

JMB1050: Biological and Bio-inspired Materials -- Winter 2021

Institute of Biomedical Engineering
Department of Materials Science & Engineering

Course Instructor: Eli Sone
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Office Hours: By appointment

Guest lecturers: Dr. Magdalena Wojtas, BME
Prof. Ben Ganss, Dentistry
Prof. Karina Carneiro, Dentistry
Prof. Naomi Matsuura, MSE/BME

Weekly meeting: Wednesday, 10-12
Location: Online, synchronous (via zoom, attendance required)

Course Description:

This course, offered jointly through BME and MSE, covers fundamental aspects of the formation, structure, and properties of natural materials, and the use of derived biological principles such as self-assembly and mineralization to design synthetic materials for a variety of applications. Examples are drawn from both structural and functional biomaterials, with emphasis on hybrid systems in which protein-mineral interactions play a key role, such as mineralized tissues and biological adhesives. Additional materials with remarkable mechanical, optical, and surface properties will be discussed. Advanced experimental methods for characterizing interfacial biological structures will be highlighted, along with materials synthesis strategies, and structure-property relationships in both biological and engineered materials.

Prerequisite:

Students should have a physical sciences/engineering background and have some familiarity with basic concepts in biochemistry and cell biology.

Course format:

The course material covers three main areas: (i) Biomineralization and composite materials; (ii) Bioinspired self-assembled materials; and (iii) Bioadhesion and biomimetic adhesives (see schedule for details). The course will be run as a kind of “guided journal club”/seminar, in which we will explore recent and/or seminal papers on various topics in these areas. Typically, the first hour of class will consist of a journal club presentation and discussion led by students. In the second hour, the instructor or guest lecturer will introduce a new topic to provide the

conceptual basis and context for the next week's topic. Readings will often be assigned as background in advance of the lecture.

Marks distribution:

Journal club presentation	30%	ongoing
Participation	10%	ongoing
Research Proposal pitch presentation	10%	March 10 and March 17
Research Proposal letter of intent	10%	March 24
Research proposal	40%	April 14

Journal club presentation

Each student (typically in pairs, depending on final course enrolment) will lead one journal club presentation and discussion during the course, based on recent literature that connects closely to the topic of the previous week's lecture. A list of papers and doodle survey will be made available in week two, and slots will be filled on a first-come, first-served basis. The length of each presentation and discussion will be one hour.

While all students are expected to read the journal club article in advance, the presenters are expected to have an in-depth knowledge of the paper and both present the paper and lead a discussion. The presentation should summarize the major findings and significance of the paper, and also explain key background principles and important techniques. Significant criticisms, limitations, and/or future directions should be discussed where relevant.

Participation

Students are expected to attend and participate in both lectures and journal clubs, having read assigned readings or the journal club article. Please bring the journal club article(s) with you to class, along with your notes, comments, or questions. In both lectures and journal clubs there will be plenty of opportunity for class discussion and questions. The participation mark will reflect both attendance and participation in class discussions during lectures, journal clubs and research proposal pitch presentations.

Research proposal

The final course assignment will consist of an original research proposal on a topic of the student's choosing, within the field of biological and bio-inspired materials. The topic need not be one that was covered in the course and should not be closely related to the student's thesis topic. The proposal will follow the formatting requirements of an NSERC Discovery Grant and will be due on Wednesday April 14 (submission via Quercus). Prior to submission of the proposal, a one page "letter of intent" is due on Wednesday March 24 (submission via Quercus). The letter of intent should also follow NSERC format and should provide a summary of the proposed research topic, objectives, and significance. No late submissions will be accepted for either the letter of intent or full proposal.

During the March 10 and March 17 lectures, each student will present a short research proposal pitch to the class of ~5 min., followed by 5 min. of questions/discussion.

Course schedule:

Week One – January 13

Introduction to the course

E. Sone

Week Two – January 20

Lecture 1 – Principles of Biomineralization

E. Sone

Lecture 2– Intrinsically disordered proteins in biomineralization

M. Wojtas

Week Three – January 27

Journal club 1 - Intrinsically disordered proteins

Students

Lecture 3– Bone: Formation, structure, and properties

E. Sone

Week Four – February 3

Journal club 2 – Bone structure and formation

Students

Lecture 4 – Mechanism of collagen mineralization

E. Sone

Week Five – February 10

Journal club 3 – Collagen biomineralization

Students

Lecture 5 – Bio-inspired scaffolds for bone regeneration

E. Sone

Week Six – February 17

No class – Reading Week

Week Seven – February 24

Journal club 4 – Scaffolds for bone regeneration

Students

Lecture 6 –DNA-based materials and mineralization

K. Carneiro

Week Eight – March 3

Lecture 7 – Enamel

B. Ganss

Journal club 5 – DNA nanostructures

Students

Week Nine – March 10

Research Proposal Pitch Presentations

Students

Week Ten – March 17

Research Proposal Pitch Presentations

Students

Week Eleven – March 24

Journal club 6 – Enamel

Students

Lecture 9 – Phospholipid bubbles for imaging and therapy

N. Matsuura

**Research proposal letter of intent due*

Week Twelve – March 31

Journal club 7 – Bioinspired nanoparticles
Lecture 10 – Mollusk shells and teeth

Students
E. Sone

Week Thirteen – April 7

Journal club 8 – Mollusk-inspired materials
Lecture 11 – Bioadhesion

Students
E. Sone

Week Fourteen – April 14

Journal club 9 – Biomimetic adhesives I
Journal club 10 – Biomimetic adhesives II

Students
Students

**Research Proposal due*