

## Biomaterials And Tissue Engineering (AB000008)

### 1. language

English

### 2. course contents

Coordinator: Prof. Luigi Ermenegildo Sangaletti

Year Course: 1<sup>st</sup> year

Semester: 2<sup>nd</sup> semester

UFC: 8

Modules and lecturers:

- NANOMATERIALS (AB000071) - 3 CFU - SSD NN - Prof. Luca Gavioli

- PRINCIPLES OF BIOMATERIAL ENGINEERING AND SCAFFOLD DESIGN (AB000074) - 2 CFU – SSD NN – Prof. Gabriela Graziani

- SCIENCE AT THE NANOSCALE: PHYSICS AND CHEMISTRY OF SURFACES (AB000066) - 3 CFU - SSD FIS/03 - Prof. Luigi Ermenegildo Sangaletti

### 3. BIBLIOGRAPHY

Instructor's notes and presentations will be made available after each lecture. The following textbooks are suggested as a reference:

#### <Nanomaterials>

- Modern Vacuum Physics, A. Chambers, Chapman & Hall/Crc (2005) ISBN 0-8493-2438-6  
 Atomic Force Microscopy, Bert Voigtländer, NanoScience and Technology Series, Springer (2019) DOI: <https://doi.org/10.1007/978-3-030-13654-3>  
 Handbook of Sputter Deposition Technology, K. Wasa, I. Kanno, H. Kotera (eds), Elsevier (2012) ISBN: 978-1-4377-3483-6  
 Scanning Electron Microscopy and X-Ray Microanalysis, J.I. Goldstein et al., Springer (2017), <https://doi.org/10.1007/978-1-4939-6676-9>

#### <Principles Of Biomaterial Engineering And Scaffold Design>

- Maria Cristina Tanzi, Silvia Farè, Gabriele Candiani, Foundations of Biomaterials Engineering - 1st Edition, Editore: Academic Press, Anno edizione: 2019, ISBN: 9780081010341  
 BD Ratner, AS Hoffman, FJ Schoen, JE Lemons, Biomaterials Science: An introduction to Materials in Medicine, Editore: Elsevier Academic press, Anno edizione: 2004, ISBN: 0125824637  
 Matthew Treiser, Sascha Abramson, Robert Langer, and Joachim Kohn, DEGRADABLE AND RESORBABLE BIOMATERIALS  
 G. Graziani, et al., Ion-substituted calcium phosphate coatings deposited by plasma-assisted techniques: A review. Materials Science and Engineering: C 74, 2017, 219-229. <https://doi.org/10.1016/j.msec.2016.12.018>.  
 R.A. Surmenev, A review of plasma-assisted methods for calcium phosphate-based coatings fabrication. Surf. Coat. Technol., 206, 2012, 2035-2056. <https://doi.org/10.1016/j.surfcoat.2011.11.002>.  
 E. Boanini, M. Gazzano, A. Bigi, Ionic substitutions in calcium phosphates synthesized at low temperature, Acta Biomater., 6, 2010, 1882-1894. Ionic substitutions in calcium phosphates synthesized at low temperature. <https://doi.org/10.1016/j.actbio.2009.12.041>.  
 G. Borciani et al., Marine biological waste as a source of hydroxyapatite for bone tissue engineering applications, Ceramics International 49, 2023 1572-1584, <https://doi.org/10.1016/j.ceramint.2022.10.341>.  
 A. Tampieri et al. Unconventional, nature-inspired approaches to develop bioceramics for

regenerative medicine, ISBN: 9780128222331; doi: 10.1016/B978-0-12-803581-8.12102-2, in: A. Leriche, F.J. Cambier, eds, Reference Module in Materials Science and Materials Engineering, Technical Ceramics and Glasses, Elsevier (2021).

M. Fosca et al., Ion-Doped Calcium Phosphate-Based Coatings with Antibacterial Properties, *J. Funct. Biomater.* 2023, 14(5), 250; <https://doi.org/10.3390/jfb14050250>.  
J. Will et al., Bioactive glass-based scaffolds for bone tissue engineering, *Advances in biochemical engineering/biotechnology* 126, 2012, 195 – 22. [https://doi.org/10.1007/10\\_2011\\_106](https://doi.org/10.1007/10_2011_106).

#### <Science At The Nanoscale: Physics And Chemistry Of Surfaces>

P. Boisseau, P. Houdy, and M. Lahmani (Eds.) *Nanoscience: Nanobiotechnology and Nanobiology; Part II Methods of Nanobiotechnology*, Springer (2007)  
Jacob N. Israelachvili, *Intermolecular and Surface Forces*, Third Edition, Elsevier (2011)

### 4. LEARNING OBJECTIVES

This course will give the students the possibility to acquire and understand major terms and concepts in order to communicate their ideas, proposals, analysis and critical reasoning in an appropriate way. This course will contribute to empower learners giving them very versatile tools that can be applied to many aspects of bio-nano-technology and stem cell growth. They can also be combined with knowledge from other disciplines to provide more accurate or alternative analysis. In detail the course is expected to provide:

Basic knowledge and understanding of (i) materials the nanoscale, (ii) nanomaterials growth and characterization techniques (iii) surfaces and interfaces and their interaction with the environment (iv) and bio-nano materials and nanostructured scaffolds.

The capability of applying knowledge and understanding to biomaterials and stem cell growth on surfaces and nanostructures scaffolds

The capability of evaluating the suitability of surfaces and nanostructures scaffolds to promote stem cells growth.

Improved communications skills both in terms of oral presentation and writing, using an appropriate and technical language related to the application of nanomaterials, surfaces and stem cells growth.

Increased skills on tackling a problem in stem cells growth exploiting nanostructured scaffolds (including criteria for materials choice in terms of morphology, adhesion properties, biocompatibility).

### 5. prerequisiteS

Bachelor level knowledge of single variable calculus, general chemistry, and classical physics is required.

### 6. TEACHING METHODS

Knowledge and understanding will be fostered by lectures and class discussions. Power point presentation, web access to proper scientific literature (reports, paper, movies and videos) will provide the basic material to start discussion aimed to enable students to focus on selected applications of nanoscience to stem cell growth and evaluate and judge specific scientific cases proposed during lectures. Discussion will foster communication skills with proper use of scientific

and technical terms in English. The lecture materials and their understanding will enable students to autonomously access to further information on the Course topics.

## 7. OTHER INFORMATIONS

### NOTE ON STUDENTS' RESPONSIBILITY

The responsibility for learning falls increasingly on students, as they advance through the course; hence, ultimately, the commitment and the dedication to learn must come from them.

As members of the Università Cattolica S. Cuore learning community, students are expected to respect the intellectual property of course instructors. All course materials presented to students are the copyrighted property of the course instructors and are subject to the following conditions of use:

- 1) Students may not record or reproduce lectures or any other classroom activities, unless differently specified by the instructor; however, they may use the recordings for their own course-related purposes only.
- 2) Students may not reproduce and/or post any course material provided by the instructors online or distribute them without the advance written permission of the course instructor and, if applicable, of any students whose voice or image is included in the recordings.
- 3) Any students violating the conditions described above may face academic disciplinary sanctions. As members of a learning community, students are expected to respect the time and efforts of their fellow classmates. Therefore, the use of social media and other electronic distractions that can disrupt the concentration of other students in the classroom is NOT allowed.

### NOTE ON ACADEMIC INTEGRITY AND CHEATING POLICY

The principles of truth and honesty are fundamental to the educational process and the academic integrity of the University. All students have a right to expect fair and honest evaluation of their work. CHEATING UNDERMINES THIS EXPECTATION AND WILL NOT BE TOLERATED.

Students must avoid the following misconduct behaviors that are considered as cheating:

DO NOT exchange ID badges to collect presence among classmates who cannot attend a lecture.

DO NOT share answers of quizzes during exams.

Any student found by the instructors to be cheating will receive a failing grade for the exam or other graded work and will be reported to the Course's Coordinator and Instructors' Committee. The instructors may, at their discretion, decide to give a failing grade for the course in severe cases of academic dishonesty.

## 8. learning verification methods

The final exam consists of two parts:

- (i) Knowledge and understanding (of basic concepts and applications) will be verified through end-of-module test with multiple answer questions.

- (ii) The capability of making judgments, along with communication and learning skills will be evaluated through the presentation of a selected topic of the course (to be defined with the instructor) with a dedicated discussion.

Grading: test (60%), presentation (40%).

The maximum score can be reached when the student has obtained the maximum from the module test and in case of excellent presentation (clarity, quality of slides, capability to outline the problem and present the basic principles and applications).

## 9. program

### <Nanomaterials>

- 1.1 An introduction to nanoscale materials: Synthetic and natural nanosystems.
- 1.2 Physical methods of nanomaterials synthesis. Introduction to vacuum. Magnetron sputtering. Gas phase deposition.
- 1.3 Measuring nanoscale properties atomic force microscopy (AFM) Scanning electron microscopy (SEM).

### <Principles Of Biomaterial Engineering And Scaffold Design>

- 2.1. Introduction to biomaterials: ceramic, metallic and polymeric biomaterials
- 2.2. Tissue modelling, repair and regeneration: general concepts
- 2.3. Biomimetism and "Nature-inspired" concepts in Biomaterials Design
- 2.4. Bioceramics in tissue engineering: Calcium phosphates and ion-doped apatites as biomaterials for regenerative medicine and tissue modelling. Bioactive glasses and their application for coatings and scaffolds. Biomineralization and bioceramics from natural sources.
- 2.5. Metallic biomaterials in reparative medicine
- 2.6. Natural polymers and their applications in regenerative medicine and tissue modelling.
- 2.7. Synthetic polymers in reparative medicine.
- 2.8. Nanoparticles and Nanostructured coatings for tissue regeneration and drug release
- 2.9. Infection and antibacterial materials. Nanoparticles and nanostructured coatings for drugs/metals release.
- 2.10. An introduction to cells and bacteria interactions with materials, also at the nanoscale: nano- and micro-patterning.

### <Science At The Nanoscale: Physics And Chemistry Of Surfaces>

- 3.1 Introduction to nanoscience. Novel properties driven by dimensionality confinement. Nanoscience @ surfaces. Bio-nanostructures.
- 3.2 The surface structure. Intermolecular and surface forces. Mechanical and thermal properties.
- 3.3 Gas and liquid adsorption on surfaces. Adsorption isotherms. Adhesion and wetting. Surface diffusion.
- 3.4 Special methods for surface investigation. Biosensing.