoideum, Caenorhabditis elegans, Drosophila melanogaster, Mus musculus, Arabidopsis thaliana • Understanding the diversity of cell sizes and shapes, primarily in bacteria, but also among eukaryotic cells, including protozoa. Recognizing fundamental similarities among living organisms that indicate their common ancestry – similarities in metabolic processes and macromolecular unity • Understanding the course and results of key scientific experiments proving that all cells of the same organism contain the same genome • Learning key facts about the structure of prokaryotic and eukaryotic cells and their major organelles, including fundamental knowledge of mitochondrial and plastid genomes • Understanding that cell diversity results from gene expression regulation, learning the mechanism of combinatorial gene expression, and the concept of key transcriptional regulators coordinating gene expression • Acquiring knowledge about biological membranes – historical context (from the sandwich model to the fluid mosaic model), structure, role in intracellular compartmentalization, and inter-compartment communication • Understanding lipid bilayer properties, the role of amphipathic lipid characteristics, self-repair mechanisms, membrane fluidity, lipid distribution, structures and domains of various membrane proteins, the role of the cell cortex and glycocalyx, and the role of the endoplasmic reticulum and Golgi apparatus in membrane synthesis • Understanding differences in membrane diffusion based on molecule size, polarity, and charge • Understanding the principles of membrane transport, the structure and function of channels, carriers, and pumps (uniport, symport, antiport). Learning the role of sodium ions in maintaining membrane transport, transport along and against concentration gradients • Understanding how different types of proteins are integrated into membranes and how vesicular transport operates • Learning the structure of the nucleus, particularly the nuclear membrane and its continuity with the endoplasmic reticulum. Understanding the structure and function of nuclear pore complexes and nuclear protein transport • Learning the fundamentals of oxidation and reduction of organic compounds, understanding the complementarity of photosynthesis and respiration • Understanding the difference between cellular respiration, which involves the gradual oxidation of organic compounds, and combustion • Learning about respiration in the context of mitochondrial structure: localization of electron transport chain proteins and ATP synthase in mitochondria, ATP synthase mechanism, chemiosmotic theory. Understanding mitochondrial morphology changes and their dynamics depending on the organelle's energy state • Learning about plastid biogenesis and plasticity, their localization in photosynthetic tissues, and morphology adapted to photosynthesis requirements. Understanding the mechanism of photosystem function and the role of water photolysis, energy utilization by electrons leaving photosystem II and I, the dual role of Rubisco as a carboxylase in the Calvin-Benson cycle and as an oxygenase in photorespiration. Learning about the mechanisms plants use to solve the problem of photorespiration •	lecture

No.	Course content	Activities
2.	• Biological material and its storage (2h) The student will acquire knowledge about the types of biological material from which genetic material can be obtained. They will also learn how to properly collect, secure, and store biological samples intended for DNA isolation. The student will become familiar with various methods of biological material preservation and their impact on different molecular techniques. They will also learn how the quality of the material affects the possibility of conducting various laboratory studies • Biological material and its preparation (4h) The exercises will use so-called dry blood spots and feathers collected by qualified personnel from different bird species. The student will independently prepare the appropriate amount of biological material necessary to obtain a high-quality DNA isolate • DNA isolation (6h) The goal of the DNA isolation performed by the student is to obtain high-molecular-weight DNA with maximum efficiency while simultaneously purifying the preparation from proteins and enzyme inhibitors that may hinder subsequent DNA work stages. The student will become familiar with various methods of deoxyribonucleic acid isolation, understand the differences between the methods, and learn their applications. During the exercises, the student will independently isolate genomic DNA (containing mitochondrial and nuclear genomes) using the column-based method and learn the principles of proper storage of obtained isolates • PCR reaction – nuclear DNA (6h) After obtaining isolates for each tested individual, a test will be performed using the polymerase chain reaction to determine the genetic sex of birds. This test is a fast and non-invasive method widely used for determining the genetic sex of very young birds or species that do not exhibit sexual dimorphism and is particularly significant for institutions such as zoos. The diagnostic accuracy of the test is based on the length polymorphism of introns in the conserved CHD1 gene, which is located on the Z and W chromosomes in birds. The student will independently design a PCR reaction according to the principles of nuclear DNA amplification • PCR reaction – mitochondrial DNA (6h) After obtaining isolates for each tested individual, the mitochondrial ND2 gene will also be amplified. The student will independently design a PCR reaction following the principles of mitochondrial DNA amplification. The student will learn the differences in the amplification of nuclear and mitochondrial DNA. They will also learn how to design primers specific to a given genome that enable the amplification of selected DNA fragments • Electrophoresis, visualization, and analysis of obtained results (6h) The student will learn about various methods of separating macromolecules under the influence of an electric field. They will become familiar with different buffers and electrophoretic carriers and their applications. The diagnostic fragments obtained by the student using PCR will be separated during the exercises using horizontal electrophoresis in an agarose gel. The student will learn how to independently prepare an agarose gel of appropriate percentage concentration. They will become familiar with the operation of the electrophoresis apparatus and the power supply device. They will also learn how to visualize electrophoretic separation effects using the "GelDoc-It Imaging System," Ultra-Violet Products Ltd., and how to interpret individual results. The student will also learn how to properly document conducted experiments •	laboratory classes

Course advanced

Teaching methods:

educational film, lecture, classes, problem-based learning (PBL)

Activities	Examination methods	Percentage in subject assessment
lecture	written exam, active participation	60%
laboratory classes	observation of student’s work, active participation, test	40%

Entry requirements

Students should have knowledge of chemistry, biology and physics within the scope of the high school curriculum. Laboratory classes will be conducted in small groups of maximum 13 students.

Literature

Obligatory

1. Essential Cell Biology, B. Alberts, D. Bray, K. Hopkin, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, Fifth Edition, WW Norton & Co
2. Genetyka molekularna. Pod redakcją P. Węgleńskiego, PWN
3. BIOS Instant Notes in Molecular Biology , P. Turner, A. McLennan, A. Bates, M. White, 3rd Edition, Taylor & Francis
4. Genomy, T.A. Brown, PWN

Optional

1. Altstein AD, The progene hypothesis: the nucleoprotein world and how life began. 2015, Biology Direct 10:67
2. Reiter F, Wienerroither S, Stark S Combinatorial function of transcription factors and cofactors. 2017, Current Opinion in Genetics and Development 43: 73-81
3. Zimorski V, Ku C, Martin WF, Gould SB Endosymbiotic theory for organelle origins. 2014, Current Opinion in Microbiology 22: 38-48
4. Yang DC, Blair KM, Salama NR Staying in shape: the impact of cel shape on bacterial survival in diverse environments. 2016, Microbiology and Molecular Biology Reviews 80 (1): 187-203
5. Forterre P The universal tree of life: an update. 2015, Frontiers in Microbiology 6, 717
6. Penny D, Poole A The nature of the last universal common ancestor. 1999, Current Opinion in Genetics and Development 9:672-677
7. McCarron JG et al., From structure to function: mitochondrial morphology, motion and shaping in vascular smooth muscle. 2013, Journal of Vascular Research 50:357-371.
8. Solymosi K, Keresztes A, Plastid structure, diversification and interconversions II. Land Plants. 2012, Current Chemical Biology 6:187-204.
9. Caccamo PD, Brun YV, The molecular basis of noncanonical bacterial morphology. 2018, Trends Microbiol. 26(3): 191-208.
10. Krysan PJ, Young JC, Sussman MR, T-DNA as an insertional mutagen in Arabidopsis. 1999, The Plant Cell, 11: 2283–2290.

Kierunkowe efekty uczenia się

Kod	Treść
BI_P6S_KK01	The graduate is ready to critically evaluate his/her knowledge and update it.
BI_P6S_KO02	The graduate is ready to appropriately set priorities to accomplish a specific task.
BI_P6S_UK14	The graduate is able to speak a foreign language in the fields of science and scientific disciplines relevant to bioinformatics, in accordance with the requirements specified for level B2 of the Common European Framework of Reference for Languages.
BI_P6S_UO12	The graduate is able to correctly make inferences on the basis of data from various sources of natural, agricultural, technical and mathematical sciences, using scientific language for discussion.
BI_P6S_UW02	The graduate is able to apply research techniques and tools in the field of experimental biology, with particular emphasis on biochemistry, biophysics and molecular biology.
BI_P6S_UW05	The graduate is able to independently design or perform expertise in the fields of biology, animal science and computer science under the leadership of a research supervisor and as part of group work and use available sources of information, including electronic.
BI_P6S_WG02	The graduate knows and understands at an advanced level the specifics of interpreting the results of biological analysis.
BI_P6S_WG03	The graduate knows and understands at an advanced level the physical, chemical and biochemical phenomena and processes occurring in nature and in living organisms.
BI_P6S_WG04	The graduate knows and understands at an advanced level the mechanisms of evolution.
BI_P6S_WG05	The graduate knows and understands at an advanced level issues of the laws of classical genetics, molecular genetics, population genetics and cytogenetics.
BI_P6S_WG06	The graduate knows and understands at an advanced level the importance of interdisciplinary use of knowledge in mathematics, physics, biophysics, chemistry, biochemistry necessary for understanding natural phenomena and processes.
BI_P6S_WK10	The graduate knows and understands at an advanced level the elementary techniques of molecular biology.