BME/MSE 410 Design and Applications of Biomaterials

Semester: Fall, 2019
Days/Times: Monday/Wednesday 10.00-11:30 AM

Classroom: 1014 Dow

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

Office: 3044W Building 28, NCRC (my office is in Building 28 of NCRC, there are campus buses that go to NCRC, and on foot it is ~15 minutes’ walk from the Duderstadt Library)

Office Hours: Dr. Geeta Mehta: Monday/Wednesday before and after lecture, just outside the classroom (1014 Dow). I generally arrive by 9 am and can stay until 12pm after class. If you are planning to come talk with me, please email me too! I will make sure to wait for you. If these times don’t work for you, you can also email me and come over to NCRC B28 and we can meet in my office.

IA Darel Crochran: Thursday 6-8pm @ Mujo Cafe

IA Alyssa Moy: Sunday 5-7pm @ Maizies in the League

E-mail: mehtagee@umich.edu

Instructional Aides: Alyssa Moy and Darel Crochran

E-mail: alyjmoy@umich.edu darelyn@umich.edu

Office Hours: TBD (IAs will poll you on the times that work best for all students)

Sending Emails: Use [BME 410] in the subject line. Copy all 3 of us: Dr. Mehta and IAs (Alyssa and Darel)

Prerequisites: One year of general biology or biochemistry and MSE 220 or 250.

Textbook: Ratner, B. D.; Hoffman, A. S.; Schoen, F. J.; Lemons, J. E., 3rd Eds, Biomaterials Science: An Introduction to Materials in Medicine,
Course website: https://canvas.umich.edu/

TopHat: https://app.tophat.com/e/157604/

Useful Websites: • NIH Public Medline:
• The Web of Science Citation Index:
http://isi10.newisiknowledge.com/portal.cgi
(need to use from on campus or with your umich uniquename and password)

Accommodations for Students with Disabilities:
If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way we teach may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the Office of Services for Students with Disabilities (SSD) to help us determine appropriate accommodations. SSD (734-763-3000 or 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 e-mail.

Inclusion and Diversity:
I create an inclusive classroom in my teaching practice. I value all students regardless of their background, country of origin, race, religion, ethnicity, disability status, gender, sexual orientation, etc., and 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/ 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/mentalhealthsvcs, or for alcohol or drug concerns, see www.uhs.umich.edu/aodresources. For a listing of other mental health resources available on and off campus, visit: http://umich.edu/~mhealth/.

**I. Course Goals**

1) To provide orientation and introduction to the broad field of contemporary biomaterials.
2) To develop a global perspective of interdisciplinary fields (biology, materials science, chemistry, and engineering) involved in biomaterials.
3) To provide examples of various applications of biomaterials in different parts of the human body.
4) To learn how to design, synthesize, evaluate, and analyze various types of biomaterials.
5) To develop an understanding of how biomaterials interact with biological system and consequences of these interactions.
6) To familiarize with the current challenges in biomaterials science.

**Structure of Lectures**

1. Materials (Lectures 1, 3)
   - Bulk properties and surface properties
2. Class of materials used in biomedical applications (Lectures 4 - 13)
3. Biological interactions with materials (Lectures 2, 14 - 27)
   - Proteins, cells, and tissues
Biological responses: Inflammation, immunity, toxicity, coagulation, tumorigenesis. Biofilms, Pathological calcification, Biocompatibility

4. Applications of biomaterials (All throughout the course): wound care, ocular, drug delivery, cardiovascular, orthopedic, dental, functional tissues, etc.

II. Grading

a) Midterm exams (2): 40% of grade (20% each)
b) Homeworks: 10% of grade
c) Active Learning/Quizzes/Class Participation: 15% of grade
d) Final Exam: 35% of grade

III Exams

Exams will be split between short-answer type questions and quantitative problems with opportunities for partial credit. Important concepts that might appear on exams will be highlighted in each lecture.

Exam preparation help: Practice problems are shared on Canvas before the Midterm and Final Exams.

No exams in this course is cumulative.

IV Homework

**HWs discussion with other students in the class:** You may discuss HWs with your classmates (it is expected), and work towards solutions together. You must submit individual work that is not a verbatim copy of any other student’s work. Do not forget that even when working in groups, you are individually responsible for your learning.

HWs will be either submitted via TopHat (Course Join Code: 157604) or collected by the IAs each time they are due, at the beginning of the class.

**Late HW Policy:**
Same day late HW: 15% deduction
Next day late HW: 50% deduction
Third day late HW: 100% deduction
V Active Learning/Quizzes/Class participation
Active learning is very important to success in this course. To ensure active learning and engagement in class, we will be using TopHat **(Course Join Code: 157604)** in lectures. You will need access to TopHat course webpage and TopHat App. Your responses to in-class questions will be recorded via TopHat, and these will go towards your participation points.

We will also conduct active learning exercises during each class. Your participation is essential for these activities, and will count towards your participation points.

VI Course Evaluation
Your feedback is extremely important to make this course better and to improve your learning experience. To encourage course evaluation, I will be awarding extra points:
- If more than 90% of the class completes the final class evaluations, 5 points (from the class participation points) will be awarded to all students.
- With your last homework assignment, share a receipt of your course evaluation, and you will be awarded an extra 2 points towards your homework points.

Please note that the course evaluations are anonymous and the final evaluations aren’t available to me until after your final course grades have been submitted.

VII Journal relevant to Biomaterials
- Nature
- Science
- Nature Biotech
- Nature Materials
- Nature Biomedical Engineering
- Nature Communications
- Proceedings of the National Academy of Science USA (PNAS)
- Biomaterials
- Scientific Reports
- Nature Biomedical Engineering
- Science Advances
- Journal of the American Chemical Society (JACS)
- European Cells & Materials (eCM)
- Lab on a Chip
Nanomedicine
Soft Matter
Journal of Biomedical Materials Research Part A

- Others (examples)
  - Critical Reviews in Biomedical Engineering
  - Journal of Biomaterials Science: Polymeric Biomaterials
  - Journal of Biomedical Materials Research, Journal of Controlled Release
  - Journal of Long Term Effects of Medical Implants
  - Journal of Materials Science: Materials in Medicine

VIII Other Textbooks and References
Atala, A; Mooney, D. J. Eds, Synthetic Biodegradable Polymer Scaffolds, Springer Verlag, New York, 1997

IX Honor Code Statement

All students in the BME/MSE/Macro 410 are presumed to be decent and honorable, and as such, are bound by the College of Engineering Honor Code. You may not seek to gain an unfair advantage over your fellow students; you may not consult, look at, or possess
the unpublished work of another without their permission; and you must appropriately acknowledge your use of another's work. Any violation of the honor policies appropriate to each piece of course work will be reported to the Honor Council, and if guilt is established penalties may be imposed by the Honor Council and Faculty Committee on Discipline.

X. Posting or Sharing Course Materials

Do not post any of the course materials online or share them with any of your friends, family or anyone else.

XI. Course Outline
Topics covered may be different than what are listed, based on how slow or fast we are moving in class

<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Homework</th>
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<tbody>
<tr>
<td>1</td>
<td>September 4 (Wed)</td>
<td>Orientation and Introduction to Biomaterials</td>
<td>Ratner: pp xxv to xxxvii, xli-lii</td>
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<td>4</td>
<td>September 16 (Mon)</td>
<td>Surface Characterization and Polymers</td>
<td>Ratner: pp 34-53, 63-109</td>
<td>HW#1 Due</td>
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<td>5</td>
<td>September 18 (Wed)</td>
<td>Polymers and Hydrogels</td>
<td>Ratner: pp 63-109, 166-176</td>
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<td>6</td>
<td>September 23 (Mon)</td>
<td>Polymers and Hydrogels</td>
<td>Ratner: pp 63-109, 166-176</td>
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<td>7</td>
<td>September 25 (Wed)</td>
<td>Hydrogels, Smart Polymers</td>
<td>Ratner: pp 166-176, 247-255</td>
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<td>8</td>
<td>September 30 (Mon)</td>
<td>Medical Fibers and Biotextiles, Biodegradable materials</td>
<td>Ratner: pp 301-319, 179-193</td>
<td>HW#2 Due</td>
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<td>9</td>
<td>October 2 (Wed)</td>
<td>Biodegradable materials, Natural materials</td>
<td>Ratner: pp 179-193, 195-206</td>
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<td>10</td>
<td>October 7 (Mon)</td>
<td>MIDTERM EXAM I During class hours</td>
<td>Lectures 1-9</td>
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<tr>
<td>Date</td>
<td>Lecture</td>
<td>Textbook References</td>
<td>HW/Due</td>
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<td>October 14</td>
<td>STUDY BREAK</td>
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<tr>
<td>October 16</td>
<td>Surface Patterning, Metals</td>
<td>Ratner: pp 276-296, 111-119</td>
<td>HW#3 Due</td>
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<td>October 21</td>
<td>Metals, Ceramics and Glasses</td>
<td>Ratner: pp 111-159</td>
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<td>October 28</td>
<td>Proteins on biomaterials</td>
<td>Ratner: pp 394-407</td>
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<td>October 30</td>
<td>Proteins on biomaterials, Non fouling surfaces</td>
<td>Ratner: pp 394-407, 241-246</td>
<td>HW#4 Due</td>
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<td>November 4</td>
<td>Cell/tissue biomaterial interactions, Cells and surfaces</td>
<td>Ratner: pp 408-422, 452-473</td>
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<td>November 6</td>
<td>Biological response to biomaterials</td>
<td>Ratner: pp 499-503</td>
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<td>November 11</td>
<td><strong>MIDTERM EXAM II</strong> During class hours</td>
<td>Lectures 11-18</td>
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<td>November 13</td>
<td>Inflammation and immunity</td>
<td>Ratner: pp 503-512</td>
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<tr>
<td>November 18</td>
<td>Innate Immunity</td>
<td>Ratner: pp 512-519</td>
<td>HW#5 Due</td>
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<td>November 20</td>
<td>Adaptive Immunity</td>
<td>Ratner: pp 519-532</td>
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<td>November 25</td>
<td>Toxicity, Hypersensitivity, Tumorigenesis</td>
<td>Ratner: pp 545-550, 558-563</td>
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<td>November 27</td>
<td>Clotting and Unclotting, Blood-Material interactions</td>
<td>Ratner: pp 551-557, 617-633</td>
<td>HW#6 Due</td>
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<td>December 2</td>
<td>Biofilms</td>
<td>Ratner: pp 565-579</td>
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<td>December 4</td>
<td>Pathological Calcification</td>
<td>Ratner: pp 739-750</td>
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<td>December 9</td>
<td>Biocompatibility, Biological testing of biomaterials</td>
<td>Ratner: pp 587-616</td>
<td>HW#7 Due</td>
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<tr>
<td>December 18</td>
<td>Final Exam 4 pm - 6 pm</td>
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