ENGR3810:
Structural Biomaterials

Course Syllabus

2012 Fall Semester
Franklin W. Olin College of Engineering

August 31, 2012

Course Information:

From the Registration Booklet:

ENGR 3810 Structural Biomaterials
Instructor: Chachra
Credits: 4
Prerequisites: SCI 1410; SCI 1210 recommended (as pre- or co-requisite)

How is a blood vessel like a garden hose? Why are seashells strong (and beautiful) even though they are made of chalk? How can your pink and squishy tendons be made of the same material as your transparent corneas? This course focuses on the materials science of natural tissues, primarily ones that fill structural roles, including bone, teeth, tendon, nacre, and wood, with an emphasis on how they are similar and different to 'engineering' materials. Additional material may include scaffolds for tissue engineering, biomimetic materials and mechanical properties of individual cells.

Course Objectives:

At the end of this course, students will be able to:

Understand the structure/function relationships in a host of structural biomaterials.

Elucidate the themes common to structural biomaterials, and how they differ from synthetic materials.

Measurable Outcomes:

Tasks that students will be able to complete at the end of this course:

Understand and describe the biological building blocks of structural biomaterials, including proteins, polysaccharides, glycosaminoglycans, and mineral.

Utilise advanced materials science concepts including viscoelasticity, composites, crack propagation, and behavior of non-Newtonian fluids.

Predict the mechanical behavior of biological materials from a knowledge of their structure.

Engage in laboratory research at the intersection of materials science and biology.

Engage in independent research in the current literature and summarize and report their findings.

Competencies:

This course will address, develop and assess the following competencies.

Qualitative analysis, at the intermediate level
Quantitative analysis, at the beginning level
Diagnosis and hypothesis testing, at the intermediate level
Communication, at the advanced level
Life-long learning, at the advanced level

Logistics:

Course Instructor:

Debbie Chachra

Office: MH 264
Phone: x2546
Mobile phone: 617 461 3413 (lab emergencies *only*)
E-mail: debbie.chachra@olin.edu (best way to get in touch with me)

Class sessions:

Monday	1:30 pm – 3:10 pm	AC318
Thursday	1:30 pm – 3:10 pm	AC318

Note that there are no scheduled lab sessions. However, approximately three weeks of the semester will be devoted to an experimental study, utilising the equipment available in the materials science laboratories and elsewhere. You will be expected to work in the laboratory during scheduled class sessions as well as outside of class.

Office Hours:

I will not be instituting formal office hours. If you need to meet with me outside class, please e-mail me to set up an appointment (while you can also just come by, I can't promise I'll be in my office or free to talk to you).

Textbooks:

SA Wainwright, WD Biggs, JD Currey, JM Gosline
Mechanical Design in Organisms
Princeton University Press (1982)

J Vincent
Structural Biomaterials (revised edition)
Princeton University Press (1990)

There's some overlapping content in both books. I recommend that you buy the first (Wainwright). Copies of both books are on reserve in the Olin library.

Additional Reference Materials:

You will likely need to refer to a basic materials science text and a basic biology text:

William D Callister Jr
Materials Science and Engineering: An Introduction (any edition)
John Wiley and Sons, Inc

Donald R Askeland and Pradeep P Phulé
The Science and Engineering of Materials
Thomson Brooks/Cole (2003)

William K Purves, David Sadava, Gordon H Orians, H Craig Heller
Life: The Science of Biology
Sinauer Associates Inc and WH Freeman and Co

Other sources:

Please expect to use additional books, scientific databases, current journals, and interlibrary loan frequently. An in-class library tutorial is scheduled.

Required for lab:

As the lab component of this course is small, I will not be asking you to purchase a lab book. However, if you have some blank pages in an existing laboratory book (or other bound book), feel free to use them. Otherwise, please be conscientious about keeping your laboratory notes together.

Academic Issues:

Overview:

This course synthesizes biological concepts of structure/function relationships with advanced materials science. Its purpose is to acquaint you with the wide array of techniques used by biological organisms to solve materials science problems. Some of the themes of the course include the use of complex mechanisms to prevent crack growth, the role of hierarchies, and the conserved use of a limited set of building blocks. This course will also include additional areas such as protein engineering, biomimetic materials, and the mechanical properties of individual cells.

The material in this course would normally be taught at a graduate level, and I will be teaching it as a discussion-based graduate course. This means that you have to act like graduate students (and no, I don't mean the beer-drinking, softball-playing slacker type). You will be expected to do the readings, critically analyse them, contribute to class discussion, and periodically present papers. You will also be submitting research proposals (both experimental and literature-based), performing the work, and communicating your results to rest of the class.

Schedule:

A draft schedule is attached. It is not meant to be set in stone, and will likely be revised as the semester goes on. You will always receive adequate notice of any changes to the due dates of deliverables.

Grading:

The components within each category may change slightly; any changes will be discussed in class.

Class involvement	5%	*(preparedness, attendance, participation etc)*
Presentation of papers (≥2)	10%	
Laboratory project *(team)*		
Proposal	5%	
Oral presentation	5%	
Written report	15%	
Research project *(individual)*		
Outline/bibliography	5%	
Draft paper	5%	
Presentation	10%	*(talk or poster)*
Written report	20%	
Oral examination	20%	

Assessment:

We will have some formal course assessment midway through the course and I would like you to feel free to contact me if you have any questions or concerns.

Deliverables:

Class involvement:

It is vital that you do the readings prior to attending class! Much of the material we cover will be sufficiently complex that you will benefit from reading it prior to class, and then participating in a discussion to amplify, clarify and expand on the material.

Presentation of papers:

Approximately twice during the semester, you will be asked to give a short (<10 min) presentation of one of the readings. You will be assessed on your understanding of the material, your summation of the key ideas, and the clarity of your presentation.

Laboratory project (team)*:*

The experimental component of the course is your opportunity to explore a biological material of your choice. In general, this will involve exploring some

aspect of the structure-function relationship in a material using the equipment in the materials science and biology labs.

Research Project (individual)*:*

The research project is your opportunity to explore an area of interest in greater depth. You will be submitting an outline and annotated bibliography as it's nominally literature-based, but you can talk to me about other approaches (eg computational)

Final exam:

An oral final exam will be held during the examination period. This exam will assess your conceptual understanding of the material covered in class.

Honor Code Issues:

All students will adhere to the Olin Honor Code. For collaborative work, you are expected to cite your collaborators. I will explicitly tell you when individual work is required.

Time expectations:

As a 4.00 credit course, a well-prepared student should spend 12 hours a week on this course, 3h 20 min of which will be in class.

Schedule v.1.0

Week	*Day*	*Date*	*Topics*
1	F	Aug 31	Introduction and overview
2	T	Sept 4	Review: Mechanical properties, proteins
2	F	Sept 7	Protein rubbers: resilin, abductin, elastin
3	T	Sept 11	Research skills and strategies *(with Dee Magnoni)*
3	F	Sept 14	**Olin Monday – no class**
4	T	Sept 18	Viscoelasticity and collagen
4	F	Sept 21	Discussion of experimental research proposals
5	T	Sept 25	Polysaccharides: cellulose and chitin
5	F	Sept 28	Brittle materials: eggshell, nacre, enamel Experimental research proposal due
6	T	Oct 2	Lab session
6	F	Oct 5	**(Debbie away)** Lab session
7	T	Oct 8	Lab session
7	F	Oct 12	Lab session
8	T	Oct 16	Lab session
8	F	Oct 19	Lab session
9	T	Oct 23	Lab session, discussion of final project
9	F	Oct 26	**(Debbie away)** Lab session
10	T	Oct 30	Composites: wood, keratin
10	F	Nov 2	Presentations of experimental work Experimental draft report due
11	T	Nov 6	Bone
11	F	Nov 9	Outline/annotated bibliography due Structures and failures
12	T	Nov 13	Non-Newtonian fluids
12	F	Nov 16	Final experimental report due TBA: emergent topics
13	M-F	Nov 19-23	***Thanksgiving – no classes***
14	T	Nov 27	TBA: emergent topics
14	F	Nov 30	TBA: emergent topics
15	T	Dec 4	Presentation of independent projects Draft final reports due
15	F	Dec 7	Presentation of independent projects Discussion of themes and wrap-up

Final exam period: final version of independent reports due
individual oral exams