Syllabus Master's Degree Course in Medicine and Surgery

BIO-ENGINEERING

Second year, first semester (6 academic credits [CFU])

Teachers

Subject	Academic credits (CFU)	Lecturer
Tissue engineering, bioprinting	2	CICALA Gianluca
Scaffolding and organoids	4	FALZONE Luca

Learning outcomes

Subject	Learning outcomes
Tissue engineering, bioprinting	By the end of the course, students are expected to: • Recognize the main classes of materials used for tissue engineering and bioprinting, identifying their structures and properties as required for medical applications. • Understand the basics of the production processes used to manufacture artificial tissues, particularly the bioprinting processes using additive manufacturing approaches.
Scaffolding and organoids	By the end of the course, students are expected to: • Gain an in-depth understanding of the principles and applications of scaffolding in tissue engineering. • Learn about the design and synthesis of biomaterials that support the growth and development of new tissues. • Explore the creation and use of organoids, which are miniature, simplified versions of organs produced in vitro from stem cells. • Enhance their knowledge of cutting-edge techniques in regenerative medicine. • Develop skills to critically analyze and apply these technologies in clinical and research settings. • Foster an innovative mindset essential for advancing healthcare. • Appreciate the ethical considerations and regulatory frameworks associated with advanced medical technologies.

Prerequisites

Subject	Prerequisites
Tissue engineering, bioprinting	The prerequisites are Chemistry and Physics. The course will provide basic knowledge where not present.

Scaffolding and organoids	Attainment of the educational objectives set by prerequisite courses.

Course contents

Subject	Course contents
Tissue engineering, bioprinting	• Tissue Engineering: an engineering perspective. • Materials used in Tissue Engineering: Materials Classification; Cell Interactions with Materials; Biodegradable Polymers, Bioceramics and metals. • Manufacturing approached for Tissue Engineering: Electrospinning; Polymer Extrusion; Ceramics processing. • Bioprinting: Fundamentals of additive manufacturing; Bioplotter structure, Bioplotter market. • Practical Examples: Artificial skin, Replacement of the intervertebral disc, Bone and cartilage reconstruction, Artificial organs by bioprinting. • Laboratory practice: The laboratory practice will be focused on the use of different 3D printers available. The aim of the laboratory practice is to show briefly the potential and limits of these approaches with some hand on experiences focused on 3D scaffold printing.
Scaffolding and organoids	• Introduction to Tissue Engineering: Overview of tissue engineering principles; Historical development and key milestones. • Scaffolding in Tissue Engineering: Definition and significance of scaffolds; Types of scaffolds: natural vs. synthetic; Mechanical and biochemical properties of scaffolds; brief overview on design and synthesis of biomaterials for scaffolding and fabrication techniques (e.g., electrospinning, 3D printing); biodegradability and biocompatibility of scaffolds). • Applications of Scaffolding: Scaffolds in bone and cartilage regeneration; Scaffolds for skin and wound healing; Use of scaffolds in cardiovascular tissue engineering; Scaffolds for neural tissue regeneration. • Introduction to Organoids: Definition and significance of organoids; Historical development and key milestones; Stem cells and their role in organoid formation. • Protocol for the Generation of Organoids: Techniques for deriving organoids from stem cells; Culture conditions and media for organoid growth; Scaling and reproducing organoids for research • Applications of Organoids: Organoids in disease modeling; Drug testing and personalized medicine using organoids; Organoids for studying developmental biology; Potential for organoids in transplantation and regenerative therapies. • Clinical Application of Bioengineering Products and Advanced Techniques in Regenerative Medicine: Integration of scaffolds and organoids in regenerative medicine; Recent advances and future directions in tissue engineering; Real-world applications of scaffolding and organoids; Case studies highlighting successful treatments and outcomes.

Assessment methods

Subject	Assessment methods
Tissue engineering, bioprinting	The final assessment of acquired knowledge is conducted by an oral examination. The grade is expressed on a scale of thirty, up to a maximum of 30/30 cum laude (with honors). The final grade is determined by the weighted average of the scores obtained in the course subjects. The oral examination consists of an interview during which questions will cover at least three different topics from the course curriculum. The assessments aim to evaluate: i) the level of knowledge in the disciplines; ii) the ability to apply this knowledge to solve specific problems related to the disciplines (autonomous problem-solving); iii) clarity of expression; iv) proficiency in medical-scientific language. The assessment of learning can also be conducted remotely if the conditions necessitate it. For the assignment of the final grade, the following parameters will be considered: • Score 29-30 with honors: The student demonstrates an in-depth knowledge of the topics, promptly and correctly integrates and critically analyzes presented situations, independently solving even highly complex problems. They possess excellent communication skills and command medical-scientific language proficiently. • Score 26-28: The student has a good understanding of the topics, is able to integrate and critically and logically analyze presented situations, can fairly independently solve complex problems, and presents topics clearly using appropriate medical-scientific language. • Score 22-25: The student has a fair understanding of the topics, although it may be limited to the main areas. They can integrate and critically analyze presented situations, although not always in a linear fashion, and present topics fairly clearly with moderate language proficiency. • Score 18-21: The student has minimal knowledge of the topics, possesses modest ability to integrate and critically analyze presented situations, and presents topics sufficiently clearly, although their language proficiency may be underdeveloped. • Exam not passed: The student lacks the minimum required knowledge of the core content of the course. Their ability to use specific language is minimal or nonexistent, and they are unable to independently apply acquired knowledge.
Scaffolding and organoids	

Examples of common questions and/or exercises

Subject	Examples of common questions and/or exercises
Tissue engineering, bioprinting	• Why is UHMPE used in knee replacements? • Which criterion can be used when choosing a polymer for application in the tissue engineering field? • How do you identify the printing time in an FDM machine?
Scaffolding and organoids	• What are the main differences between natural and synthetic scaffolds? Provide examples for each category; • What are the main characteristics of stem cells and describe their role in the formation of organoids?

	• Describe the culture conditions, growth factors, and media required for growth of organoids; • Describe the main cryopreservation techniques of organoids and their preclinical and clinical use.

Reference texts

Subject	Textbooks
Tissue engineering, bioprinting	• **Book 1**: W. R. Wagner et al Biomaterials Science. An Introduction to Materials in Medicine. Academic Press Elsevier • **Book 2**: R. Lanza, R. Langer, J.P. Vacanti, A. Atala. Principles of Tissue Engineering 5th Edition - March 26, 2020 Academic Press Hardback ISBN: 9780128184226 • **Book 3**: O. Gunduz, C. Egles, R. A. Pérez, D. Ficai, C. Bulent Ustundag Biomaterials and Tissue Engineering. Springer Cham ISBN 978-3-031-35831-9. Any additional educational material (slides, videos, handouts, etc.) will be distributed or indicated during the lessons.
Scaffolding and organoids	• **Book 1:** Migliaresi, C., & Motta, A. (Eds.). (2014). Scaffolds for Tissue Engineering: Biological Design, Materials, and Fabrication (1st ed.). Jenny Stanford Publishing. https://doi.org/10.1201/b15649 • **Book 2:** Shay Soker and AleksanderSkardal. Tumor Organoids, Series: Cancer Drug Discovery and Development. I Edition, Humana Press, Year: 2018 Any additional educational material (slides, videos, handouts, etc.) will be distributed or indicated during the lessons.

Course format

Subject	Course format
Tissue engineering, bioprinting	The teaching will primarily be conducted through in-person lectures with a blend of theory and practical exercises. In the event that teaching is delivered in a blended or remote mode, necessary adjustments may be introduced compared to what has been previously stated, in order to adhere to the planned program as outlined in the Syllabus.
Scaffolding and organoids	

Attendance

Subject	Attendance
Tissue engineering, bioprinting	Mandatory attendance.
Scaffolding and organoids	

Course schedule

Subject	Course schedule
Tissue engineering, bioprinting	• Tissue Engineering: Book 3: Chapter 1. • Materials used in Tissue Engineering: Book 1: Section 1.1, 1.2 and 1.3. Book 2: Part Four.

	• Manufacturing approaches for Tissue Engineering: Book 3: Chapter 10 and 12. Book 1: Section 1.4. • Bioprinting: Book 3: chapter 13. • Practical Examples: Book 1: Section 2.6. Book 2:Chapter 39, Chapter 40, Chapter 56, Chapter 76.
Scaffolding and organoids	• Introduction to Tissue Engineering – Book 1, Chapter 1 and Chapter 17 • Scaffolding in Tissue Engineering – Book 1, Chapter 6, Chapter 7, Chapter 8, Chapter 9 • Applications of Scaffolding – Book 1, Chapter 6, Chapter 7, Chapter 8, Chapter 9 • Introduction to Organoids – Book 2, Chapter 1, Chapter 4 • Protocol for the Generation of Organoids – Book 2, Chapter 4 and Chapter 5 • Applications of Organoids – Book 2, Chapter 2, Chapter 3 and Chapter 6 • Clinical Application of Bioengineering Products and Advanced Techniques in Regenerative Medicine – Book 2, all Chapters