

## Course Syllabus for Winter 2024

MATSCIE 593 - 053 **Advanced Biomaterials** (3 Credits)

**Semester:** Winter, 2024

**Days/Times:** Monday/Wednesday 12:00 PM - 1:30 PM

**Classroom:** 1008 EECS

### **Instructional Staff:**

**Professor:** Geeta Mehta, Ph.D., Associate Professor, Depts. of Materials Science and Engineering, Biomedical Engineering, and Macromolecular Science and Engineering

**E-mail:** [mehtagee@umich.edu](mailto:mehtagee@umich.edu)

Please see Communications section for notes about contacting the instructor

**Office Hours:** By appointment either on Zoom or in NCRC

### **Prerequisites:**

This course is intended for graduate students in MSE, BME, CHE, Macro, Chemistry, ME, and PIBS. There are no formal prerequisites, but students are advised to have completed an introductory course in materials or biomaterials, and basic knowledge of chemistry, materials science and engineering, & biochemistry/cell biology concepts.

### **Communications Policy:**

All instructor communication must be conducted through Canvas conversations (<https://umich.instructure.com/conversations#filter=type=inbox>).

Select "Inbox" from the left menu bar, choose "MATSCIE 593-053 W 2024" from the course list, and in the "To:" field type Geeta Mehta, and my name will be easily available to message. Using Canvas Inbox is important for tagging each of your messages, and identifying them as course communication, to ensure that your messages aren't lost in our mailboxes.

### **Accommodations for Students with Disabilities:**

If you think you need an accommodation for a disability, please let us know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way I teach may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, I can work with the Office of Services for Students with Disabilities (SSD) to help me determine appropriate accommodations. SSD (734-763-3000 or [ssd.umich.edu](http://ssd.umich.edu)) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. I will treat any information you provide as private and confidential.

Your success in this class is important to me. If you are not formally registered with Office of Services for Students with Disabilities (SSD) and have anxiety, depression, learning disabilities or any other issues that affect your ability to fully participate and learn in this class, you are encouraged to check-in with me so that I can best help you do well. Please set up a meeting with me via Canvas Inbox e-mail.

### **Inclusion and Diversity:**

I aim to create an inclusive classroom where I value all students regardless of their background, country of origin, race, religion, ethnicity, disability status, gender, sexual orientation, etc. I am committed to providing a climate of excellence and inclusiveness within all aspects of the course. If there are aspects of your culture or identity that you would like to share with me, as they relate to your success in this class, I am happy to meet to discuss. Likewise, if you have any concerns in this area or are facing any special issues or challenges, you are encouraged to discuss this matter with me (set up a meeting via e-mail) with an assurance of full confidentiality (only exception being mandatory reporting of academic integrity/honor code violations and sexual harassment).

### **Student Mental Health and Well-being:**

University of Michigan is committed to advancing the mental health and wellbeing of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, contact **Counseling and Psychological Services (CAPS)** at (734) 764-8312 and <https://caps.umich.edu/Links to an external site.> during and after hours, on weekends and holidays, or through its counselors physically located in schools on both North and Central Campus. You may also consult **University Health Service (UHS)** at (734) 764-8320 and <https://www.uhs.umich.edu/mentalhealthsvcsLinks to an external site.>, or for alcohol or drug concerns, see [www.uhs.umich.edu/aodresourcesLinks to an external site.](http://www.uhs.umich.edu/aodresourcesLinks to an external site.) For a listing of other mental health resources available on and off campus, visit: <http://umich.edu/~mhealth/Links to an external site.>

Normal levels of stress and anxiety are exacerbated by the continued uncertainties associated with the COVID-19 global pandemic. The College of Engineering has resources specifically designed to support students through this especially difficult time (<https://care.engin.umich.edu/>). Prof. Mehta is willing to contact the C.A.R.E center on behalf of any students (with their consent). Please don't hesitate to reach out!

## **Religious Observances**

The University of Michigan, as an institution, does not observe religious holidays. However, I will make every reasonable effort to help students avoid negative academic consequences when their religious obligations conflict with academic requirements. If you find that an assignment due date conflicts with a religious observance, it is your obligation to let Prof. Mehta know at least 2 weeks in advance of the conflict. You will be given every opportunity to make up the work without penalty, unless it interferes unreasonably with course delivery. Please read the University of Michigan's full policy here: [http://www.provost.umich.edu/calendar/religious\\_holidays18-19.html#conflicts](http://www.provost.umich.edu/calendar/religious_holidays18-19.html#conflicts)Links to an external site.

It is recommended that you review all other general University of Michigan College of Engineering policies, academic rules, information and more in the online bulletin, which can be found at <https://bulletin.engin.umich.edu/>Links to an external site.

## **Course structure and Expectations:**

This is a graduate level course in Advanced Biomaterials that provides foundation on contemporary biomaterials principles. The overall objectives of this course include:

1. Provide graduate-level knowledge on biomaterials principles and applications
2. Introduction of biomimetic & rational design approaches to biomaterial engineering.
3. Understand fundamental principles of biomaterials surfaces and interfaces
4. Discuss the cellular and molecular aspects cell and tissue interactions with biomaterials.
5. Develop critical analysis and evaluation skills through literature review and proposal writing

The following assignments comprise the final scores and assess your understanding of the materials discussed in this course.

### **Mini-reviews:**

Each student will be required to write 4 mini-reviews (one page). The goal of this assignment is to develop paper reading skills and provide experience with writing manuscript reviews.

It is expected that each student (as part of a group) will assist in leading one discussion during a specific class. Each group will sign up for a paper for the presentation of a specific assigned paper.

### **Final project (Market Research Plan):**

Each student will participate in a group **Market Research Plan**. You will work as a team (3-4 students per group) to prepare the final project. Group assignments will be based on students' background and education level.

Each group will formulate and present an idea for a new start-up company that will develop a materials-based technology or therapy.

A 1/2 paragraph summary providing a general overview of the project is due on 8th March (tentatively), more than 6 weeks prior the final proposal. Each group will present their project proposal as a group to judges consisting of instructors, other faculty members and a student group. Critiques and a final score will be provided by the judges.

Final Market Research Plan reports should be no more than four pages long (not including references), Arial 11 font, single spaced and 0.5" margins. The reports must address the sections detailed below. Please include schematics and pictures to illustrate and outline your project.

**Significance:** Outline the healthcare problem that your project aims to address. Explain the clinical importance of the problem or existing barriers that your technology/therapy will solve.

**Product overview:** Provide an overview of the technology/therapy that you will develop. Explain how your product/therapy will change current clinical standards. Describe any new concepts, approaches or methodologies that you will develop or apply.

**Innovation/Market analysis:** Describe current technologies/therapies that compete with your idea. Explain the advantages of your idea over existing technologies/therapies (this may be from other companies or still in developmental stage).

**Approach/aims:** Detail the overall approach, methodology required to implement your technology/therapy. Include any research experiments, pre-clinical and clinical studies that will be needed.

**Contingency plan:** Describe the anticipated challenges and strategies how you will address these to bring your technology/therapy to the market.

**References:** Include references to relevant literature for all aspects of your proposal. Place your idea in the context of existing research and technologies/therapies.

The overall grading breakdown consists of the following:

**Grading Criteria:**

**Participation** (attendance; in-class discussions) 20%

**Mini-reviews** (4 written critiques of discussion papers) 25%

**Paper Presentation** (of 1 paper) 25% (group)

**Market Research Plan** (paragraph abstract, written draft Market Research Plan, Presentation, Final Market Research Plan) 30% (group)

Grading Breakdown for **Market Research Plan (group)** is shown below:

5% Paragraph Summary

45% Presentation in Class

45% Final Proposal

5% Peer Evaluations

**References and Additional Reading:**

- *Biomaterials Science: An Introduction to Materials in Medicine*. Wagner, W., Sakiyama-Elbert, S., Zhang, G., Yaszemski, M., (Editors) 4th Edition, Academic Press, 2020.
- *Advanced Materials and Manufacturing Techniques for Biomedical Applications*. Prasad, A., Kumar, A., Gupta, M., John Wiley and Sons. 2022.
- *Regenerative Medicine: Emerging Techniques to Translation Approaches*. Chakravorty, N., Shukla, P. C. (Editors), Springer Nature Singapore, 2023.
- *Advances in 3D bioprinting*. Narayan, R. (Editor), CRC Press, Taylor & Francis, 2024.
- *Hydrogels for tissue engineering and regenerative medicine: from fundamentals to applications*. Oliveira, J. M., Silva-Correia, J., Reis, R. L., (Editors), Academic Press, 2024.
- *Biomimetic biomaterials for tissue regeneration and drug delivery*, Dash, M., Springer, 2022.
- *Biomaterials: The Intersection of Biology and Materials Science*, Temenoff, J. S.; Mikos A. G., Prentice Hall, New Jersey, 2008.

- *Principles of Tissue Engineering*, Lanza, R. P.; Langer, R.; Vacanti, J., (Editors) 2nd Ed., Academic Press, San Diego, 2000.
- *Biomaterials: An Introduction*, Park, J. B.; Lakes R. S., 3rd Ed, Plenum Press, New York, 2007.
- *Synthetic Biodegradable Polymer Scaffolds*, Atala, A; Mooney, D. J. (Editors), Springer Verlag, New York, 1997.

### Tentative Schedule for Winter 2024:

| No | Date  | Modules                              | Topic                                                                                                                                               |
|----|-------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | 01/10 | 1: Fundamentals                      | Overview and Introduction<br>Final project instructions and examples                                                                                |
| 2  | 01/17 |                                      | Final project instructions and examples<br>Native tissue and cell sources                                                                           |
| 3  | 01/22 |                                      | Concepts of biocompatibility and signaling                                                                                                          |
| 4  | 01/24 | 2: Biomimetic & Engineered Materials | Hydrogels I                                                                                                                                         |
| 5  | 01/29 |                                      | Hydrogels II                                                                                                                                        |
| 6  | 01/31 |                                      | Biomimetic materials I                                                                                                                              |
| 7  | 02/05 |                                      | Biomimetic materials II                                                                                                                             |
| 8  | 02/07 |                                      | Biofabrication                                                                                                                                      |
| 9  | 02/12 |                                      | Surface characterization I<br><b>Mini-review 1 due on Feb 11th</b><br><b>Paper discussion on 2024 Nature Comm, Bioinspired Structural Hydrogels</b> |
| 10 | 02/14 |                                      | Surface characterization II                                                                                                                         |
| 11 | 02/19 | 3: Surfaces and interfaces           | Protein adsorption                                                                                                                                  |

|    |       |                                  |                                                                                                                                                                                          |
|----|-------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12 | 02/21 |                                  | Biodegradation                                                                                                                                                                           |
| 13 | 03/04 |                                  | Cell-Biomaterial interactions I<br><b>Mini-review 2 due on March 3rd</b><br><b>Paper presentation on 2023 Nature, Cartilage Protein Entanglements</b>                                    |
| 14 | 03/06 |                                  | Cell-Biomaterial interactions II<br><b>Mini-review 3 due on March 5th</b><br><b>Paper discussion for 2023 Nature BME, Inflammation-induced Neovascularization</b>                        |
| 15 | 03/11 | 4: Host reaction/Immune-response | Wound healing I                                                                                                                                                                          |
| 16 | 03/13 |                                  | Wound healing II<br><b>Paragraph summary due on Market Research Project Plan</b><br><b>Paper presentation on 2022 Nature Comm, Dynamic actuation</b>                                     |
| 17 | 03/18 |                                  | Inflammation I                                                                                                                                                                           |
| 18 | 03/20 |                                  | Inflammation II<br>Immune responses guest lecture (Dr. Priyan Weerappuli)                                                                                                                |
| 19 | 03/25 |                                  | Immune responses guest lecture (Dr. Priyan Weerappuli)                                                                                                                                   |
| 20 | 03/27 |                                  | Immune response guest lecture (Dr. Priyan Weerappuli)<br><b>Mini-review 4 due on March 26th</b><br><b>Paper discussion on 2023 Nature Comm, Tracing immune cells around biomaterials</b> |
| 21 | 04/01 |                                  | Immune modulation of biomaterials                                                                                                                                                        |
| 22 | 04/03 | 5: Applications of Biomaterials  | Drug delivery systems/Tissue engineered products/grafts                                                                                                                                  |
| 23 | 04/08 |                                  | Clinical products in market<br><b>Market Research Project Report Draft proposal due</b>                                                                                                  |
| 24 | 04/10 |                                  | Practical aspects and commercialization of biomaterials I                                                                                                                                |

|           |       |                               |                                                                      |
|-----------|-------|-------------------------------|----------------------------------------------------------------------|
| <b>25</b> | 04/15 | <b>6: Final Presentations</b> | Final Presentations                                                  |
| <b>26</b> | 04/17 |                               | Final Presentations                                                  |
| <b>27</b> | 04/22 |                               | Final Presentations                                                  |
|           | 04/28 |                               | <b>Final Market Research Project Plan and Final Presentation due</b> |