NARODOWA AGENCJA WYMIANY AKADEMICKIEJ

UR an international PhD student

COURSE SYLLABUS – DOCTORAL SCHOOL
EDUCATION CYCLE FROM 2024/2025 TO 2027/2028
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EDUCATION CYCLE FROM 2025/2026 TO 2028/2029

GENERAL INFORMATION ABOUT THE SUBJECT	
Subject title	**OPTIONAL SPECIALISED SUBJECT: Nanomaterials in biotechnology**
Name of the unit offering the subject	Doctoral School at the University of Rzeszów
Type of subject *(compulsory, optional)*	*compulsory - optional specialist*
Year/semester	Year I, semester I, year II, semester III
Discipline	*Biotechnology*
Language	English
Name and surname of the course coordinator	**Raluca Maria Fratila, PhD**
Name and surname of the person(s) teaching the subject	**Raluca Maria Fratila, PhD**
Prerequisites	Extensive knowledge of biotechnology, familiarity with issues related to nanomaterials used in biotechnology. Knowledge of English at the B2 CEFR level, with a focus on specialised vocabulary.

COURSE SUMMARY

(synthetic description of the content and objectives of the course; 100-200 words)

SPECIALISED OPTIONAL SUBJECT: Nanomaterials in biotechnology

The course aims to organise the doctoral student's knowledge and explore the latest global discoveries related to nanomaterials used in biotechnology and biomedicine. This specialist workshops will provide an in-depth exploration of cutting-edge topics in nanobiomedicine and nanobiotechnology, offering students the opportunity to engage with emerging concepts and technologies that are shaping the future of healthcare. The course combines theoretical foundations with practical insights, fostering a comprehensive understanding of how nanoscience is revolutionizing biomedical and biotechnological applications.

LEARNING OUTCOMES FOR THE COURSE AND VERIFICATION METHODS

Learning outcome symbol	Expected learning outcomes	Reference to learning outcomes for level 8 PRK qualifications (symbol)	Form of teaching (lectures, practical classes, etc.)	Assessment methods (e.g. test, oral examination, written examination, project, etc.)
Knowledge: *knows and understands* No.	**Knowledge: *knows and understands, has knowledge***			
P8S_WG1	He has extensive theoretical knowledge supported by research experience in biotechnology and is familiar with current scientific achievements, including global ones, in the field of nanomaterials used in biotechnology. He is able to independently refer to patterns related to nanotechnological materials used in biotechnology.	P8S_WG	*seminar	paper/ research project

P8S_WG2	Has knowledge of global trends in the development of nanomaterials used in biotechnology and understands the need for ongoing scientific research in the field of nanomaterials.	P8S_WG	*seminar	paper/ research project
P8S_WG3	Knows, understands and communicates with the scientific and professional community using terminology related to nanomaterials in their native and foreign languages.	P8S_WG	*seminar	paper/ research project
P8S_WK1	Has extensive knowledge of nanomaterials used in biotechnology and understands their impact on the progress of civilisation.	P8S_WK	*seminar	paper/ research project
Skills: able to No.	**Skills: *able to***			
P8S_UW1	Based on interdisciplinary knowledge in the field of exact and natural sciences, is able to formulate and set ambitious research goals related to research on nanomaterials used in biotechnology. Is able to identify and improve research methods, techniques and tools, as well as draw constructive conclusions based on the results of research work.	P8S_UW	*seminar	paper/ research project
P8S_UW2	Based on the available global literature, they are able to diagnose and solve research and scientific problems (both theoretical-conceptual and technical), is able to implement innovative activities related to research interests, and apply the appropriate course of action to create new elements of scientific achievement in nanomaterials.	P8S_UW	*seminar	paper/ research project
P8S_UW3	He/she is able to use his/her interdisciplinary knowledge and research experience to analyse and evaluate available scientific achievements in the field of nanomaterials used in biotechnology, expert opinions and other scientific publications on nanomaterials, formulating his/her own opinions, including critical judgements.	P8S_UW	*seminar	paper/ research project
P8S_UK6	Able to conduct research based on foreign-language literature and actively participate in international scientific and professional events, communicating at B2 CEFR level.	P8S_UK	*seminar	paper/ research project

Social competences: *is ready to* No.	**Social competences: *is ready to***			
P8S_KK3	Is ready to take substantive action to solve cognitive and practical problems using their knowledge of biotechnology in the field of nanomaterials.	P8S_KK	*seminar	paper/ research project

FORMS OF TEACHING ACTIVITIES, NUMBER OF HOURS AND CREDITS

Semester (no.)	Lecture	Practical/Seminar	Lab	Practical	Other	**Number of ECTS points**
I and III	-	**15 hours**	-	-	-	**2**

TEACHING METHODS

- seminars;
- classes with multimedia presentations;
- project;
- correction;
- discussion.

PROGRAMME CONTENT

Seminar:

1. Bioorthgonal chemistry and nanotechnology: concept of bioorthogonality, main chemical reactions that can be performed in living systems. Applications of bioorthogonal chemistry in nanobiomedicine, including labelling, imaging, and therapeutic strategies.
2. Nanomaterials for tissue engineering applications: main types of nanomaterials, synthesis, characterization and integration into regenerative medicine and tissue engineering applications.
3. Nanoparticle-mediated hyperthermia: concepts and applications of magnetic and optical hyperthermia in cancer therapy, drug delivery and other biomedical fields.

COURSE COMPLETION REQUIREMENTS (ASSESSMENT CRITERIA)

The examination takes place after each semester of the course (semester 1, semester 3).

- preparation of a presentation (15-20 min) on a selected topic related to the use of nanomaterials in biotechnology – during the last class;
- prepartation of a short draft of review manuscript (max 2 pages without ref.) entitled "Application of nanomaterials in biotechnology"
- active and systematic work of the doctoral student;
- ability to lead discussions and draw constructive conclusions;
- attendance

The doctoral student prepares a paper on a topic indicated by the teacher from the scope of issues related to the subject, or carries out a research project with a short substantive description;

Very good grade:

- substantive activity and engagement during classes,
- demonstrable ability to lead discussions and draw constructive conclusions,
- very high substantive value of the paper or research project;
- attendance at least 4/5 of the total number of classes;
- active use of the recommended literature, expanded and deepened on one's own.

Good plus grade:

- substantive activity during classes;
- high substantive value of the paper or research project;
- attendance at least 4/5 of the total number of classes;

- visible satisfactory ability to lead discussions and draw conclusions;
- active use of the recommended literature.

Good grade:
- satisfactory substantive activity during classes;
- satisfactory substantive value of the paper or research project;
- attendance at least 4/5 of the total number of classes;
- moderate ability to lead discussions and draw conclusions;
- satisfactory use of the recommended literature.

Pass with distinction:
- moderate level of substantive activity during classes
- relatively poor substantive value of the paper or research project;
- attendance at least 3/5 of the total number of classes;
- moderately poor ability to lead discussions and draw conclusions;
- moderate use of the recommended literature.

Satisfactory grade:
- low level of activity during classes
- poor substantive value of the paper or research project;
- attendance at least 3/5 of the total number of classes;
- poor ability to lead discussions and draw conclusions;
- sporadic use of the recommended literature.

Fail grade:
- lack of activity during classes;
- unacceptable substantive value of the paper or research project;
- lack of ability to lead discussions and draw conclusions;
- absence from more than 3/5 of the total number of classes;
- failure to use the recommended literature.

TOTAL WORKLOAD REQUIRED FOR A DOCTORAL STUDENT TO ACHIEVE THE SET OBJECTIVES IN TERMS OF HOURS AND ECTS POINTS

Form of activity	Average number of hours to complete the activity
Hours spent in direct contact resulting from from the study programme	**15**
Other with teacher participation (participation in consultations, examinations)	**1**
Hours completed independently by the doctoral student (preparation for classes, examinations, writing papers, etc.)	**44**
TOTAL HOURS	**60**
TOTAL NUMBER OF ECTS POINTS *	**2**

LITERATURE

Basic literature:	Chemistry in living systems. *Nat. Chem. Biol.*, 2005, 1, 13-21. https://doi.org/10.1038/nchembio0605-13 From Mechanism to Mouse - A Tale of Two Bioorthogonal Reactions. *Acc. Chem. Res.*, 2011, 44, 666-676. https://doi.org/10.1021/ar200148z

	Coordinating bioorthogonal reactions with two tumor-microenvironment-responsive nanovehicles for spatiotemporally controlled prodrug activation. *Chem. Sci.*, 2020, 11, 2155. https://doi.org/10.1039/C9SC05036A Artificial Chemical Reporter Targeting Strategy Using Bioorthogonal Click Reaction for Improving Active-Targeting. *Mol. Pharmaceutics*, 2017, 14, 1558-1570. https://doi.org/10.1021/acs.molpharmaceut.6b01083 Nanoparticles and bioorthogonal chemistry joining forces for improved biomedical application. *Nanoscale Adv.*, 2021, 3, 1261-1292. https://doi.org/10.1039/D0NA00873G Applications of nanomaterials in tissue engineering. *RSC Adv.*, 2021, 11, 19041-19058. DOI: 10.1039/d1ra01849c Is Graphene Shortening the Path toward Spinal Cord Regeneration? *ACS Nano*, 2022, 16, 13430–13467. https://doi.org/10.1021/acsnano.2c04756 Nanomaterials and nanomaterials-based drug delivery to promote cutaneous wound healing. *Advanced Drug Delivery Reviews*, 2023, 193, 114670. https://doi.org/10.1016/j.addr.2022.114670 Wound management materials and technologies from bench to bedside and beyond. *Nature Reviews Materials*, 2024, 9, 550-566. https://doi.org/10.1038/s41578-024-00693-y Magnetic Nanoparticle-Mediated Heating for Biomedical Applications. *Journal of Heat Transfer*, 2022, 144, 030801. DOI: 10.1115/1.4053007 2D Nanomaterials and Their Drug Conjugates for Phototherapy and Magnetic Hyperthermia Therapy of Cancer and Infections. *Small* 2024, 20, 2306137. DOI: 10.1002/smll.202306137 Triggering antitumoural drug release and gene expression by magnetic hyperthermia. *Advanced Drug Delivery Reviews* 138 (2019) 325–342. https://doi.org/10.1016/j.addr.2018.10.004 Hyperthermia and protein homeostasis: Cytoprotection and cell death. *Journal of Thermal Biology* 91 (2020) 102615. https://doi.org/10.1016/j.jtherbio.2020.102615 Nanomaterials for Magnetic and Optical Hyperthermia Applications. Editors: Raluca Maria Fratila, Jesús Martínez De La Fuente, Paperback ISBN: 9780128139288, eBook ISBN: 9780128139295. 2018, Elsevier.
Supplementary literature:	A bioorthogonal nanosystem for imaging and in vivo tumor inhibition. *Biomaterials*, 2017, 138, 57-68 - https://doi.org/10.1016/j.biomaterials.2017.05.036 Nano-sized metabolic precursors for heterogeneous tumor-targeting strategy using bioorthogonal click chemistry in vivo. *Biomaterials*, 2017, 148, 1-15. https://doi.org/10.1016/j.biomaterials.2017.09.025 Coordinating bioorthogonal reactions with two tumor-microenvironment-responsive nanovehicles for spatiotemporally controlled prodrug activation. *Chem. Sci.*, 2020, 11, 2155. https://doi.org/10.1039/C9SC05036A Harnessing nanoparticles and bioorthogonal chemistries for improving precision of nuclear medicine. *Biomater. Sci.*, 2025,13, 2297-2319. https://doi.org/10.1039/D4BM01387E Nanosystems-enabled regenerative strategies for spinal cord Injury: Recent advances and future prospects. *Materials & Design*, 2024, 237, 112617. https://doi.org/10.1016/j.matdes.2023.112617

	Nanomaterials in Regenerative Medicine: Advancing the Future of Tissue Engineering. *Regenerative Engineering and Translational Medicine*, 2025, https://doi.org/10.1007/s40883-025-00416-x Electrospinning based biomaterials for biomimetic fabrication, bioactive protein delivery and wound regenerative repair. *Regenerative Biomaterials*, 2025, 12, rbae139. https://doi.org/10.1093/rb/rbae139 Mechano-Activated Cell Therapy for Accelerated Diabetic Wound Healing. *Adv. Mater.*, 2023, 35, 2304638. DOI: 10.1002/adma.202304638 Membrane-localized magnetic hyperthermia promotes intracellular delivery of cell-impermeant probes. *Nanoscale*, 2024, 16, 15176, https://doi.org/10.1039/d4nr01955e Heat up, silence on: IDO1 gene silencing in THP-1-derived dendritic cells triggered by magnetic hyperthermia. *Cancer Immunology, Immunotherapy* 2025 74:292, https://doi.org/10.1007/s00262-025-04148-3 Nanoparticle-Based Photothermal Therapy for Breast Cancer Noninvasive Treatment, *Adv. Mater*. 2025, 37, 2305140, DOI: 10.1002/adma.202305140 Magnetic–Plasmonic Nanoscale Liposomes with Tunable Optical and Magnetic Properties for Combined Multimodal Imaging and Drug Delivery, *ACS Appl. Nano Mater*. 2024, 7, 3668−3678, https://doi.org/10.1021/acsanm.3c05100 Combining Photothermal-Photodynamic Therapy Mediated by Nanomaterials with Immune Checkpoint Blockade for Metastatic Cancer Treatment and Creation of Immune Memory, *Adv. Funct. Mater*. 2021, 31, 2010777, https://doi.org/10.1002/adfm.202010777

(1 ECTS** POINT CORRESPONDS TO **25–30** HOURS OF TOTAL WORK REQUIRED OF A DOCTORAL STUDENT TO ACHIEVE THE INTENDED LEARNING OUTCOMES)*

.....Raluca M- Fratila, 21.11.2025.....
Date and signature of the course lecturer

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Approval of the Head of the Unit or authorised person