Course guide
295706 - MNB - Natural Materials and Biomaterials

Last modified: 02/10/2025

Unit in charge: Barcelona East School of Engineering
Teaching unit: 702 - CEM - Department of Materials Science and Engineering.

Degree: BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: CRISTINA CANAL BARNILS

Others: Primer quadrimestre:
CRISTINA CANAL BARNILS - Grup: M11, Grup: M12
ANNA DÍEZ ESCUDERO - Grup: M11, Grup: M12
MONTSERRAT ESPAÑOL PONS - Grup: M11, Grup: M12
MARIA PAU GINEBRA MOLINS - Grup: M11, Grup: M12
JOSE MARIA MANERO PLANELLA - Grup: M11, Grup: M12

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.

Transversal:
3. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.

TEACHING METHODOLOGY

- Participative lectures
- Invited lectures
- Lab practices
- Online questionnaires
- Cooperative learning: group work

LEARNING OBJECTIVES OF THE SUBJECT

Once this subject is finished, the student must be able to:
- Describe the natural materials, or biological materials , including both the vegetal and animal tissues from the perspective of its composition, structure and properties
- Examine the interest these materials have got from the perspective of optimization and efficiency in the techniques of design and process, the contributions of the biomimetic approach in the design and process of the advanced materials.
- Describe the different types of biomaterials used in medical applications, for the substitution with/or regeneration of tissues, with diagnostic or therapeutic purposes.
- Identify the outstanding characteristics and the interaction mechanisms between the biomaterial and the receptor organism.
- Identify and describe the techniques which allow to evaluate the biocompatibility of materials

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	50,0	33.33
Hours small group	10,0	6.67

Total learning time: 150 h

CONTENTS

Part 1: Natural Materials

Description:
STRUCTURE-PROPERTIES RELATIONSHIP IN NATURAL MATERIALS
Natural materials definition and relevance. Hyerarchic structure. Design and function. Multifunctionality and design optimisation. Biomimetic approach. Nacre and silk.

NATURAL COMPOSITE MATERIALS. BIOLOGICAL PLANT TISSUES: WOOD.
Composition and structure. Wood and water. Physical and mechanical properties of wood. Wood durability.

NATURAL COMPOSITE MATERIALS COMPOSTOS: BIOLOGICAL ANIMAL TISSUES
Cells and extracellular matrix. Classification of animal tissues. Soft tissues: tendons, ligaments and cartilage. Mussles. Blood vessels. Composition, structure and properties. Hard tissues: bone and teeth. Composition, structure and properties.

Specific objectives:
After finishing this part, the student must be able to:
- Describe the compostion, structure and properties of the most important natural materials, specifically of the main plant and animal tissues.
- Identify the benefits of the biomimetic approach in the design of advanced materials.

Related activities:
Attendance to theory classes
Attendance to laboratory classes
Self study

Related competencies :
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.

Full-or-part-time: 40h
Theory classes: 13h
Laboratory classes: 3h
Self study : 24h

Part 2: Biomaterials

Description:
MATERIALS FOR CLINICAL APPLICATIONS
Definition of a biomaterial. Historical perspective. Classification of the different types of biomaterials. Metals as biomaterials: stainless steel, titanium alloys, chobalt-chromium alloys, shape memory alloys. Polymers as biomaterials stable and resorbable polymers. Textile biomaterials. Degradation mechanisms. Bioceramics: inert, bioactive and resorbable ceramics. Calcium phosphates. Composites as biomaterials.

BIOMATERIAL-TISSUE INTERACTIONS
Biological host response to the biomaterial. Biomaterial degradation in the biological environment. Biocompatibility. In vitro and in vivo tests to assess biocompatibility.

Specific objectives:
After finishing this part, the student will be able to:
- Identify the common traits and the distinctive features of the different materials used in clinical applications.
- Describe the basic principles that govern biocompatibility of biomaterials.
- Define the fundamental criteria that a material must meet to be used in medical applications.
- Recognise the biological principles that affect the host-material interactions, and correlate them with the in vivo performance of biomaterials.

Related activities:
Attendance to theory classes
Attendance to laboratory classes
Self study

Related competencies :
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
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Full-or-part-time: 47h 30m
Theory classes: 13h
Laboratory classes: 6h
Self study : 28h 30m

Part 3: Biomaterials Applications

Description:
BIOMATERIALS APPLICATIONS IN IMPLANTS AND BIOMEDICAL DEVICES
Orthopaedic surgery and traumatology applications; Odontology and maxillofacial surgery applications; Digestive surgery applications; Cardiovascular applications; Drug delivary appications; Topical applications. Tissue Engineering applications. Concept of sterility, and methods of sterilisation of biomaterials and medical devices.

Specific objectives:
After finishing this part the student will be able to:
- Recognise and select the most adequate materials for the design of medical devices and implants.

Related activities:
- Attendance to invited talks by medical doctors
- Cooperative work: group project and presentation

Related competencies :
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
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Full-or-part-time: 25h
Theory classes: 10h
Self study : 15h

ACTIVITIES

THEORY CLASSES

Description:
Lectures given by the professors of the subject, with powerpoint presentations and participation of the students.

Specific objectives:
After attending the lectures, the student will be able to identify the main aspects and the most relevant issues of the structure, design and properties of natural materials and biomaterials.

Material:
Power point presentations uploaded in the virtual campus

Delivery:
Lecture attendance
Online or class questionnaires
Exams
Laboratory notebook
Final subject work

Related competencies :
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.

Full-or-part-time: 65h
Self study: 39h
Theory classes: 26h

LABORATORY CLASSES

Description:
The student will carry out exeprimental laboratory classes on the characterisation of animal and plant tissues and on the processing and characterisation of different biomaterials.

Specific objectives:
The student will be able to describe and apply the experimental protocols used for the characterisation of natural materials and for the processing and characterisation of some biomaterials.

Material:
Guidelines of the laboratory classes

Delivery:
Laboratory notebook
Tests (in person or online)

Related competencies :
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.

Full-or-part-time: 13h 30m
Self study: 4h 30m
Practical classes: 9h

INVITED TALKS

Description:
The course includes three invited talks by medical doctors and surgeons on clincal aspects of the application of biomaterials in different medical areas

Specific objectives:
The student will be able to identify the main requirements and the limitations of biomaterials in some specific clinical applications

Material:
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Delivery:
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Related competencies :
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.

Full-or-part-time: 6h
Theory classes: 6h

SUPERVISED GROUP WORK

Description:
The students will perform a work in small groups (3-4 students) on material selection for a specific implant or biomedical device

Specific objectives:
The student will be able to analyse in terms of material selection a specific implant or biomedical device, and to make an oral presentation on the conslusions achieved.

Material:
Guideline for the group work

Delivery:
Power point presentation and oral defence of the work

Related competencies :
CEM2. Knowledge on mechanical, electronic, chemical and biologic behaviour of materials, and capacity to apply this behaviour into design, calculation and modelling of aspects of elements, components and equipment.
CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.

Full-or-part-time: 28h
Self study: 24h
Theory classes: 4h

GRADING SYSTEM

Final mark = 0.40* Final exam + 0.15*partial exam + 0.15*continuous evaluation tests + 0.15* laboratory sessions+ 0.15* group work

EXAMINATION RULES.

- All activities are compulsory
- The tests and continuous evaluation activities will be distributed throughout the course as the different subjects of the course are addressed. There will not be prior notice.
- The group work will be presented orally, with the help of a power point presentation. Evaluation will be performed on the basis of the oral presentation.

BIBLIOGRAPHY

Basic:
- Nordin, Margareta. Basic biomechanics of the musculoskeletal system. 4th ed. Philadelphia: Lippincott Williams & Wilkins, 2012. ISBN 9781451117097.
- Ratner, Buddy D. Biomaterials science : an introduction to materials in medicine. 3rd ed. Amsterdam: Elsevier/Academic Press, 2013. ISBN 9780123746269.
- Meyers, M.A., Chen, P.Y., Lin, Y.M, Seki Y. "Biological materials: structure and mechanical properties". Progress in materials science [on line]. vol 53 (2008), p. 1-206 [Consultation: 05/06/2020]. Available on: http://www.sciencedirect.com/science/journal/00796425.- J. Jeronimidis. "Structure-Property Relationships in Biological Materials; Design and Function of Structural Biological Materials". Elices, Manuel. Structural biological materials : Design and structure-property relationships. Amsterdam: Pergamon, 2000. p. 3-29.
- "Special topic : Wood". Ashby, M. F.; David R. H. Jones. Engineering Materials. Vol. 2. Oxford: Elsevier Butterworth-Heinemann, 2012-2013.

Complementary:
- Black, Jonathan. Biological perfomance of materials : fundamentals of biocompatibility. 4th ed. Boca Raton: Taylor & Francis, 2006.

ISBN 0849339596.
- Dinwoodie, J. M. Timber, its nature and behaviour. 2nd ed. London: E & FN Spon, 2000. ISBN 0419235809.