Nanomedicina i Biomaterials 2012/2013

Code: 42266
ECTS Credits: 6

Degree	Syllabus	Type	Year	Semester
4313132 Nanotecnologia i Ciència de Materials / Nanotechnology and Materials Science	1096 Nanotecnologia i Ciència de Materials / Nanotechnology and Materials Science	P	1	0

Contact

Name: Anna Laromaine Sague
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Use of languages

Principal working language: anglès (eng)

Teachers

Name	???descripcio???
Anna Lopez Periago	ICMAB
Anna Roig Serra	ICMAB
Jaume Veciana Miró	ICMAB
Laura Garcia Carrascosa	CIN2
Nora Ventosa	ICMAB
Santi Sala	ICMAB
Silvia Lope	UAB
Victor Franco Puntes	ICN

Prerequisites

No prerequisites.

Objectives and Contextualisation

The objective of this course is to give a broad overview of how nanotechnology is impacting medicine and biomaterials. Brief basic concepts in nanomedicine and biomaterials will be detailed at the beginning of the course. Following the introduction, the course is divided in four main sections: Nanotoxicology, Drug delivery, Imaging and Tissue Engineering.

Finally information of research clusters and facilities around UAB will be facilitated.

Skills

- Analyse the research results to obtain new products or processes evaluating their industrial and commercial viability for transfer to society.

- Apply the principal physical and chemical methods of preparation and synthesis of materials and nanomaterials
- Demonstrate a mastery of scientific technology and develop skills for arguing the research results in the context of scientific production to understand and interact effectively with other professionals.
- Demonstrate knowledge of the basic structure of materials, nanomaterials and their properties
- Possess and comprehend knowledge that offers the basis and opportunity to be original in the development and/or application of ideas, frequently in a research context
- Students must be capable of integrating knowledge and dealing with the complexity of formulating judgements on the basis of incomplete or limited information, including considerations of the social and ethical responsibilities associated to the application of their knowledge or judgements
- Students must possess learning abilities to enable them to continue studying in a way that will to a large extent have to be self-managed and autonomous
- Students should know how to apply the knowledge acquired and their capacity for resolution to problems in new or little known environments in broader (or multidisciplinary) contexts related with their field of study

Learning outcomes

1. Analyse the differences among different systems of liberation of drugs
2. Analyse the research results to obtain new products or processes evaluating their industrial and commercial viability for transfer to society.
3. Define the concepts of biocompatibility and toxicity of nanomaterials
4. Demonstrate a mastery of scientific technology and develop skills for arguing the research results in the context of scientific production to understand and interact effectively with other professionals.
5. Describe how to carry out bioconjugation and what it is for
6. Describe the concept of biomineralisation and the role of the different components in play
7. Describe the different types of sensors for medical diagnoses based on nanotechnology and analyse their action mechanism
8. Describe the methods used for encapsulation of drugs
9. Describe the most important characteristics for designing materials for tissue regeneration
10. Describe the principles of tissue engineering
11. Describe the techniques for obtaining biosensors with the best results using nanomaterials and nanoelements
12. Describe the typologies of biomaterials on the basis of their composition, structure and function.
13. Interpret the role of the different types of nanoparticles in medical analysis
14. Possess and comprehend knowledge that offers the basis and opportunity to be original in the development and/or application of ideas, frequently in a research context
15. Recognise the role of the particle size in bioavailability
16. Students must be capable of integrating knowledge and dealing with the complexity of formulating judgements on the basis of incomplete or limited information, including considerations of the social and ethical responsibilities associated to the application of their knowledge or judgements
17. Students must possess learning abilities to enable them to continue studying in a way that will to a large extent have to be self-managed and autonomous
18. Students should know how to apply the knowledge acquired and their capacity for resolution to problems in new or little known environments in broader (or multidisciplinary) contexts related with their field of study

Content

1. Concepts and Generalities in Nanomedicine and Biomaterials:

A general section which will give to the students the basic concepts and methodologies used in Nanomedicine and Biomaterials.

a) Biological modification of surfaces, concepts: Laura Carrascosa - 2h

Biological elements of interest in Nanomedicine: DNA, RNA, proteins (antibodies), virus, bacterias and cells .Immobilization of biological elements for the development of novel biomaterials and nanomedicine tools

b) Preparation of materials for nanomedicine and biomaterials: Nora Ventosa - 2h

In order to achieve optimal performance of nanomedicines, a tight control over their structural characteristics at micro, nano, and supramolecular scale is required. Concepts related to bottom-up and top-down strategies most commonly followed for the preparation of nanomedicines and biomaterials with defined structural characteristics will be presented. Special emphasis will be given to the scalability and regulatory aspects of the preparation procedures.

Preparation of materials using Biology: Neus Ferrer Miralles 2h

Nanomaterials produced in biological systems. Advantages and disadvantages over chemical synthesis. Natural andgenetically modified materials. Recombinant proteins as biopharmaceuticals. Eukaryotic and prokaryotic protein expression systems. Cellular inclusions: biolopymers, polymeric nanoparticles, magnetosomes and self assembling proteins.

c) Characterization of materials in nanomedicine: Victor Puntes- 2h

The biological matrix is complex and tracing how nanomaterials evolve in it is key. Characterization fisico-chemical of materials involving techniques as photonic and magnetic probes or mass spectroscopy, and functional characterization describing *in vitro* , in vivo and clinical tests. Concepts described will be inorganic signatures of nanomaterials and nanokinetics in biological systems.

2. Nanotoxicology Victor Puntes 4h

Does the nanoform of a substance entail an increased toxicity? How the biological activity of nanometarials may become dangerous? How nanomaterials can act as pro-toxins? Which is the balance between intended -primary- and undesirable -side- effects of nanomaterials in medicine? These questions will be addressed in the context of intended and unintended use of nanomaterials.

Drug delivery

Micro and nanostructured materials for drug delivery : Jaume Veciana 2h

A general overview of the main micro- and nanostructured materials used for passive and active drug delivery will be presented. Special emphasis will be given to conjugation of Active Pharmaceutical Ingredients (APIs) to "smart" nanocarriers, which are stimulus sensitive nanocarriers, and to the integration of molecules that bind to over-expressed antigens or receptors on the target cells in structured materials, as a successful strategy for achieving active nanomedicines.

- Case study: Nanocarriers as an emerging platform for cancer therapy: Nora Ventosa 2h

Cancer remains one of the world's most devastating diseases; with more than 10 million new cases every year. However, mortality has decreased in the past two years owing to better understanding of tumors biology and improved diagnostic devices and treatments. Using cancer as a model disease, in this session will be reviewed the recent achievements in the design and synthesis of nanocarriers and molecules that can selectively target tumours. The challenges in translating some of the basic research to the clinic will be highlighted.

Gene therapy: Esther Vazquez 2h

Definition of gene therapy. Different strategies for the transport of nucleic acids. Nucleic acid binding. Specific entrance into the cell. Endosomal escape. Intracellular trafficking. Transport into the nucleus. Factors to consider in designing a vehicle for gene therapy. Case Study: Design of a protein nanoparticle directed to metastatic cells in colorectal cancer.

4. Biosensors for Diagnostic

From Macro-micro to nanosensing devices in nanomedicine- Laura Carrascosa 4h

Introduction to Biosensors: Biosensors in nanomedicine. The biosensing principle.Types of biosensors. Nanotechnology to generate novel transduction systems. Nanotechnology to multiplex the analysis. Nanodeposition systems, nano-in-situ immobilization and nano-scaled biosensing arrays platforms

From Microsensors to nano-sensors: Nanotechnology to increase sensitivity. Strategies of signal amplification Nanotechnology to decrease sample requirements: nanochannels and nanopores to detect molecules in confined spaces, single-molecule detection methods

Lab-on-a-chip and point-of care devices: What is point of care; What is lab-on-a-chip and how to achieve it; Miniaturization;Towards biosensing inside the body and inside the cell

Case study and visit to the Nanobiosensors and Bioanalytical applications group lab at CIN2 research center: Laura Carrascosa (2h)

Students will have the opportunity to see several biosensing platforms and how they work to develop applications devoted to nanomedicine. They will also perform a practical case of label-free detection of a DNA sequence using a biosensor.

5. Tissue Engineering 4h

Biomaterials for Tissue Engineering Ana Lopez

The objective of this course is to provide an insight into the area of biomaterials and tissue engineering. It will be show the importance of the preparation of these materials in the nanoscale.

This course will include the study of the chemical nature of the biomaterials, from inorganic to organic, as well as polymeric materials. Thus, it will be show an introduction to biomineralization, bioceramics and bone generation, giving examples such as generation of nano-hydroxyapatite.

From the point of view of polymeric biomaterials, it will be study the chemical composition and function of synthetic biodegradable and no-biodegradable polymers.

Regarding the development in biomaterials, special attention will be focus on *Tissue engineering*, where it will be explained the direct use of a material within a biological system. It will be describe the need and general aspects of the topic. It will include the study of the biomaterials used for tissue engineering (natural and artificial). Introduction to the term *scaffold,* properties and characteristics of scaffolds andprinciples of scaffold design, scaffold architecture, and techniques of fabrication.

- Case study and visit tothe*Biomaterial Processing and Nanostructuring Unit* of CIBER-BBN at the ICMAB of CSIC: Santi Sala (2h)

A practical example of preparation of nanomedicines using compressed fluids will be presented. Equipment for processing of materials using compressed fluids is in the techniques portfolio of this instrumentation platform unit.

6. Imaging

Magnetic nanoparticles as contrast agents and cell tracking:Anna Roig 3h

Fundamentals to diagnostics imaging modalities (Positron Emission Tomography, Computed Tomography, Magnetic Resonance Imaging, Optical Imaging, Ultrasounds). Basic working principles and comparision of the medical imaging modalities

Nanomaterials as contrast agents and multimodal imaging probes

Facilities at the UAB and CIBER BBN platforms forNanomedicine and Biomaterials: 2h Silvia Lope

Visit to the NMR facility at the UAB. Basic magnetic resonance imaging (MRI) concepts for detection of MRI contrast agents will be explained and images of a prepared phantom composed of contrast agents at different concentrations will be obtained in a Bruker BioSpec 7 tesla MR scanner.

Case Study MRI and visit to MRI facility: Silvia Lope 2h

7.**Nanomedicine and Biomaterials conclusions.** 1h

Nanoparticles in translational medicine; diagnosis, therapy and biological barriers**.**

Antonio Villaverde

Types and chemical nature of nanoparticles of biomedical value. Applications in diagnosis and imaging. Therapeutic potential in drug delivery. Pharmacokinetics, biodistribution, clearance and biological barriers. Toxicology concerns at organic and environmental levels.

Methodology

- Lectures of each topic by the professors assigned.

- Practical classes at the laboratories.

- Projects and readings to be conducted individually or in group.

- Oral presentation of a research paper and the projects.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Lectures	37.5	1.5	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16
Type: Supervised			
Preparation lectures	7.5	0.3	2, 4, 14, 16, 18
Type: Autonomous			
Preparation lectures and study	103	4.12	14, 16, 17, 18

Evaluation

40% Oral exposition of a research paper for 8 min following of 2 min of questions by the evaluation panel.

Research paper: Each student will chose a paper from the list provided the first day of class. The paper can´t be repeated. The selection of the paper must be communicated to the coordinator, and she will confirm it to the student.

Evaluation panel: Professors of the block. Professors will evaluate the presentation skills, understanding of the topic and the questions answered.

It is not necessary to provide any written work.

40% Multiple choice exam.

It will consist of 16 questions about general concepts of the subject. Each question correctly answered contributes (0.625 points) to the final mark. Each unanswered or incorrect question will penalize with (0.2 points).

20% Class participation.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Class participation	20%	0	0	2, 4, 14, 16, 17, 18
Exam	40%	1	0.04	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16
Oral presentation of a research paper	40%	1	0.04	2, 4, 14, 16, 17, 18

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