

BIOE 370

Biomaterials

Fall 2023

MWF 11:00 am - 12:20 pm (BRC 284)

Course Description

This course will introduce both basic materials science and biological concepts with an emphasis on application of these basic principles to understanding the interactions between materials and biological systems. Topics covered include chemical structure of biomaterials, physical, mechanical and surface properties of biomaterials, biomaterial degradation, and biomaterial processing. Additional topics include protein and cell interactions with biomaterials, biomaterial implantation and acute inflammation, wound healing and the presence of biomaterials, immune responses to biomaterials, biomaterials and thrombosis, as well as infection, tumorigenesis and calcification of biomaterials.

Instructor

Tony Mikos (mikos@rice.edu)

Teaching Assistants

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Office Hours

Tuesday 6:00 - 7:00 pm and Thursday 5:00 - 6:00 pm (Room TBD)

Course Objectives

Students should learn:

1. That the physical and mechanical properties of a biomaterial are derived from its chemical structure. [Course Outcome 1]
2. That the size, shape and properties of a biomaterial should match the requirements of the intended area of application and that various processing techniques can be applied to prepare biomaterials for the intended applications. [Course Outcomes 1-2]
3. That the surface properties of a biomaterial affect the manner in which a material interacts with its environment, and that surface treatments can be applied to modify the surface properties of a biomaterial. [Course Outcomes 3-5]
4. That a biomaterial can induce biological responses through a number of complex mechanisms and that the biological environment can dynamically affect a biomaterial. [Course Outcomes 4-5]

Course Outcomes

Student completing the course should be able to:

1. Apply knowledge of how material subunits for metals, ceramics and polymers interact to form bulk materials to predict the effects of processing parameters (such as thermal treatment) and environmental factors (such as mechanical forces) on the properties and three-dimensional structures of the materials.
2. Integrate understanding of the molecular mechanisms behind environmental degradation of metals, ceramics and polymers in the human body to select and predict the performance of appropriate biomaterials for specific biomedical applications.
3. Harness knowledge of the thermodynamic principles governing protein adsorption to different biomaterial surfaces and the material properties that influence interactions with eukaryotic cells toward the design of biomaterials with properties engineered to control protein adsorption and cell interactions for specific applications.
4. Apply knowledge of the potential effects of the presence of a biomaterial upon the wound healing/inflammatory response, immune response cascade and blood coagulation cascade to select and/or design appropriate materials for specific biomedical applications.

5. Leverage understanding of the steps involved in, and results of, three potentially deleterious responses to implanted biomaterials (infection, tumorigenesis, and pathologic calcification) toward the prediction of the performance of a given biomaterial in a specific biomedical application.
6. Demonstrate awareness of general concepts related to the regulatory pathway for biomaterials and basic ethical and societal issues involved in the development of biomaterials, including the environmental impact of the development and use of biodegradable materials and naturally-derived biomaterials.
7. Identify requirements associated with a potential biomaterial application and to synthesize knowledge from physics, chemistry, biology, and engineering to design a biomaterial for a specified application to meet specific design criteria.

Grade

The final grade will be based 10% on homeworks (total six), 10% on project, 37.5% on first-term exam, 37.5% on second-term exam, and 5% on class participation. The exams will be in-class (one hour and twenty minutes) and closed-books and closed-notes. No late homeworks or project will be accepted (homeworks and project will be uploaded on Canvas by 11:59 pm on the due date). All requests for regrading must be submitted in writing via e-mail to the instructor within one week of the return of the graded assignment or exam. Please note that the instructor reserves the right to regrade the assignment or exam in its entirety, which may result in a credit of points and/or a deduction of points, as appropriate. The score resulting from the regrade will be final, and no additional requests to regrade the particular assignment will be considered.

Absence and Class Participation

Students are expected to attend and actively participate in class. Participation will be determined by the instructor based upon attendance and contributions to classroom discussion, among other factors, and will account for 5% of the final grade.

Required Textbook

J.S. Temenoff and A.G. Mikos, “Biomaterials: The Intersection of Biology and Materials Science,” 2nd Ed., Pearson, Hoboken, 2023. (TM)

Purchase options provided by the publisher include:

Pearson eText: <https://www.pearson.com/en-us/subject-catalog/p/biomaterials-the-intersection-of-biology-and-materials-science/P200000003370/9780137625963>

Rental edition: <https://www.pearson.com/en-us/subject-catalog/p/biomaterials-the-intersection-of-biology-and-materials-science/P200000003370/9780134605456>

Channel partner eBook available on VitalSource:

<https://www.vitalsource.com/products/biomaterials-johnna-s-temenoff-antonios-v9780134632544> or Redshelf: <https://www.redshelf.com/app/ecom/book/2146060/biomaterials-2146060-9780134632544-johnna-s-temenoff-antonios-g-mikos>

Honor Code

Besides the university honor code, the following rules apply:

- As far as the homeworks and the project in this class are concerned, you are allowed to discuss them with your fellow students, the teaching assistants, and the instructor, but you need to write and submit your own work. You need to indicate clearly all your collaborators. You are not allowed to look at homeworks, projects, or exams of previous years. Also, you are not allowed to look at the solution manual of the textbook. The instructor will distribute practice material in class.
- As far as the exams are concerned, you are not allowed to give or receive any help.

Information contained in this syllabus, exclusive of the absence and participation policy, is subject to change with reasonable advance notice, as deemed appropriate by the instructor.

Disability Accommodations

The Americans with Disabilities Act requires that all qualified persons should have equal opportunity and access to education regardless of the presence of any disabling conditions. Any student with a documented disability who needs academic accommodations should 1) visit the [Disabilities Resource Center](#) (DRC) to make sure that the required documentation is on file and 2)

Speak to the instructor as soon as possible. The DRC is located in Allen Center 111, and can also be reached at adarice@rice.edu or x5841.

Mental Health Statement

The wellbeing and mental health of students is important; if you are having trouble completing your coursework, please reach out to the [Wellbeing and Counseling Center](#). Rice University provides cost-free mental health services through the Wellbeing and Counseling Center to help you manage personal challenges that threaten your personal or academic well-being. If you believe you are experiencing unusual amounts of stress, sadness, or anxiety, the Student Wellbeing Office or the Rice Counseling Center may be able to assist you. The Wellbeing and Counseling Center is located in the Gibbs Wellness Center and can be reached at 713-348-3311 (available 24/7).

Title IX Responsible Employee Notification

Rice University cares about your wellbeing and safety. Rice encourages any student who has experienced an incident of harassment, pregnancy discrimination or gender discrimination or relationship, sexual, or other forms interpersonal violence to seek support through The SAFE Office. Students should be aware when seeking support on campus that most employees, including the instructor and teaching assistants, are required by Title IX to disclose all incidents of non-consensual interpersonal behaviors to Title IX professionals on campus who can act to support that student and meet their needs. For more information, please visit safe.rice.edu or email titleixsupport@rice.edu.

Syllabus

Date	Lecture Topic	Lecturer	Reading	Homework/ Project Due
M 8/21	Materials for Biomedical Applications	Mikos	TM Ch. 1	
W 8/23	Materials for Biomedical Applications	Mikos	TM Ch. 1	
F 8/25	Chemical Structure of Biomaterials	Mikos	TM Ch. 2	
M 9/4	No Classes – Labor Day			
M 9/11	Chemical Structure of Biomaterials	Mikos	TM Ch. 2	
M 9/11	<i>Project Posted on Canvas</i>			
W 9/13	Physical Properties of Biomaterials	Mikos	TM Ch. 3	Homework 1
F 9/15	Physical Properties of Biomaterials	Mikos	TM Ch. 3	
M 9/18	Mechanical Properties of Biomaterials	Mikos	TM Ch. 4	
W 9/20	Mechanical Properties of Biomaterials	Mikos	TM Ch. 4	
F 9/22	Biomaterial Degradation	Mikos	TM Ch. 5	Homework 2
M 9/25	Biomaterial Degradation	Mikos	TM Ch. 5	
M 10/2	Biomaterial Processing	Mikos	TM Ch. 6	
W 10/4	Review Session	Mikos		Homework 3
F 10/6	Exam 1			
M 10/9	No Classes – Midterm Recess			
W 10/11	Surface Properties of Biomaterials	Mikos	TM Ch. 7	
M 10/16	Surface Properties of Biomaterials	Mikos	TM Ch. 7	
W 10/18	Protein Interactions with Biomaterials	Mikos	TM Ch. 8	
F 10/20	Protein Interactions with Biomaterials	Mikos	TM Ch. 8	
M 10/23	Cell Interactions with Biomaterials	Mikos	TM Ch. 9	Homework 4
W 10/25	Cell Interactions with Biomaterials	Mikos	TM Ch. 9	
M 10/30	Biomaterial Implantation and Acute Inflammation	Mikos	TM Ch. 10	
W 11/1	Wound Healing and the Presence of Biomaterials	Mikos	TM Ch. 11	Homework 5
F 11/3	Immune Response to Biomaterials	Mikos	TM Ch. 12	
M 11/13	Immune Response to Biomaterials	Mikos	TM Ch. 12	
W 11/15	Biomaterials and Thrombosis	Mikos	TM Ch. 13	Project
M 11/20	Infection, Tumorigenesis and Calcification of Biomaterials	Mikos	TM Ch. 14	
W 11/22	No Classes – Thanksgiving Recess			
M 11/27	Review Session	Mikos		Homework 6
W 11/29	Exam 2			

Homeworks

<p>Homework 1</p> <ol style="list-style-type: none"> 1. (20 points) TM problem 1.1 2. (20 points) TM problem 1.4 3. (20 points) TM problem 2.1 4. (20 points) TM problem 2.5 5. (20 points) TM problem 2.9 	<p>Homework 4</p> <ol style="list-style-type: none"> 1. (25 points) TM problem 7.4 2. (25 points) TM problem 7.8 3. (25 points) TM problem 8.3 4. (25 points) TM problem 8.4
<p>Homework 2</p> <ol style="list-style-type: none"> 1. (20 points) TM problem 3.1 2. (20 points) TM problem 3.4 3. (20 points) TM problem 4.1 4. (20 points) TM problem 4.3 5. (20 points) TM problem 4.4 	<p>Homework 5</p> <ol style="list-style-type: none"> 1. (25 points) TM problem 9.4 2. (25 points) TM problem 9.5 3. (25 points) TM problem 10.5 4. (25 points) TM problem 10.6
<p>Homework 3</p> <ol style="list-style-type: none"> 1. (20 points) TM problem 5.1 2. (20 points) TM problem 5.3 3. (20 points) TM problem 5.5 4. (20 points) TM problem 6.1 5. (20 points) TM problem 6.2 	<p>Homework 6</p> <ol style="list-style-type: none"> 1. (25 points) TM problem 11.4 2. (25 points) TM problem 12.5 3. (25 points) TM problem 13.1 4. (25 points) TM problem 14.3