Carleton University
Department of Systems and Computer Engineering

SYSC4906
Principles of Cell and Tissue Engineering

Calendar description

This interdisciplinary course introduces the core principles of tissue engineering, combining concepts from biology, engineering, and materials science. Topics include cell culture, scaffold design, bioreactors, biomaterials, and microscopy-based tissue characterization. Through lectures, demos, and group projects, students will explore applications in tissue regeneration and gain hands-on experience with data analysis and design tools. Ideal for students in Biomedical Engineering, Biology, Chemistry, Health Sciences, Medical Physics, and related fields. Includes: Experiential Learning Activity.

https://calendar.carleton.ca/grad/courses/SYSC/

Prerequisites

- Third-year status in Engineering or Science

Prior knowledge

Students should:

- Have basic knowledge of cell biology (e.g., cell structure, function, and signaling) and/or fundamental chemistry (organic and/or biochemistry)
- Be comfortable with working with quantitative data analysis and use of basic scientific software (e.g., Excel, ImageJ, MATLAB, Python)
- Be proficient writing reports, summarizing complex concepts and formulating hypothesis with scientific and statistical rigor.

Course objectives

The course aims to enable students to describe and explain the foundational principles of tissue engineering, including the roles of cells, scaffolds, and signaling molecules in tissue regeneration (Understanding). Students will identify and compare different classes of biomaterials and their properties relevant to biomedical applications (Analyzing). They will demonstrate practical knowledge of cell culture methods and apply concepts to support tissue growth *in vitro* (Applying). The course will also prepare students to analyze biological data derived from microscopy and other characterization techniques, and to evaluate the performance of engineered tissues based on

structural and functional criteria (Evaluating). Through team-based projects, students will design scaffold-based systems and collaborate across disciplines to solve tissue engineering challenges (Creating). Finally, students will be expected to critically assess current and emerging applications of tissue engineering in clinical and research contexts (Evaluating).

List of topics

- Introduction to Tissue Engineering and Biomaterials
- Cell Culture Techniques and Bioreactors
- Scaffold Design and Fabrication
- Microscopy and Tissue Characterization
- Applications of Tissue Engineering

Learning outcomes

By the end of this course, students should be able to:

- Understand the fundamentals of tissue engineering, including cell culture, scaffold design, and biomaterials.
- Apply principles of engineering and biology to design solutions for tissue regeneration.
- Develop practical skills in analyzing biological data from microscopy and other technologies.
- Collaborate in interdisciplinary teams to solve tissue engineering challenges.

Instructor

Dr. Leila Mostaço-Guidolin

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Office hours: by appointment

Textbook (or other resources)

Although no specific textbook will be followed in this course, students might refer to the following books for additional information:

- Robert Lanza, Robert Langer, Joseph P. Vacanti, Anthony Atala, *Principles of Tissue Engineering*, 5th Edition, Academic Press, Hardback ISBN: 9780128184226, eBook ISBN: 9780128214015
- Meyer, U., Meyer, T., Handschel, J., & Wiesmann, H. P. (Eds.). (2009). *Fundamentals of tissue engineering and regenerative medicine*. Springer Science & Business Media.
- Any other textbooks and peer-reviewed papers for tissue engineering, microscopy imaging would also be useful.

Additional resources/books

Lecture notes will be provided online by the instructor. Additional references will be provided for studying and further reading; extra references will be posted on lecture notes.

Class Structure

The instructor will present content referent to each module during the scheduled class time. The course will be a blend of in person lectures and online components. Learning resources will be assigned for each module and students are expected to review and understand these materials and they will be useful when solving the practical assignments.

Brightspace

The course will take place in the Brightspace Learning Management System. Brightspace can be accessed from a web browser on most internet-enabled devices, including laptops, Chromebooks, tablets, and smartphones, by going to: brightspace.carleton.ca. Login to cuLearn using your MC1 credentials. Click on the course link for your Winter 2026 course, read the information about Brightspace, review the introductory video to familiarize yourself with the Brightspace interface, and use the Brightspace link to login to your course in Brightspace. The BrightspacePulse App is also available for iPhone and Android devices. The App is not the best way to review the course content. To explore course content, please use a web browser instead.

Persuall

Students are required to create a free account on Perusall (https://perusall.com/) and enroll in the course using the code: **MOSTACO-GUIDOLIN-3AJ7R**

Course materials will be posted on Perusall on a weekly basis. Students will be able to access scientific papers and any other additional resource shared during the course. Students will be able to post comments on the posted material, open specific discussion topics, ask questions and connect with other students to discuss all the available material.

Copyright on Course Materials: The materials created for this course (including the course outline and any slides, posted notes, labs, project, assignments, quizzes, exams, and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).

Evaluation and grading scheme

To pass the course, a student must:
(1) obtain a minimum grade C- (or 60%) on the final exam, + have completed the Biosafety awareness training (Lab 0) **and**
(2) obtain an overall passing average.

For students who meet criteria (1), the final grade will be calculated as follows:

Component	Weight
Biosafety awareness training	N/A*
Laboratories (8x5%)	40%
Group Project	20%
Final Exam	40%

Participation	1%**

**Mandatory completion.*
***bonus - optional*

General regulations

Attendance: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, visit https://calendar.carleton.ca/grad/gradregulations/administrationoftheregulations/#19 for Graduate Regulations

Health and Safety: Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: http://sce.carleton.ca/courses/health-and-safety.pdf

Deferred Term Work: Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor. In all cases, this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule.

Instructors may, at their discretion, require students to provide medical documentation to support requests for accommodation for missed course work including exams and assignments. As per the Provost's message of August 27, 2021, for the Fall 2021 term, students have been instructed to complete the Medical Self-Declaration form available on the Registrar's Office website rather than seeking to obtain a doctor's note or medical certificate. Instructions for the Winter 2026 term will be communicated by the Provost's office.

For more information, visit:
https://calendar.carleton.ca/grad/gradregulations/administrationoftheregulations/#19 for Graduate Regulations

Appeal of Grades: Within one month of the release of grades or the announcement of examination by committee (comprehensive examination, research essay or thesis) results, a graduate student may request, through the Faculty of Graduate and Postdoctoral Affairs, that one or more of their grades or results be reviewed. The results of examination by committee (including comprehensive, research essay or thesis examinations) will only be reviewed on procedural grounds. Grades for other courses will be reviewed through the submission of all or part of the written coursework to two re-readers. The average grade of the re-readers will replace the original of the reviewed work. Parts of grades based on non-written work (e.g., participation) will not be reviewed. The process for the conduct of reviews can be found at http://gradstudents.carleton.ca/wp-content/uploads/Grade-Appeal-Procedures.pdf

Academic Integrity: Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: https://carleton.ca/registrar/academic-integrity/. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

Plagiarism: The University Academic Integrity Policy defines plagiarism as "*presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own.*" This includes reproducing or paraphrasing portions of someone else's published or unpublished material,

regardless of the source, and presenting these as one's own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, artworks, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another's data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and
- failing to acknowledge sources using proper citations when using another's work and/or failing to use quotations marks.

Academic Accommodation: You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://www.carleton.ca/equity/ For an accommodation request, the processes are as follows:

- **Pregnancy or Religious obligation**: Carleton University accommodates students who, by reason of religious obligation, must miss an examination, test, assignment deadline, laboratory, or other compulsory event.
  Accommodation will be worked out directly and on an individual basis between the student and the instructor(s) involved. Students should make a formal request to the instructor(s) in writing for alternative dates and/or means of satisfying requirements. Such requests should be made during the first two weeks of any given academic term, or as soon as possible after a need for accommodation is known to exist. Instructors will make reasonable accommodation in a way that shall avoid academic disadvantage to the student. Students unable to reach a satisfactory arrangement with their instructor(s) should contact the Office of Equity Services at http://www.carleton.ca/equity/.
  Instructors who have questions or wish to verify the nature of the religious event or practice involved should also contact this office.

  For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form. https://carleton.ca/equity/contact/form-pregnancy-accommodation/
- **Academic Accommodations for Students with Disabilities**: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC,

contact your PMC coordinator to send me your ***Letter of Accommodation*** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).

- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/sexual-violence-support/.
- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf
- **Parental/Caretaking Accommodations:** Based on my commitment to students who are parents or the primary caretaker for a young child, the following is my own classroom policy (much of this does not apply since the course is offered online; however, the sentiments remain):
    - Nursing or bottle-fed babies are welcome in class anytime, and you are welcome to feed your baby during class. If class lasts for more than 1.5 hours, you are welcome to take a break to pump.
    - For older children, I understand that illnesses and unforeseen disruptions in childcare happen. It is acceptable to bring a child to class during emergencies like these as long as the child does not distract other students and it does not become a regular occurrence.
    - When babies and children come to class, I recommend that you sit close to the door so that if your little one needs special attention and is disrupting learning for other students, you may step outside until their need has been met.
    - You do not need to request prior permission for any of the points above. Please communicate with me if we need to discuss other accommodations related to parenting/caregiving.

Tentative Topics and Schedule

Week	Module #	Topic
1		Overview of tissue engineering principles and applications.

2	1: Introduction to Tissue Engineering and Biomaterials	Biomaterials for scaffolds: properties, selection, and fabrication.
3	2: Cell Culture Techniques and Bioreactors	Cell types used in tissue engineering: stem cells, primary cells, and immortalized cell lines. Cell culture techniques: aseptic handling, media preparation, and growth conditions.
4		Design and use of bioreactors for tissue engineering. Microfluidics and 'on-a-chip' devices.
5	3: Scaffold Design and Fabrication	Scaffold design principles: porosity, degradation, mechanical strength.
6		Fabrication techniques: 3D printing, electrospinning, and freeze-drying.
Winter Break [16-20/2]		
7	4: Microscopy and Tissue Characterization	Microscopy techniques (confocal, Raman, SEM, TEM) and their application in tissue engineering.
8		
9		Interpreting images and data for scaffold-cell interactions and tissue formation.
10	5: Applications of Tissue Engineering	Clinical applications, current challenges and future directions
11		Ethics and regulatory aspects of tissue engineering
12	Project Presentations	
13	Final Review	

Tentative Laboratory Themes

Lab 0: Biosafety Awareness Training (attendance grade)
Offered by Environmental Health and Safety (EHS) at Carleton University. This mandatory session provides an overview of biosafety principles, proper laboratory conduct, and safe handling of biological materials. Completion of this training is required before participating in any laboratory activities.

Lab 1: 3D Bioprinting Demo
Students will be introduced to the principles of 3D bioprinting and its applications in tissue engineering. Through live or recorded demonstrations, students will learn about bioink preparation, print path design, and layer-by-layer fabrication of scaffolds. The lab emphasizes how geometry, porosity, and material composition influence cell attachment and tissue regeneration.

Lab 2: Introduction to Cell Culture and 3D Models
This lab introduces students to basic aseptic techniques, culture media preparation, and maintenance of mammalian cell lines. Students will design a conceptual experiment involving the seeding of cells on 3D scaffolds or hydrogels, discussing expected outcomes and common challenges in maintaining viable, reproducible 3D models.

Lab 3: Cells and Tissues Imaging
Students will explore microscopy techniques used to visualize cells and engineered tissues. Guided by the teaching assistant, they will examine fixed samples and learn how confocal and other optical imaging methods reveal cell morphology, scaffold integration, and early tissue organization. Emphasis will be placed on choosing the right imaging approach for different biological questions.

Lab 4: Image Analysis and Interpretation I
Students will analyze microscopy datasets to quantify cell morphology, distribution, and interaction with scaffolds. The focus will be on image segmentation, thresholding, and measurement tools using ImageJ or equivalent software. Students will prepare a short report summarizing their analytical workflow and preliminary findings.

Lab 5: Additive Manufacturing
This session builds on the 3D bioprinting lab by introducing students to broader additive manufacturing approaches for biomaterials. Students will examine design-to-fabrication pipelines, comparing extrusion, stereolithography, and electrospinning techniques. Data interpretation will focus on print fidelity, resolution, and material characterization relevant to tissue scaffold applications.

Lab 7: Raman Microspectroscopy
Students will be introduced to Raman microspectroscopy as a label-free technique for biochemical characterization of cells and tissues. The lab will include demonstration data showing how spectral fingerprints can distinguish material composition and cellular changes. Students will interpret spectra and discuss how molecular mapping complements traditional imaging methods.

Lab 8: Image Analysis and Interpretation II
This advanced image analysis lab extends the previous session, focusing on quantitative tissue characterization and data integration. Students will analyze complex, multi-channel microscopy datasets to assess co-localization, intensity ratios, or texture metrics. Each group will prepare a short presentation summarizing their analytical insights and methods used.

Final Group Project – Design a Tissue Engineering Strategy

Groups will select a tissue or organ and will write a grant-style proposal (4-5 pages) for bioengineering such system, including scaffold design, cell choice, bioreactor conditions, and expected outcomes. Groups are expected to base their choices on peer-reviewed papers and protocols. Each group will present their project to the class and will be evaluated by a 'scientific panel', composed by the instructor, TA, and other students.