Universidad Zaragoza

Academic Year/course: 2021/22

69713 - Nano-therapy

Syllabus Information

Academic Year: 2021/22
Subject: 69713 - Nano-therapy
Faculty / School: 110 - Escuela de Ingeniería y Arquitectura
Degree: 633 -
ECTS: 3.0
Year: 2 and 1
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

The subject consists of 3 ECTS credits or 75 hours of student work.

The primary objectives are to show the student how nanoscience and nanotechnology are contributing to the development of new therapeutic systems, as well as to the improvement of existing ones. Current examples will be shown on how this Science and the technological equipment derived from it are allowing to improve the quality of patient?s care, allowing the progress towards a personalized healthcare technology, at an affordable cost, offering competitive and high-value products.

From the point of view of therapy, the emergence of localized drug delivery using nanoparticles will first be described as a new therapeutic technique that minimizes the drawbacks of standard therapies by carrying out a historical review of the field. The fundamental concepts to understand the mechanisms of pharmacokinetics and pharmacodynamics will be reviewed. The nanoparticles synthesis and characterization techniques used in the production of localized drug delivery systems will be detailed. The applications of the nanoparticles will be described according to the different physiological administration routes by which drugs can be delivered. It is a subject in which emphasis is placed on the concepts seen in the introductory subject: Nanobiomedicine: Fundamentals and applications.

The syllabus interconnects with the subject of "Design of prostheses and implants" and with "Biomaterials", as well as with "Medical imaging systems" and "Technologies for capturing medical images", since drugs are locally delivered from devices implanted directly in the organism. In the same way, Biomaterials seek bone or tissue regeneration in many of their biomedical applications, and consequently, the localized delivery of drugs is a tool to use (i.e., encapsulating growth factors). It is related to the subject: "Fundamentals of anatomy and cell biology" of which many aspects are necessary to know to understand well the part of Biosensors. In the therapeutic part, the subject "Optical Technologies in Biomedicine" would also be complementary.

These approaches and objectives are aligned with some of the Sustainable Development Goals, SDG, of the 2030 Agenda (https://www.un.org/sustainabledevelopment/es/) and certain specific goals, in such a way that the acquisition of the Learning outcomes of the subject provides training and competence to the student to contribute to a certain extent to their achievement:

- Goal 3: ensure healthy lives and promote well-being for all ages

Target 3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, waterborne diseases, and other communicable diseases.

Target 3.9: By 2030, substantially reduce the number of deaths and illnesses caused by hazardous chemicals and air, water, and soil pollution.

Target 3.d Strengthen the capacity of all countries, particularly developing countries, in early warning, risk reduction, and management of national and global health risks.

- Goal 4: Ensure inclusive, equitable, and quality education and promote lifelong learning opportunities for all

Target 4.4 By 2030, significantly increase the number of young people and adults who have the necessary skills, particularly technical and professional ones, to access employment, decent work, and entrepreneurship.

- Objective 9: Industry, innovation, and infrastructure

Target 9.5 Increase scientific research and improve the technological capacity of industrial sectors in all countries, particularly developing countries, including by fostering innovation and significantly increasing, by 2030, the number of people working in research and development per million inhabitants and the spending of the public and private sectors in research and development.

1.2. Context and importance of this course in the degree

Applications based on Nanoscience represent some of the fastest-growing sectors in the entire pharmaceutical industry. We believe that within the field of Biomedical Engineering the knowledge of some of the Biomedical applications of Nanoscience will be of great impact in the future. This knowledge will allow the student to get to know a new area of ??great growth and impact that can revolutionize classical medicine.

The knowledge acquired in the degree on medical imaging and the fundamentals of anatomy and cell biology, materials in general, and biomaterials, in particular, contribute to facilitating learning.

1.3. Recommendations to take this course

The subjects:

- Nanobiomedicine: Fundamentals and Applications (3 ECTS)
- Nanotherapy (3 ECTS)
- Nanodiagnosis (3 ECTS)

They are sequential subjects and it is recommended to take them in succession if you want to receive an expert and specific vision of the applications of nanostructured materials in the biomedical field. Nanomedicine, as an application of nanotechnology to the development of new diagnostic and therapy systems, as well as to the improvement of existing ones, and has been indicated as a priority in both the strategic agendas of OECD countries and emerging countries, hence its great interest and importance. Its implementation is focused on improving the quality of patient?s care, allowing

progress towards a more personalized healthcare technology, with an affordable cost level, offering competitive products with high added value. These three courses offer a vision of the field as exhaustive as possible in the timelineprovided.

If you simply want to have a global vision of the field of nanobiomedicine without going into detail in knowing how nanomedicine is already a reality that is producing advances in the diagnosis, prevention, and treatment of diseases, it would be enough to take the introductory course: " Nanobiomedicine: Fundamentals and Applications (3 ECTS) "but if you want to get in-depth into the field and carry out laboratory practices related to Biomedical applications, you should take all three subjects. This is one of the specialization subjects that is focused on the use of Nanomaterials in Therapy, specifically in Localized Drug Delivery.

The professors in charge of teaching Nanotherapy belong to the area of ??Chemical Engineering.

The language used in the classes is Spanish (or if there is consensus among students, English).

2. Learning goals

2.1. Competences

After passing the subject, the student will be more competent to ...
Possess and understand the knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context (CB. 6)

The students will know how to apply the knowledge acquired and their ability to solve problems in new or unfamiliar environment within broader (or multidisciplinary) contexts related to their area of ??study (CB.7)

The students will be able to integrate knowledge and face the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments (CB.8)

The students will know how to communicate their conclusions and the knowledge and ultimate reasons that support them to specialized and non-specialized audiences in a clear and unambiguous way (CB.9)

The students will possess the learning skills that will allow them to continue studying in a way that will be largely self-directed or autonomous (CB.10)

The students will possess the aptitudes, skills, and methodology necessary to carry out multidisciplinary research and / or development work in any area of ??Biomedical Engineering (CG.1)

The students will be able to use the engineering techniques, skills, and tools necessary for solving problems in the biomedical and biological fields (CG.2)

They will be able to understand and critically evaluate scientific publications in the field of Biomedical Engineering (CG.3)

They will be able to learn continuously and develop autonomous learning strategies (CG.4)

They will be able to manage and use bibliography, documentation, legislation, databases, software and hardware specific to biomedical engineering (CG.5)

The will be able to analyze, design, and evaluate solutions to problems in the biomedical field through knowledge and advanced technologies of biomechanics, biomaterials, and tissue engineering (CO.3)

2.2. Learning goals

The student, to pass this subject, must demonstrate the following results ...

He/she must be able to develop a scientifically valid report by developing one of the topics described during the course on Materials and Devices currently used in Nanoscience or Nanotechnology specifically in the field of Nanotherapy.

The student, passing this subject, will acquire specific knowledge in the field of Biomedical Applications of Nanoscience, specifically in the field of Nanotherapy, starting from learning to synthesize said nanomaterials, to characterize them, and to apply them in therapy and diagnosis. The requirement in the report requested to pass the subject is such that a merely informative work without scientific value is not admissible.

The student is able to handle the basic terminology of the field of Nanotherapy, understands the concepts, and is able to relate them. He/she has learned to synthesize nanomaterials for applications in Nanotherapy in the laboratory. He/she is able to see in the global context of Biomedical applications the importance and role of Nanotherapy. He/she is able to make public presentations of scientific works and to make critical evaluations on them.

2.3. Importance of learning goals

The student can expand the range of possibilities that his/her training offers after completing the master's by "discovering" the multidisciplinary possibilities that Nanoscience offers in the field of Nanotherapy. As well as being able to apply their training to the Pharmaceutical Industry, Biotechnology, etc.

The importance of the learning outcomes designed for this subject lies in being able to demonstrate basic knowledge in one of the fields with the greatest current projection in the field of Bioengineering, Biomaterials, Personalized Medicine, and Biomedicine.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The student must demonstrate that they have achieved the expected learning outcomes through the following assessment activities:

CONTINUOUS ASSESSMENT

If the student opts for continuous assessment:

A1: Personal work:

The student is able to develop a scientifically valid report by developing a scientific review article on any of the examples or applications described during the course.

The student, passing this subject, acquires a basic knowledge in the field of Biomedical Applications of Nanoscience, as well as more specific learning in Localized Drug Delivery and in that of Biosensors through the elaboration of said revision work. The requirement in the work requested to pass the subject is such that a merely informative work without scientific value is not admissible.

The professor will propose to each of the enrolled students a topic related to the subject of the course and as close as possible to the interests of the student, taking into account their professional tasks or thesis project that they are developing (if applicable).

The work will have to have the structure of a review scientific article with the following structure:

-Title

-Author

-Summary of the work: Without exceeding 250 words, it should be a concise description of the material presented in the work and its implications.

-Introduction: It should be 1 or 2 paragraphs, from 250 to 750 words each defining and introducing the topic of the work.

-Review of the state of the art: There is no limit to the number of words. This section will describe the most recent advances in the field on which this scientific review is being carried out, emphasizing those advances that have given the area a great boost, the directions to follow in this field, and the applications that are foreseen for the next years.

-Conclusions: Summary of the key conclusions obtained from the review. 1 to 2 paragraphs with a total of 250 to 750 words.

-Bibliography: Bibliographic citations that are mentioned in the text.

The student will also publicly present the personal work developed. The public presentation will last approximately 10 min per student.

The student will carry out a laboratory practice that consists of the synthesis of magnetic nanoparticles and their stabilization in organic and aqueous media to potentially be used in therapy (magnetic hyperthermia) or in diagnosis (magnetic sensors or magnetic concentration of analytes)

In addition to the revision work, the student will take an exam that will consist of 10 questions and that will encompass basic concepts of the subjects covered during the course (one of the questions will deal specifically with the practices carried out).

Evaluation criteria:

The revision work will be evaluated from 0 to 10 depending on how the student has described the current state of the art in the chosen topic as well as the quality of his personal vision on said field. It is not a question of making a review mentioning each and every one of the advances in the area, but rather having an overview mentioning those that have had an impact and mentioning which future lines of research and in which lines they will direct the efforts of researchers in the next years. The personal opinion of each student on the topic in question will be specifically assessed. The public presentation held will also be valued.

A2: Exam with theoretical questions:

The exam will be evaluated from 0 to 10 based on the valid answers obtained.

The exam grade will count as 50% of the student's final grade. The mark for the revision work will be 30% of the final mark for the course. Likewise, the presentation and defense of the work will count with a 10% in the final grade. To pass the course, both the work and the theoretical exam must be passed separately with a grade equal to or greater than 5. Student participation and follow-up will be assessed with 10% of the final grade.

If the student fails the theoretical exam but passes the personal work, the latter will be saved until September.

OVERALL EVALUATION

If the student chooses this modality, they will have the right to a global assessment exam. This exam will be evaluated from 0 to 10 and will represent the final grade for the course.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology to be followed in this subject is based on cooperative work between the teacher and the student. Although the classic methodology of teaching lectures will be followed, the active participation of the student will be sought during the learning process, so participation and discussion during the class will be encouraged.

4.2. Learning tasks

The subject has a clear orientation applied to the field of clinical and in vivo therapy. After the theoretical and practical sessions, the student will work individually and apply the knowledge acquired in preparing a monographic work that reflects the most cutting-edge advances, published in the literature, in the field of nanotherapy in the field of a specific application to be designated.

The learning process that has been designed for this subject is based on the following:

A01 Participatory master class (26 hours). Presentation by the teacher of the main contents of the subject. This activity will be carried out in the classroom in person.

A02 The rest of the activities (including tutored work, evaluations, practices, public exhibitions, and personal study) corresponds to 49 hours.

A1 Carrying out a practical application or research work.

The professor will propose to each of the enrolled students a topic related to the subject of the course and as close as possible to the interests of the student, taking into account their professional tasks or thesis project that they are developing (if applicable).

The work will have to have the structure of a review scientific article with the following structure:

-Title

-Author

-Summary of the work: Without exceeding 250 words, it should be a concise description of the material presented in the work and its implications.

-Introduction: They will have to be 1 or 2 paragraphs, from 250 to 750 words each defining and introducing the topic of the work.

-Review of the state of the art: There is no limit to the number of words. This section will describe the most recent advances in the field on which this scientific review is being carried out, emphasizing those advances that have given the area a great boost, the directions to follow in this field, and the applications that are foreseen for the next years.

-Conclusions: Summary of the key conclusions obtained from the said review. 1 to 2 paragraphs with a total of 250 to 750 words.

Bibliography: Bibliographic citations that are mentioned in the text.

The student will publicly expose for 10 min the work developed during it to the rest of the class.

A3: Tutoring. Schedule personalized attention to the student in order to review and discuss the materials and topics presented in the theoretical classes.

A4: Evaluation. Theoretical written tests. The detail is in the section corresponding to the evaluation activities

A5: Practices. The student will carry out a laboratory practice that consists of the synthesis of magnetic nanoparticles and their stabilization in organic and aqueous media to potentially be used in therapy (magnetic hyperthermia) or in diagnosis (magnetic sensors or magnetic concentration of analytes).

4.3. Syllabus

The program offered to the student to help him/her to achieve the expected results comprises the following contents:

Topic 1. Generalities. General applications, localized drug and gene delivery, magnetic or optical hyperthermia, tissue engineering.

Unit 2. History of localized drug delivery. Adsorption and desorption of drugs in nanostructured micro and mesoporous materials and in polymeric matrices. Basic concepts of drug delivery routes (oral or parenteral). Encapsulation or covalent linking of drugs to nanovectors (i.e., dendrimers, dendritic polymers). Nanoparticles functionalization. Evasion of the reticulo-endothelial system. Synthesis of organic materials (micelles, liposomes, dendrimers, etc.) and inorganic (based on silica, titania, etc.). Biomimicry.

Unit 3. Gene therapy. History of gene therapy. Introduction to gene therapy: what it is, what diseases it treats, mechanisms of action, types of nanocarriers used in gene therapy.

Unit 4. Materials used in the localized drug delivery. Applications of organic nanoparticles in localized drug delivery. Dendrimers, dendritic polymers, micelles, liposomes. Polymers that respond to external stimuli: Photosensitive, thermosensitive, pH-dependent polymers, etc. Applications of inorganic nanoparticles in localized drug delivery. Particles composed of micro and mesoporous nanostructured materials. Microcapsules and microspheres. Biodegradable silica gels.

Unit 5: Applications of nanoparticles in theragnostic. The use of different types of nanoparticles as in vivo tracers (MRI, fluorescent tomography, sonoacoustics, etc.) will be introduced. Examples of the use of these materials with the dual purpose of diagnosis and therapy (controlled drug delivery, gene therapy, etc.) also known as theragnostic capacity will also be presented. Emphasis will be placed on the barriers that NPs will have to face according to their administration route and that must be taken into account in order to be able to develop truly effective theragnostic nanosystems.

Unit 6. Selectivity. Localization of the drug where therapy is necessary using active and passive strategies. Passive techniques using the body's natural physiology. Active techniques: localized drug delivery through physical interactions (magnetism, light, ultrasound, etc.) or through biological interactions. Localized drug delivery by conjugation with recognizing or over-expressed biomolecules.

Unit 7. Pharmacokinetics and pharmacodynamics. Analysis of the different toxicological requirements and biocompatibility analysis to go from the synthesis of a drug based on nanoparticles to its

commercialization. Different analytical and instrumental techniques (i.e., isotopic marking) to evaluate the diffusion of the drug conjugated to nanoparticles in the body, evaluation of collateral effects. Description of different drugs used in localized delivery based on nanoparticles and their psychology. Disadvantages of many drugs (hydrophilicity, hydrobobicity, solubility, etc.)

4.4. Course planning and calendar

Calendar of face-to-face sessions and student?s presentations of their work
The start and end dates of the theoretical and problem classes, as well as the dates of the laboratory practices and global assessment tests, will be those set by the School of Engineering and Architecture and published on the master's website (http://www.masterib.es). The delivery dates and monitoring of the tutored practical work will be announced well in advance in class and on the subject's website in moodle, https://moodle.unizar.es/> (or in the Alfresco server of the Master).

The practical sessions will be held in the laboratories of the Aragón Institute of Nanoscience and Materials (INMA) in the R&D Building of the Rio Ebro Campus, Mariano Esquillor S / N street (Floor 1-Block 8). The day and time will be agreed upon between all participants without altering their participation in other subjects. It will be necessary to take the chemical security measures required by the University of Zaragoza, which include: Protective glasses, gown,s and gloves. The student must have their own protective glasses and gown. The student will not be able to carry out the laboratory practice with contact lenses or if they do not have eye protection and a gown.

The subject is taught in the second semester. Among the main activities planned are the presentation of the theoretical contents, the realization of laboratory practices, and the realization of tutored practical work related to the contents of the subject as well as developing public presentations.

The start and end dates of the theoretical classes, as well as the dates of the laboratory practices and the global assessment tests will be those set by the School of Engineering and Architecture and published on the master's website (http: / /www.masterib.es). The delivery dates and monitoring of the tutored practical work will be announced well in advance in class and on the subject's website in moodle, https://moodle.unizar.es/> (or in the Alfresco server of the Master).
The student will carry out a laboratory practice on the synthesis of nanomaterials.

4.5. Bibliography and recommended resources