



BME 499: Principles and Applications of Tissue Engineering

Spring 2021, Units: 3

Lecture: Mon & Wed, 3:30 - 4:50PM

Location: Online (Zoom)

Instructor: Dr. Nathan Cho

Office: Online (Zoom)

Office Hours: Tues 9:30 – 11AM or by appointment

Contact Info: chonatha@usc.edu

Teaching Assistant: Natalie Khalil

Office: Online (Zoom)

Office Hours: Mon 10 – 11AM

Contact Info: nnkhalil@usc.edu

Course Description

In-depth survey of cells, biomaterials, and techniques used to engineer human tissues for applications in regenerative medicine and drug screening.

Learning Objectives

- (1) Describe key features of cells and extracellular matrix that influence the form and function of human tissues.
- (2) Compare and contrast common types of stem cells, biomaterials, and fabrication techniques for engineering two-dimensional (2-D) and 3-D human tissues.
- (3) Discuss multiple applications for tissue engineering in society.

Course Outcomes

- (1) Interpret and critique data from research papers related to tissue engineering.
- (2) Collaborate with classmates to communicate important findings from research articles.
- (3) Summarize the current state of tissue-engineered products for regenerative medicine and drug screening in society today.
- (4) Evaluate the ethical implications of different tissue engineering strategies.

BME Student Outcomes

Students who complete the BME program have:

- (1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- (2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- (3) an ability to communicate effectively with a range of audiences
- (4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- (5) an ability to function effectively on a team whose members together provide leadership, create

- a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- (6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- (7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Relationships between Course and BME Student Outcomes

Course outcomes ↓	Student Outcomes →	1	2	3	4	5	6	7
Outcome 1:		X		X				X
Outcome 2:				X		X		
Outcome 3:					X			
Outcome 4:					X			
All course outcomes		X		X	X	X		X

Course Preparation

Pre-/Co-Requisites: Chem 322A: Organic Chemistry

Course Notes

Lecture slides are posted on Blackboard (Bb) at least 24 hours before each lecture. All other course materials (syllabus, reading assignments, assignment descriptions, etc.) will also be posted on Bb.

Technological Proficiency and Hardware/Software Required

Students are required to use an internet-enabled device with browser capabilities, such as a laptop or tablet. The course will be delivered over Zoom. Blackboard and Zoom will be used extensively for in-class work and polls. Thus, a cell phone is not recommended as the primary means for accessing the class. Camera use is not required but highly encouraged. Students will also be asked questions during lectures using Poll Everywhere software, which can be easily accessed through a web browser or smart phone app.

Required Reading Assignments

Students should read the assigned reading materials (posted on Bb) before each lecture. Because this course does not follow a single textbook, students are highly encouraged to take notes during lecture and use the supplemental reading material to clarify concepts from the lectures. Any topics that appear only in reading material (and not in lectures) will NOT be included on quizzes or exams.

Description and Assessment of Assignments:

In-Class Work: During some sessions, students will work in small groups for graded in-class work assignments, such as short presentations, short write-ups, and group quizzes. These assignments will be administered during class via randomly generated breakout sessions and must be completed and submitted on Bb within the allotted time. Quizzes will be open-book and open-note.

Group Presentations: At the end of the semester, students will work in groups of 3-4 to present a journal club article during regular class time. More details regarding the presentation and a rubric will be distributed in a separate document.

Homework Assignments: Students will be assigned homework assignments roughly biweekly. Homework assignments will require students to read a journal article and answer several questions related to its content and the course material.

Lab Demo Assignments: During two course periods, students will observe the TA performing procedures virtually and learn how to perform their own data analysis. Each student will then submit an assignment related to the demonstrations.

Exams: Two midterm exams will be administered during regular class time and a final exam will be administered during the final exam period. Midterm exams will not be cumulative. The final exam will be cumulative. Exams will focus on lecture material. Students may be tested on material that appears in lecture and not reading assignments, but not vice versa.

Students are expected to spend 6 hours per week on work outside of class, on average.

Assignment Submission Policy

Homework assignments, lab demo assignments, and group presentation files are to be submitted via Bb **before the start of lecture (3:30PM) on their indicated due date.** Homework and lab demo assignments will be accepted late, but 10% of the total possible points will be subtracted every 24 hours (including holidays and weekends), starting immediately after the due date and time. Late group presentation files will not be accepted.

Grading Timeline

All assignments will be graded and grades will be posted on Bb within one week of the due date.

Regrade Policy

Regrade requests for homework assignments, lab demo assignments, and midterm exams are due within one week of the date they are returned to the students. The regrade request must total at least 10% of the total grade for the assignment. Students must **type a justification for their request and email both the original assignment and justification to Dr. Cho.** Each student is limited to **two regrade requests** for any type of assignment throughout the semester. This does not include administrative errors (incorrect point additions, etc.), which should be brought to the attention of a TA immediately for correction without penalty.

Grading Breakdown

Assessment	% of Grade
In-Class Work (5)	10
Group Presentation	15
Homework Assignments (7)	25
Lab Demo Assignments (2)	10
Midterm Exams (2)	25
Final Exam	15
TOTAL	100

Grading Scale

Final letter grades will be assigned based on the following scale:

90 - 100%	A
86 - 89%	A-
82 - 85%	B+
78 - 81%	B
74 - 77%	B-
70 - 73%	C+
66 - 69%	C
62 - 65%	C-
50 - 61%	D
0 - 49%	F

Final grades will be rounded up if ≥ 0.50 and rounded down if < 0.5 (e.g. 89.6% is an A, but 89.4% will be an A-). Depending on the class distribution, grades may be altered from this structure, but only in a way that favors the students.

Collaboration Policy

Students may work together on homework and lab demo assignments, but every student should write and submit their own individual work. Any identical (or nearly identical) assignments will be given zero points. The Turnitin feature on Blackboard will be used to check for plagiarism. Students may not work together for exams. Plagiarism or other forms of academic misconduct will result in a zero grade for the assignment and will be reported to USC's Office of Student Judicial Affairs and Community Standards, as detailed at the end of the syllabus.

Technology Policy

During class time, students should use devices only to participate in activities guided by the instructor or for note-taking. Use of devices for other purposes is not permitted. Device use for non-academic purposes that distracts the instructor or other students will result in no credit for in-class work for the day. During exams, device use is strictly prohibited and will result in a zero grade for the exam. Restroom use during exams is permitted, but all devices must be left with the instructor or TA at the front of the classroom.

Communication Policy

If a student has a question, he/she should ask during class time or follow these steps in order: (1) consult the syllabus; (2) ask a classmate; (3) review lecture slides and reading material; (4) ask the TA at office hours; (5) ask the instructor at office hours; (6) email the TA; (7) email the instructor. Emails that require short responses (at the discretion of the instructor or TA) will be answered within 24 hours between 9am-5pm on business days. Responses received on weekends or holidays will be delayed to the next business day. Emails that require a long response (at the discretion of the instructor or TA) will not be answered over email. Instead, the student will be directed to office hours.

Attendance Policy

Attendance for student presentations and exam periods is mandatory and will only be excused in case of an emergency, at the discretion of the instructor. If a student knows in advance that

he/she will be absent on the day of an exam or presentation for an important occasion (at the discretion of the instructor), **notify the instructor as soon as possible or at least two weeks in advance such that arrangements can be made.** Notifications given with less than two weeks notice cannot be excused.

Course Schedule

Date	Topics and Deliverables
1/18 (M)	NO CLASS (Martin Luther King's Birthday)
1/20 (W)	Lecture 0: Course Introduction
1/25 (M)	Lecture 1: Human Cell and Tissue Structure Readings: <ul style="list-style-type: none"> • https://toxtutor.nlm.nih.gov/08-004.html (PDF available on Bb) • PTE Ch. 7, "CYTOSKELETON" to "EXTRACELLULAR MATRIX", "CELLS IN TISSUE AND ORGANS" to end
1/27 (W)	Lecture 2: Structure and Function of Chromatin Readings: <ul style="list-style-type: none"> • PTE Ch. 7, start to "Signal Transduction" • MBoC Ch. 4
2/1 (M)	Lecture 3: Cell Culture <u>In-Class Work #1</u> Reading: <ul style="list-style-type: none"> • PDF Cell Culture
2/3 (W)	Lecture 4: Embryonic Stem Cells Reading: <ul style="list-style-type: none"> • https://stemcells.nih.gov/info/Regenerative_Medicine/2006Chapter1.htm (PDF available on Bb) Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • <u>HW1</u> (submit via Bb)
2/8 (M)	Lecture 5: Embryonic Stem Cell Differentiation and Applications in the Clinic Reading: <ul style="list-style-type: none"> • PTE Ch. 4
2/10 (W)	Lab Demo 1: Cell Culture and Image Analysis Readings: <ul style="list-style-type: none"> • PDF C2C12 • https://www.olympus-lifescience.com/en/microscope-resource/primer/lightandcolor/fluoroexcitation/ Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • <u>HW2</u> (submit via Bb)
2/15 (M)	NO CLASS (President's Day)

Date	Topics and Deliverables
2/17 (W)	<p>Lecture 6: Adult Stem Cells and Induced Pluripotent Stem Cells <u>In-Class Work #2</u> Readings:</p> <ul style="list-style-type: none"> • https://stemcells.nih.gov/info/basics/4.htm (PDF available on Bb) • https://stemcells.nih.gov/info/basics/5.htm (PDF available on Bb) <p>Assignment Due (before 3:30PM):</p> <ul style="list-style-type: none"> • <u>Lab Demo 1 Assignment (submit via Bb)</u>
2/22 (M)	<p>Lecture 7: Gene Editing with CRISPR/Cas9 Video:</p> <ul style="list-style-type: none"> • https://www.youtube.com/watch?v=2pp17E4E-O8 <p>Readings:</p> <ul style="list-style-type: none"> • PDF CRISPR Cardiac Biology • PDF CRISPR Ethics
2/24 (W)	<p>Lecture 8: Properties of Biomaterials Readings:</p> <ul style="list-style-type: none"> • PDF Biomaterial Properties • PDF Polymers • PTE Ch. 25
3/1 (M)	<p>EXAM 1: Lectures 1-7</p>
3/3 (W)	<p>Lecture 9: The Extracellular Matrix Reading:</p> <ul style="list-style-type: none"> • PTE Ch. 10
3/8 (M)	<p>Lecture 10: Natural Biomaterials <u>In-Class Work #3</u> Reading:</p> <ul style="list-style-type: none"> • PDF Natural Biomaterials
3/10 (W)	<p>Lecture 11: Non-Degradable Synthetic Biomaterials Readings:</p> <ul style="list-style-type: none"> • PDF PEG Hydrogels • https://www.elveflow.com/microfluidic-tutorials/microfluidic-reviews-and-tutorials/the-poly-di-methyl-siloxane-pdms-and-microfluidics/ (PDF available on Bb) <p>Assignment Due (before 3:30PM):</p> <ul style="list-style-type: none"> • <u>HW3 (submit via Bb)</u>
3/15 (M)	<p>Lecture 12: Photolithography, Microcontact Printing, and Microfluidic Devices Guest Lecturer: Natalie Khalil (PhD student, McCain Lab) Readings:</p> <ul style="list-style-type: none"> • PDF Microcontact Printing • PDF Microfluidics

Date	Topics and Deliverables
3/17 (W)	Lab Demo 2: Substrate Fabrication and Preparation Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • HW4 (submit via Bb)
3/22 (M)	Lecture 13: Bioreactors and Organs-on-Chips for 2-D Tissues Guest Lecturer: Dr. Megan Rexius-Hall (Postdoc, McCain Lab) Readings: <ul style="list-style-type: none"> • PTE Ch. 14, start to "CELLULAR MIGRATION" • PDF 2-D Organs-on-Chips
3/24 (W)	Lecture 14: Degradable Synthetic Biomaterials and Conventional 3-D Scaffold Fabrication Readings: <ul style="list-style-type: none"> • PTE Ch. 23, "SYNTHETIC POLYMERS" to "POLY(ORTHO ESTERS)" • PDF 3-D Scaffold Fabrication Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • Lab Demo 2 Assignment (submit via Bb)
3/29 (M)	Lecture 15: Bioprinting Guest Lecturer: Natalie Khalil (PhD student, McCain Lab) Reading: <ul style="list-style-type: none"> • PDF 3-D Bioprinting, start to "3. Applications of 3D Cell-Printing to Tissue Models"
3/31 (W)	Lecture 16: Bioreactors and Organs on Chips for 3-D Tissues <u>In-Class Work #4</u> Reading: <ul style="list-style-type: none"> • PDF 3-D Bioprinting, "3. Applications of 3D Cell-Printing to Tissue Models" to end Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • HW5 (submit via Bb)
4/5 (M)	EXAM 2: Lectures 8-16
4/7 (W)	NO CLASS (Spring 2021 Wellness Day)
4/12 (M)	Lecture 17: Cardiovascular Tissue Engineering 1: Blood Vessels Reading: <ul style="list-style-type: none"> • PDF Vascular Tissue Engineering
4/14 (W)	Lecture 18: Cardiovascular Tissue Engineering 2: Myocardium <u>In-Class Work #5</u> Reading: <ul style="list-style-type: none"> • PDF Cardiac Tissue Models

Date	Topics and Deliverables
4/19 (M)	Lecture 19: Cardiovascular Tissue Engineering 3: Heart Valves Reading: <ul style="list-style-type: none"> • PDF Heart Valve Engineering Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • HW6 (submit via Bb)
4/21 (W)	Lecture 20: Skin Tissue Engineering Reading: <ul style="list-style-type: none"> • PDF Skin Tissue Engineering
4/26 (M)	Class Presentations – Group 1 Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • HW7 (Group 2) (submit via Bb)
4/28 (W)	Class Presentations – Group 2 Assignment Due (before 3:30PM): <ul style="list-style-type: none"> • HW7 (Group 1) (submit via Bb)
5/7 (F)	FINAL EXAM (2 – 4PM): Lectures 1-20

Statement on Academic Conduct and Support Systems

Academic Conduct: Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call

studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call

studenthealth.usc.edu/sexual-assault

Free & confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)- (213) 740-5086 | Title IX – (213) 821-8298

equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298

usc-advocate.symplicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

ucsa.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.