Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Photopharmacology	
Course name in Polish:	Fotofarmakologia	
Number of hours:	30	
Type of course:	Elective course	
Form of course:	lecture	
Code of course:		
Course leader:	Dr. Inz. Marco Deiana	
Faculty of the course leader:	W3 Faculty of Chemistry	
Email address of the course leader:	m.deiana@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, electrical engineering and space technologies	☐
	Information and communication technology	☐
	Biomedical engineering	☒
	Chemical engineering	☒
	Civil engineering, geodesy and transport	☐
	Materials engineering	☒
	Mechanical engineering	☐
	Environmental engineering, mining, and energy	☐
	Mathematics	☐
	Chemical sciences	☒
	Physical sciences	☒
	Management and quality studies	☐

2. Objectives

O1. Provide students with a strong understanding of the fundamental principles of photochemistry and photophysics as they pertain to photopharmacology.

O2. Equip students with the skills to analyze light-induced drug activation mechanisms, utilize key optical tools (light sources, spectroscopy, microscopy), and design and optimize photoresponsive compounds.

O3. Demonstrate how photopharmacology can be applied to medical fields such as oncology, neurology, and infectious diseases, and enable students to critically assess its advantages and limitations compared to traditional approaches.

O4. Facilitate the evaluation of current challenges—such as tissue penetration, side effects, and regulatory considerations—and promote multidisciplinary strategies that integrate photopharmacology with emerging technologies.
O5. Develop students' abilities in literature analysis, scientific communication, and the presentation of original research findings.

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes
1	**Introduction to Photopharmacology** ● Definition, history, and scope ● Key principles: light-responsive molecules, photochemical switches, photoisomerization ● Overview of light's interaction with biological matter	2	lecture
2	**Fundamentals of Photochemistry and Photophysics** ● Processes to characterize molecular switches' states: absorption and NMR ● Jablonski diagrams and excited state dynamics ● Importance of wavelength, intensity, and photostability ● Kinetics of isomerization ● Photoisomerization quantum yields	2	lecture
3	**Photopharmacological Mechanisms** ● Mechanistic categories: phototriggered release, photoregulation, photoconversion ● Common photochemical reactions in drug design (e.g., cis-trans isomerization, cycloreversions) ● Advantages of light-mediated drug action over traditional pharmacology	2	lecture
4	**Light-Sensitive Molecules and Photoresponsive Groups** ● Azobenzenes, spiropyrans, diarylethenes ● Design principles for photoresponsive molecules ● Properties and criteria for selection: photostability, reversibility, response wavelength	2	lecture
5	**Delivery Strategies in Photopharmacology** ● Methods for delivering light-sensitive compounds to biological targets	2	lecture

	● Photoactivatable prodrugs and drug delivery systems ● Challenges in site-specific activation		
6	**Optical Tools and Techniques** ● Light sources: lasers, LEDs, and their application in photopharmacology ● Microscopy methods for visualizing photoreactions (e.g., confocal, two-photon) ● Techniques for quantifying photopharmacological effects	2	lecture
7	**Case Studies: Light-Activated Anticancer Agents** ● Examples of photoactivated drugs and therapeutic agents ● Mechanistic insights from recent studies ● Challenges in developing clinically relevant photopharmacological agents	2	lecture
8	**Photopharmacology in Neurology** ● Light-activated modulation of neural pathways ● Optopharmacology: combining optogenetics and photopharmacology ● Case studies in neural receptor targeting	2	lecture
9	**Photopharmacology in Infectious Diseases** ● Using light to control antimicrobial agents ● Development of photoresponsive antibiotics ● Overcoming antibiotic resistance with light-regulated approaches	2	lecture
10	**Phototherapy and Photodynamic Therapy (PDT)** ● Concepts and mechanisms of PDT ● Comparison with photopharmacological approaches ● Synergies and differences in therapeutic applications	2	lecture
11	**Combining Photopharmacology with Other Modalities** ● Coupling light-triggered drugs with nanotechnology ● Photoresponsive nanoparticles and liposomes ● Integration with imaging techniques for theranostics	2	lecture
12	**Challenges and Current Limitations** ● Stability, tissue penetration, and side effects ● Toxicological and pharmacokinetic considerations	2	lecture

	● Regulatory and practical hurdles in drug development		
13	**Advances and Cutting-Edge Research** ● Emerging photoresponsive compounds ● Novel activation strategies (e.g., NIR-responsive molecules) ● Recent breakthroughs in clinical translation	2	lecture
14	**Photopharmacology in the Clinic** ● Case studies of clinical trials and real-world applications ● Success stories and lessons learned ● Future directions in therapeutic photoregulation ● Reviewing key concepts and synthesizing knowledge	2	lecture
15	**Student Seminar & Discussion Session** ● Short student presentations on literature-selected photopharmacology.	2	lecture

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

1. Basic Organic Chemistry
2. General Physical Chemistry
3. Spectroscopy Fundamentals

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	Learning outcome	
	KNOWLEDGE. Doctoral student knows and understands:	
SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☒
SzD_W4	research methodology;	☒
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☐
SzD_W6	the fundamental dilemmas of modern civilization;	☐
SzD_W7	the legal and ethical conditions of scientific activity;	☐
SzD_W8	the economic and other relevant conditions of scientific activity;	☐
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☐

	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☐
SzD_U4	disseminate research results, including in popular forms;	☐
SzD_U5	initiate debates and participate in a scientific discourse;	☒
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☐
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☐
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☐
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☐
	SOCIAL COMPETENCES. Doctoral student is ready to:	
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☐
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☐

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Oral presentation on a selected topic

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

• Blackboard lectures • Multimedia presentations • Group discussions • Quantitative problem-solving sessions • Individual student work and critical literature analysis

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

Primary and Secondary Literature

1. Mahavir Chhajed and Sumeet Dwivedi. Title: PHOTOPHARMACOLOGY: Design & Applications
2. Molecular Photoswitches: Chemistry, Properties, and Applications

Current scientific articles related to the subjects (examples):

1. J. Am. Chem. Soc. 2014, 136, 6, 2178–2191
2. Angew. Chem. Int. Ed. 2016, 55, 10978–10999
3. Angew. Chem. Int. Ed. 2023, 62, e202300681
4. Chem. Soc. Rev., 2021,50, 12377–12449
5. Chem. Rev. 2018, 118, 21, 10710–10747
6. Nat. Rev. Chem. 2021, 5, 816–834
7. Nat. Rev. Clin. Oncol. 2020, 17, 657–674

9. Other remarks

Additional remarks, comments, (e.g., language of the course)

This specialized course focuses on the principles and applications of photopharmacological switches and light-activated molecules. Students will explore the mechanisms of photochemical control over molecular function, with an emphasis on photochromic switches, photocages, and reversible light-responsive compounds. Key topics include cis-trans isomerization, photocleavage reactions, and the rational design of photoactivatable molecules that enable precise spatial and temporal control of biological processes.

The course highlights state-of-the-art approaches in photopharmacology, from photoactivated drug delivery systems and controlled release strategies to photoreversible binding agents and light-triggered enzymatic modulation. In addition, students will gain hands-on insight into how photochemical tools can be used to regulate complex biological pathways, modulate receptor activity, and develop novel therapeutic strategies.

By the end of the course, participants will have a deep understanding of photopharmacological switches, their design and optimization, and their implementation in cutting-edge research.