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EUROPEAN UNIVERSITY FOR CUSTOMISED EDUCATION

STUDY GUIDE

THERANOSTICS AND NANOMEDICINE

Organised by

Università di Catania

Co-funded by the Erasmus+ Programme of the European Union

1. IDENTIFYING DATA.	
· **Course Name.**	*Theranostics and Nanomedicine*
· **Coordinating University.**	*University of Catania*
· **Partner Universities Involved.**	*University of Mons, Poznan University of Technology*
· **Course Field(s).**	*Physical Chemistry, Biophysics*
· **Related Study Programme.**	*Master of Science in Chemical Sciences (MSc in Chemical Sciences), LM54*
· **ISCED Code.**	*0531 Chemistry*
· **SDG.**	*SDG Goal 3: Good health and well-being* *SDG Goal 4: Quality education* *SDG Goal 9: Industry, innovation and infrastructure*
· **Study Level.**	*2nd*

· **Number of ECTS credits allocated.**	*6*
· **Mode of Delivery.**	*Online (only intended for EUNICE)*
· **Language of Instruction.**	*English*
· **Course Dates.**	*from 01/10/2024 to 18/01/2025*
· **Schedule of the course.**	*First semester*
· **Key Words.**	*Physical Chemistry of Biological Systems and Interfaces; Biomaterials; Tissue Engineering; Wound healing; Drug delivery; Photothermal and Photodynamic Cancer therapy; Antifouling and Antibacterial Surfaces; Hydrogels; Biointerfaces; Smart Surfaces; Nanozymes*
· **Catchy Phrase.**	*Biomimicry in nanotechnology towards personalized medicine.*

· **Prerequisites and co-requisites.**	*Basic mathematics, basic physics, general chemistry, biochemistry, physical chemistry*
· **Number of EUNICE students that can attend the Course.**	*unrestricted number*
· **Course inscription procedure(s).**	----

2. CONTACT DETAILS.

· **Department.**	*Department of Chemical Sciences*
· **Name of Lecturer.**	*Cristina Satriano*
· **E-mail.**	*cristina.satriano@unict.it*
· **Other Lecturers.**	-----

3. COURSE CONTENT.

1. Definition of nanomedicine and theranostics.
2. Various types of interactions at the nano-biointerfaces.
3. Thermodynamic and kinetic aspects of the biomolecule-biomaterial interface.
4. The role of water at biointerfaces.
5. Biomimetic and bioinspired systems.
6. The influence of mechanical, physical and chemical properties of surfaces on cellular processes
7. Smart systems that respond to chemical, physical and/or biological stimuli.

4. LEARNING OUTCOMES.

The course aims to provide insights into the chemical and physical concepts already covered in other disciplines of the B.D. and M.D. courses, such as physics of biological systems, chemistry, organic chemistry, biochemistry. The course contents relate to the basic principles and properties of surfaces, especially the solid-liquid interface, and of nano-biointerfaces. In reference to the so-called Dublin Descriptors, this course helps to acquire the following transversal skills:

Knowledge and understanding: getting to know the essential characteristics of biointerfaces and be able to solve, both qualitatively and quantitatively, simple problems about the biomolecule-material interaction.

Applying knowledge and understanding: application of the acquired theoretical knowledge for the comparison of experimental results with those of calculation, relative to case studies of biointerfaces between cells and the extracellular matrix (ECM) and between cells, ECM and medical devices.

Making judgments: gathering and interpreting relevant data, critical reasoning skills, ability to identify the predictions of a theory or a model.

Communication skills: ability to describe a scientific topic in oral form, with properties of language and terminological rigor, explaining the reasons and results. Learning skills: to have developed the necessary skills to undertake subsequent studies with a high degree of autonomy.

5. OBJECTIVES.

Specific educational objectives of the course*: to provide the necessary tools for understanding the various types of interactions that occur at the nano-biointerfaces, including that between cells and tissues and their natural or artificial surroundings, thermodynamic and kinetic aspects of the*

biomolecule-biomaterial interface, with insights into the fundamental role of water at biointerfaces, biomimetic and bioinspired systems (e.g., supported lipid bilayers, nanozymes). Another educational objective of the course is to explain how cellular processes such as adhesion, differentiation and proliferation can be influenced by mechanical (viscoelasticity), physical (topography) and chemical (surface free energy, composition and structure) properties of surfaces and how these can be modulated, particularly at the nanoscale, to obtain 'smart' systems that respond to environmental conditions (chemical, physical and/or biological stimulus) for application in nanomedicine and theranostics (therapy + diagnosis/imaging). In the laboratory part, the student will become aware not only of the fundamental role played by this discipline in different scientific-technological fields (drug transport and delivery, sensing, imaging, theranostics), but will also acquire acquaintance with chemical synthesis processes of colloidal systems currently in use in nanomedicine and theranostics.

6. COURSE ORGANISATION.

UNITS

1.	*Physical chemistry of nano-biointerfaces. Introduction to the biointerface concept. Definition and properties (in air and water) of the surface.*
2.	*Biomaterials. Preparation of biomaterials and biomedical prostheses and physico- chemical characterization of their surface properties. External body reaction and implant encapsulation. Biosensors. Bioelectronics. Tissue engineering. Nanomedicine and theranostics.*
3.	*Theoretical and application aspects of biointerfaces. Nanoscale biointerfaces. Cell- biological environment interactions. Cell-cell and cell-extracellular matrix (ECM) interactions. Protein-solid-surface interactions.*
4.	*Role of water in surface adsorption. The Goldilocks surface. Surface concentration, kinetics, conformation, effect on cell behavior.*
5.	*Case studies of self-organizing biomolecular systems: the supported lipid bilayer (SLB).*
6.	*Nanozymes and the concept of multimodal platforms.*
7.	*Examples of characterization of biological surfaces and interfaces. Comparison of acoustic (quartz crystal microbalance with dissipation monitoring, QCM-D), optical (surface plasmon resonance, SPR; optical waveguide spectroscopy, OWLS) and microscopic (atomic force microscopy, AFM; laser scanning confocal microscopy, LSM) techniques.*
8	*Laboratory exercises on model biointerface systems of interest in drug delivery, biosensors and imaging. (on-site)*

LEARNING RESOURCES AND TOOLS.

Lectures will be delivered by using slides prepared by the teacher.

PLANNED LEARNING ACTIVITIES AND TEACHING METHODS.

Learning activities are in the form of lectures on the different topics. Seminars could be also delivered. Frontal lessons delivered in the classroom with the aid of the blackboard and suitable projection of

slides (3 ECTS). Classroom solution of problems and answers to exercises relevant to the main topics of the course (1 ECTS). Laboratory experiences (2 ECTS). The results of each laboratory experience must be accurately reported by each student in their laboratory notebook. The aim of the writing of this notebook is a self-assessment by the student of the degree of understanding of the experimental activities and the ability to describe them in a scientific and reproducible way.
Should teaching be carried out in mixed mode or remotely, it may be necessary to introduce changes with respect to previous statements, in line with the programme planned and outlined in the syllabus.

7. ASSESSMENT METHODS, CRITERIA AND PERIOD.

Oral test. Delivery of written reports related to the exercises conducted in the laboratory.

OBSERVATIONS.

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8. BIBLIOGRAPHY AND TEACHING MATERIALS.

Handouts and lecture slides provided by the teacher.

1. Physical chemistry for the life sciences. 2nd ed. By Atkins, P. W.; De Paula, J.; Ed. W.H. Freeman and Co., Oxford University Press: New York; Oxford, 2011; p xxvi, 590 p.
2. W. Pauli - Physical Chemistry in the Service of Medicine - Wiley &Sons
3. Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology - John Wiley & Sons
4. H. Ohshima - Biophysical Chemistry of Biointerfaces - Wiley
5. B.D. Ratner, A.S. Hoffman - BIOMATERIALS SCIENCE: An Introduction to Materials in Medicine - Elsevier
6. NANOMATERIALS INTERFACES IN BIOLOGY - METHODS AND PROTOCOLS, Editors: Bergese, Paolo, Hamad-Schifferli, Kimberly (Eds.) SPRINGER