Universidad Zaragoza

**Academic Year/course: 2021/22**

# 69712 - Nano-biomedicine: Fundamentals and applications

## Syllabus Information

**Academic Year:** 2021/22
**Subject:** 69712 - Nanobiomedicina: Fundamentos y aplicaciones
**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 nanotechnology is contributing to the development of new
diagnostic and therapy systems, as well as the improvement of existing ones. Current examples on how nanoscience and the technological equipment derived from it are making it possible to improve 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. It is also planned as an objective to differentiate those approaches
of Nanotechnology that are applied to Therapy of those that are applied to Diagnosis with special emphasis on the
use of Biosensors.
From the point of view of therapy, the emergence of localized drug delivery will first be described. We will describe how by using nanoparticles as a new therapeutic technique that minimizes the inconveniences of the usual therapies is possible to obtain outstanding improvements.
The fundamental concepts to understand the mechanisms of pharmacokinetics and phrmacodynamics will be reviewed.
The nanoparticles synthesis and characterization techniques used in localized drug delivery will be described. The applications of nanoparticles will be described according to the different physiological administration routes. The strategies and key aspects for the immobilization of the element of recognition in biosensing will be also described. The course program will be divided into two large groups of nanoparticles, organic and inorganic.
The way to deliver nanoparticles will also be divided into two large groups, using active and passive mechanisms. Special emphasis will be placed on the description of the nanoparticles used in therapy and diagnosis.
Magnets as therapeutic instruments (in localized drug delivery and in magnetic hyperthermia) will also be reviewed. We will
describe the future and social, ethical, and environmental implications of these technologies and we will introduce the field of
Nanotoxicology.
Within the diagnostic part, special emphasis will be placed on the development of Biosensors, from their manufacture, the
different types of sensors and transducers as well as different fields of application. The sensors will be compared

based on Nanotechnologies with conventional sensors currently used in the Biological and Medical fields.
The syllabus interconnects with the subject of the Design of prostheses and implants and with Biomaterials, as well as with
medical imaging (Medical Imaging Technologies), since drugs are locally delivered from devices implanted directly in the body. In the same way, Biomaterials search in many of their biomedical applications bone or tissue regeneration, and consequently, localized drug delivery 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.
This subject positions the student in the knowledge of the most advanced tools used today in the biomedical context in the field of clinical and in vivo diagnosis, which is part of the objectives of the Degree
Biomedical Engineering. In addition to internalizing the student in the synthesis of nanomaterials and their biofunctionalization to the development of nanobiosensors, students will also be introduced in the most advanced characterization techniques to research in Nanoscience and Nanobiotechnology (TEM, SEM, XPS, DLS, EDX, SQUID, etc.).

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

The applications based on Nanoscience represent some of the most important breakthroughs for the pharmaceutical industry. We believe that within the field of Biomedical Engineering the knowledge of some of the applications of Nanoscience will have a large projection and impact. This knowledge will allow the student to
get to know a new area of ??rapid development and impact that can revolutionize classical medicine.

The knowledge acquired in the courses on medical imaging and on fundamentals of anatomy and cell biology, on materials in general and biomaterials in particular will help to facilitate 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 timeline provided.

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 deve

The students will know how to apply the knowledge acquired and their ability to solve problems in ne

The students will be able to integrate knowledge and face the complexity of formulating judgments b

The students will know how to communicate their conclusions and the knowledge and ultimate reaso

The students will possess the learning skills that will allow them to continue studying in a way that wi

The students will possess the aptitudes, skills, and methodology necessary to carry out multidisciplina

The students will be able to use the engineering techniques, skills, and tools necessary for solving pro

They will be able to understand and critically evaluate scientific publications in the field of Biomedical

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 ar

The will be able to analyze, design, and evaluate solutions to problems in the biomedical field through

The student is able to develop a scientifically valid report by developing a scientific review article on any of the examples or app

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 nanobiomedicine 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 defend 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

### 4.3. Syllabus

Topic 1. Generalities of Nanoscience, historical review, underlying scientific basis to explain the behavior of nanomaterials. Manipulation of materials at the atomic and molecular scale.
Unit 2. Synthesis and characterization of nanoparticles and nanostructured materials. Physical and chemical methods of synthesis of nanoparticles. Nanomaterial characterization techniques.
Unit 3. Biochemistry applied to Nanomedicine. Basic knowledge of biology (structure and function of biomolecules: DNA probes, enzymes, antibodies, etc.).
Topic 4. Strategies and key aspects for the immobilization of the recognition element. We will discuss the most suitable functionalization methods according to the type of recognition element to be used (acids nucleic acids, enzymes, antibodies, etc.). Other key aspects such as the importance of controlling stoichiometry by controlling the number of attached recognition moieties will also be discussed.
Unit 5. Introduction to the therapeutic and diagnostic applications of Nanobiomedicine.
Topic 6. Future and social, ethical, and environmental implications of these technologies. Nanotoxicology

### 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, gowns, 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

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=69313