BME/CHE 466: Biomaterials (3 credits)

Course Syllabus, Spring 2021

Course Details

Instructor: Dr. Ryan Poling-Skutvik (he/him)

Email: ryanps@uri.edu. Please include [BME/CHE 466] in your subject heading. I sort email into a specific inbox for classes and may miss your email otherwise.

Meeting Times: Wednesdays 4:00 pm to 6:45 pm on Cisco Webex. Link to the meeting will be posted on Brightspace.

Office Hours: Mondays 10 am – 12 pm or email to schedule

Teaching Assistant: Daniel Keane (dkeane@uri.edu). Office hours:

Required Texts: Although there are no required textbooks to be purchased for this course, there are two e-textbooks that are available through the URI library that will be used.

- *Biomaterials*, Brian J. Love. Academic Press 2017. (link)
- *Foundations of Biomaterials Engineering*, M.C. Tanzi, S. Farè, and G. Candiani. Academic Press 2019. (link)

Additional readings and resources will be made available on the course Brightspace.

Course Website: All course materials will be hosted on the dedicated BME/CHE 466 Brightspace.

Technology Requirements: Because all instruction will be conducted online, students are expected to have a personal computer with a high-speed internet access, a webcam, and a microphone. Students are expected to participate in synchronous online meetings as much as possible. If attendance or participation in these meetings will be difficult for you (such as slow internet speed at home, limited working space, or other reasons), please email me explaining your situation and we can work together to develop a plan to help you be successful in this course.

Software: This course will make use of several software programs. Each of these software programs is free to URI students and can be downloaded onto your personal computer. If you have limited access to a computer, there are resources on campus to help students with virtual learning. Please email me and we can develop a solution.

- *Required:* Microsoft Office Suite (https://web.uri.edu/its/office-365/)
- *Required*: Cisco Webex (https://web.uri.edu/its-webex/getting-started-guide/)
- *Recommended:* MATLAB (https://web.uri.edu/research-computing/matlab/)
- *Recommended*: LaTeX compiling software
    - Online (quick and easy): www.overleaf.com
    - Offline: MiKTeX (https://miktex.org/download) for Windows machines or MacTeX (http://www.tug.org/mactex/) for Macs
- *Recommended*: Graphic design software
    - Free: Inkscape (https://inkscape.org/)
    - Paid: Adobe Illustrator (https://www.adobe.com/products/illustrator.html)

Course Description

URI Catalog Description: (3 crs.) A biomaterial is any material designed to interact with a biological system. This course will examine the structure, properties, and processing of biomaterials in a wide variety of biomedical applications.

This class provides an overview of biomaterials, from fundamentals to applications. Biomaterials is a strongly interdisciplinary field that works at the interface between biological systems and materials. Traditionally, this field has focused on producing and characterizing synthetic materials to replace parts of the human or animal body, but modern advances in the field have begun to use biology to create a new generation of materials. To address these advances, this class is structured into three broad categories – synthetic materials, interactions at the biology/material interface, and bio-derived materials.

In the synthetic materials section, we will discuss polymeric, ceramic, and metallic materials that reproduce biological functionality. These synthetic materials are often placed into the body where their interactions with proteins, cells, and other biological species control their fate. To understand these interactions, we will focus on the fundamental physics and biology that underlie the attachment and growth of biological species at the material interface. Finally, we will begin an overview of selected topics in which biology has informed material design and generated novel materials.

Throughout the semester, we will cover the following topics:

- Introduction and classification of biological and synthetic materials
- Phase diagrams and mechanics of metals and ceramics
- Synthesis and characterization of polymers
- Properties and composition of hydrogels and tissue scaffolds
- DVLO theory and colloidal interfacial adsorption
- Bacterial attachment mechanics and biofilm growth
- Recognition of materials by the immune system and their response
- ELISA and diagnostic assays
- Nanoparticle and viral vectors for targeted therapeutics
- Composites of biological and synthetic materials
- Engineering tissues as materials

Course Learning Objectives

By the end of this course, you should be able to do the following:

1. Explain the relationship between biological and synthetic materials
2. Extract mechanical properties of metals and ceramics from experimental data
3. Compare and contrast the properties and characteristics of synthetic polymers and natural proteins
4. Describe and enumerate the stages of biofilm growth
5. Discuss how the body recognizes foreign materials and identify potential methods to mitigate the foreign-body response
6. Construct the recognition pathway of an ELISA diagnostic assay
7. Summarize important properties of an engineering scaffold for tissue growth and regeneration

Course Schedule

Below is a tentative schedule for this course. Given the online environment and potential for significant disruptions this semester as we continue to deal with this on-going pandemic, we may need to significantly revise this schedule throughout the semester.

Week	Day	Date	Topic / SHR Section	Due
1	Wed	01/27	Introduction and Classification of Materials in Body	
2	Wed	02/03	**Synthetic:** Metals and ceramics	
3	Wed	02/10	**Synthetic:** Polymer synthesis	HW #1
4	Wed	02/17	**Synthetic:** Polymer characterization	
5	Wed	02/24	**Synthetic:** Hydrogels and scaffolds	
6	Wed	03/03	**Biocompatibility:** Protein and colloidal adsorption	HW #2
7	Wed	03/10	**Biocompatibility:** Biofilms	
8	Wed	03/17	**Biocompatibility:** Foreign-body response	
9	Wed	03/24	Review for Midterm: **Due 11:59 pm on Sunday 03/28**	HW #3
10	Wed	03/31	**Bio-derived:** Diagnostic assays	
11	Wed	04/07	**Bio-derived:** Drug delivery	
12	Wed	04/14	**Bio-derived:** Biomimetic composites	HW #4
13	Wed	04/21	**Bio-derived:** Tissue engineering	
14	Wed	04/28	Finals week	Final Project

Grading

Your final grade will be calculated based on the following weights:

Homework	20%
Participation	20%
Midterm exam	30%
Final project	30%

Grading Scale

Final letter grades will be assigned based on the following grading scale. I reserve the right to grade on a curve and to adjust the weight of each grading category based on class performance and any unexpected changes (e.g. schedule).

93 ≤ A ≤ 100
90 ≤ A- < 93
87 ≤ B+ < 90
83 ≤ B < 87
80 ≤ B- < 83
77 ≤ C+ < 80
73 ≤ C < 77
70 ≤ C- < 73
67 ≤ D+ < 70
60 ≤ D < 67
F < 60

Homework

Homework is assigned to help you master the course material. Completed homework assignments **will not** be graded in the traditional sense. You will be asked to verify that you have completed each problem set by the beginning of class on Brightspace. During our synchronous meetings, I will ask individual students to present their answers and work to a given problem to the class or in small breakout sessions. These presentations will serve to help you present and defend your assumptions and work, which are fundamental to effective engineering communication. Grades will be based on attempts at the problem but will not be based on if you achieve the correct answer. For homework, I mostly care about **how** you approach problems rather than if you can fully solve them. After all, homework is a learning exercise.

Participation

A significant portion of our synchronous meetings will be targeted to critically thinking about problems and working through examples. Participation is not about getting the "correct" answer but about your willingness to think critically about engineering problems and to justify your best guess. Throughout the course, I expect each student to actively participate three times this semester. Examples of active participation are asking a question, answering a question, or presenting your homework problems. Although you are responsible for insuring that you participate, I will call on students who are behind in their participation.

Exams

There will be one midterm exam for this class. This exam will be take-home and open book. You may print the exam if you have access to a printer, or simply write your answers on blank paper. You will then upload photos or scans of your work to Brightspace for grading.

Office Hours

I will be holding regular office hours during the week to help you with questions about material covered in class, in required readings, or with homework questions. These office hours will be open meetings on Webex where you can join at any time. Attendance at these office hours is completely optional but can be very helpful to understand the material. To incentivize participation, you will receive a bonus of 0.5 percentage points on your final grade for each week in which you attend at least one session of office hours, up to a total of 3 percentage points in a semester (i.e. raise an 80% to an 83%). This bonus credit can also be earned by attending the TA office hours.

Additional Policies

Attendance

As currently planned, this course will be offered fully online for the semester. Attendance is strongly encouraged but I recognize that it may not be feasible for some people at all times. If you know that you will miss a meeting, please email me at ryanps@uri.edu before the scheduled meeting time.

Accommodations for special needs

Your access in this course is important. Please send me your Disability Services for Students (DSS) accommodation letter early in the semester so that we have adequate time to discuss and arrange your approved academic accommodations. If you have not yet established services through DSS, please contact them to engage in a confidential conversation about the process for requesting reasonable accommodations in the classroom.

Academic honesty and integrity

Academic dishonesty, such as plagiarism and cheating, will not be tolerated and will result in immediate disciplinary actions. This includes but not limited to presenting someone else's work in class or on assignments, using unapproved resources during exams, distributing test questions to other students, or communicating with other students during exams. If you have any doubt about what constitutes plagiarism, visit the following websites: the URI Student Handbook, and Sections 8.27.10 – 8.27.21 of the University Manual.

Anti-Bias and Diversity

This class exists as a welcoming environment for **all** students regardless of race, gender, sexual orientation, age, or socioeconomic background. Students are expected to treat faculty and fellow classmates with dignity and respect. If you experience any action that makes you feel unwelcome or unsafe, please let me know and you are additionally encouraged to submit a report to the URI Bias Response Team at www.uri.edu/brt.