Chemical Engineering 440/540
Biomedical Applications of Chemical Engineering
Fall 2011

Instructor: I.C. Schneider, 3053 Sweeney Hall, (515) 294-0450, ians@iastate.edu

Lecture: MWF 11:00-11:50, 204 Marston Hall

Office Hours: WR 12:00-2:00 or by appointment

Prerequisites: ChE 210 (material and energy balances), Phys 222 (general physics), Math 266 (differential equations)

Text and Materials: J.D. Enderle and J.D. Bronzino, *Introduction to Biomedical Engineering*, Cambridge, 3rd ed. Academic Press (2012). Bruce Alberts, *Molecular Biology of the Cell*, 5th ed. Garland Science (2007).

Course Description: This course is a survey course on biomedical applications of chemical engineering. Because of the breadth of the field, we will not be able to cover all topics in biomedical engineering nor will we be able to fully examine each topic in depth. The course material will cover biomedical engineering techniques used to understand fundamental biology as well as specific applied problems that biomedical engineers are attacking. Medical problem are intrinsically cross-disciplinary and require many different minds including engineers, biologists, doctors, sociologists, political scientists, economists and various others with diverse backgrounds. Engineers particularly bring an aptitude for design. The ability for design manifests through the formulation and application of mathematical models describing physical, chemical and biological systems. As such a significant component of the class will be mathematical modeling in the context of biomedical engineering. Assessment of your conceptual and quantitative understanding of the topics in class will come in the form of homeworks, quizzes and exams and the grading breakdown is shown below. As an added requirement students enrolled in ChE540 will have to complete a final project as mentioned in the course catalog.

Grading (440):

Exam I	16%
Exam II	16%
Quiz I	8%
Quiz II	8%
Quiz III	8%
Quiz IV	8%
Home Problems	24%
Extended HW	12%

Grading (540):

Exam I	15%
Exam II	15%
Quiz I	7%
Quiz II	7%
Quiz III	7%
Quiz IV	7%
Home Problems	21%
Extended HW	11%
Final Project	10%

If you feel that the score you received for homework or an exam was incorrect or unfair, submit to me a typed 1 page document outlining the reason why you think the grade to be incorrect or unfair. I will evaluate the request and regrade the entire homework or exam, not solely the section in question.

Homework: Some homework will be assigned in groups of three or four. You are expected to hand in one copy from each group on time. The homework should be hand written on engineering paper and should be neat and easy to follow. Units are an important part of the material in this course as well as any other chemical engineering course. Answers that do not contain units carried out through the entire calculation will lose points. Late homework will not be accepted unless there is a good reason and I approve of it before the homework is due. Groups are intended to facilitate learning, not hinder it. The

best approach is to do the homework on your own, come to the group meeting and discuss whose approach is correct. It is particularly helpful to really dissect why your thinking was incorrect. You are free to consult members of your homework group, the text, class notes or me without reference.

Exams: Exams will be closed book and comprehensive, however you will be provided information so that "memorization" will be limited. I will only answer questions about the exams during the class hour, so that everyone has the benefit of hearing them. Makeup exams will not be given.

Quizzes: Quizzes will be open book and will be given either the first 25 minutes or the last 25 minutes of class over one or two ideas covered since the last quiz.

Extended HW: There will be a extended HW assignment due towards the middle of the semester and the problem will be solved in groups of three or four. Any books or online references can be consulted, but must be properly referenced. ***No person*** outside of those in the group, except me can be consulted on ***specific*** design questions.

Final Project (ChE 540): ChE 540 students will additionally have an individual project that is due at the end of the semester. It will most likely involve writing a proposal to solve a biomedical engineering problem, but this will be discussed later in the semester.

Expectations and Academic Honesty: I expect you to show up on time to class and remain in class until dismissed. Any absences from class should be brought to my attention at least one day before, barring family emergencies or illnesses. However, if you are running a fever, please stay at home and do not come and expose me or the rest of your classmates. A portion of the lectures will include class exercises, so please bring your book, a pen, paper and a calculator to class. Turn off your cell phones before class and cell phone use during class will not tolerated.

Both the University and Departmental Student Handbooks and the University Catalog contain policy statements with which you should be familiar. Simply stated, anything you turn in under your name is to be your work and not that of others. If others have contributed (knowingly or unknowingly) to your work, they need to be referenced.

Course Objectives:

1. Understand the role of biomedical engineering in society.
2. Develop a broad understanding of molecular-, cellular- and tissue-level principles involved in normal physiology and pathology that impact biomedical engineering problems.
3. Formulate mathematical models to predict behavior of biomolecular or cellular systems.
4. Understand the advantage of a systems biology approach to the analysis of gene and signal transduction networks in the design of disease therapeutics.
5. Understand the role of materials and mechanics in tissue and cellular engineering goals such as the design of artificial tissues, therapeutic delivery systems or diagnostic approaches.

Course Outline Description:

The course outline contains topics marked with either A, B or C. These correspond to topics on systems biology (A), tissue engineering (B) or cellular and molecular engineering (C). Topics will be introduced in the context of a problem and the relevant biology and chemical engineering will be discussed in as much as they will help to answer the question or meet the challenge.

Course Outline:

Date	Topic	Readings
Aug 22	What do biomedical engineers do?	1
24	(A) How are gene networks regulated during disease?	3.2, 6.2, 8
26	(A) How are gene networks regulated during disease?	3.2, 6.2, 8
29	(A) How are gene networks regulated during disease?	3.2, 6.2, 8
31	(A) How are gene networks regulated during disease?	6.2, 8
Sept 2	***HW1 due***, (A) How do therapeutics regulate signal transduction networks?	6.2, 8
5	***Labor Day***	
7	(A) How do therapeutics regulate signal transduction networks?	3.5, 6.2, 7, 8
9	***Quiz I***, (A) How does diffusion and convection affect biological systems?	3.5, 6.2, 7, 8
12	(A) How does diffusion and convection affect biological systems?	3.5, 6.2, 7, 8
14	(A) How does female infertility operate?	4.1-3, 5.3, 6.1-2, 8
16	***HW2 due,*** (A) How does female infertility operate?	4.1-3, 5.3, 6.1-2, 8
19	(A) How does cell migration enhance wound healing?	3.3, 5.1-4, 6.1-2, 8
21	(A) How do mechanics regulate cell biology?	3.3, 5.1-4, 6.1-2, 8
23	***Quiz II***, (A) How do mechanics regulate cell biology?	3.3, 5.1-4, 6.1-2, 8
26	(B) How do mechanics regulate stem cell differentiation?	3.3-4, 5.1-5, 6.1-2
28	(B) How do mechanics regulate leukocyte rolling?	3.3-4, 5.1-5, 6.1-2
30	***HW3 due***, review of mass action kinetics	4.7, 5.1-2, 6.1-6, 14.1
Oct 3	(B) How should artificial kidneys be designed?	4.7, 5.1-2, 6.1-6, 14.1
5	***Quiz III***, (B) How should artificial kidneys be designed?	3.3, 5.1-5, 6.1-6, 7.1-2, 14.2
7	(B) How should artificial kidneys be designed?	3.3, 5.1-5, 6.1-6, 7.1-2, 14.2
10	(B) How are artificial teeth built?	3.3, 5.1-5, 6.1-6, 7.1-2, 14.2
12	review for exam	
14	***Exam I (Proctored by Laura Lara Rodriquez, CBE)***	
17	(B) How should artificial livers be designed? (Elizabeth Whitley, VetPath)	3.3, 5.1-3, 6.1-6, 14.3
19	(B) How should artificial livers be designed? (Amanda Riddle, MCDB)	
21	(B) How should artificial livers be designed?	3.3-4, 5.1-5, 6.1-2
24	(B) How should artificial livers be designed?	3.3-4, 5.1-5, 6.1-2
26	(B) Heart physiology and artificial heart valves.	3.3-4, 4.1-7, 5.1-7, 6.1, 14.2
28	***Extended HW assigned,*** (B) How are artificial blood vessels built?	3.3-4, 4.1-7, 5.1-7, 6.1, 14.2
31	(B) How are artificial blood vessels built?	4.1-5, 5.1-2,5.5, 6.1
Nov 2	(C) How are drugs delivered?	5.1-2, 5.7, 6.7, 7
4	(C) How are drugs delivered?	5.1-2, 5.7, 6.7, 7
7	(C) How are genes delivered?	
9	(C) How are vaccines designed? (Marian Kohut, Kin)	5.1-7, 6.7, 8
11	***Final project assigned (540),*** (C) How are vaccines designed? (Balaji Narasimhan, CBE)	5.1-7, 6.7, 8 5.1-7, 6.7, 8
14	(C) How are cancer diagnostics designed?	
16	(C) How are cancer diagnostics designed?	5.1-2, 6.7, 8, 10.6, 15, 16, 17
18	(C) How are cancer diagnostics designed? (Deb Thompson, McFarland Clinic)	5.1-2, 6.7, 8, 10.6, 15, 16, 17 5.1-2, 6.7, 8, 10.6, 15, 16, 17
21	***Thanksgiving Break***	
23	***Thanksgiving Break***	
25	***Thanksgiving Break***	
28	Bioethics	5.3, 6.2, 10.6, 17
30	***Extended HW(written) due***, Bioethics	2
Dec 2	***Quiz IV***, ***HW4 due***, Clinical trials and patents	2, 5.6, 6.5
5	student presentations (2)	
7	student presentations (2)	
9	***Final project due (540),*** student presentations (2)	

13	***Exam II (Tuesday)***	9:45 -11:45