CHEMICAL ENGINEERING 6T3: Applications of Chemical Engineering in Medicine

January – April 2012

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LECTURE HOURS: Mondays and Thursdays 12:30-1:20 PM T13/125
Tuesdays 1:30-2:20 PM T13/125

COURSE OBJECTIVE:

To impart some detailed knowledge and an overall appreciation of the contributions, actual and potential, of chemical engineering to medicine and biotechnology

TOPICAL OUTLINE:

Introduction - Basic Cell Biology, Biochemistry, Anatomy and Physiology – self study/ group project

Unit 1: Biomaterials - definitions, types (metals, ceramics, polymers), applications, properties, characterization; how to choose the best biomaterial for specific applications

Unit 2: Biological Responses to Biomaterials – protein adsorption, thrombosis, immune/inflammatory responses, proliferation/initial repair, resolution

Unit 3: Tissue Engineering – tissue organization, intracellular communication, scaffold design and preparation, cell selection and culturing, stem cells

Unit 4: Drug Delivery – materials, transport aspects, reservoir vs. matrix systems, degradable systems, commercially available drug delivery systems, nanomedicine, "personalized medicine"

Unit 5: Applications of Chemical Engineering Principles in Medicine – mass transfer (hemodialysis), fluid mechanics (cardiovascular engineering, vessels and valves), thermodynamics (work cycles and artificial hearts), reactor design (bioreactors for tissue engineering), heat transfer (homeostasis, thermotherapy), process control (pharamaceutical standardization)

Unit 6: Professional Skills in Biomedical Engineering – how to read biomedical papers, patents (process, feasibility), bioethics, regulatory considerations → to be discussed throughout the term

FORMAT:

Full class sessions (3 lectures per week), smaller groups for discussion sessions and literature reviews, design projects, skills workshops

ASSESSMENT:

Self-study biology background project	5%
Biomaterials analysis project	8%
Design assignments (2)	25%
Literature discussion	5%
Final examination question and solution	2%
Presentation (on your own research)	10%
Research paper	20%
Final examination	25%

KEY DATES:

January 3 – First class
January 5 – Biology background project available on Avenue
January 17 – Biology background project due (in class; no later than 2:20PM)
January 24 – Topic for final research paper due (e-mail to Dr. Hoare, no later than noon)
Biomaterials analysis project available on Avenue
February 9 – Biomaterials analysis project due (in class; no later than 1:20PM)
Design assignment #1 available on Avenue
February 16 – One-page outline for final research paper due (in class; no later than 1:20PM)
February 20-24– No classes (reading week)
March 1 – Design assignment #1 due (in class; no later than 1:20PM)
Design assignment #2 available on Avenue
March 20 – Design assignment #2 due (in class; no later than 2:20PM)
March 27 – Final examination question and solution due (hard copy in class no later than 2:20PM; electronic copy via e-mail to Dr. Hoare no later than 3PM)
March 27 and March 29 (if necessary) – Graduate student presentations (in class)
April 3 – Research paper due (in class; no later than 2:20PM)

NOTES ON ASSESSMENTS:

- In response to the highly diverse backgrounds on biology in the class, the biology background project to be completed over the first two weeks of class will cover the basic areas of anatomy, physiology, cell biology, and biochemistry that are relevant for understanding the course material. This material will be covered in a self-study format, in which the cell biology module is tested on an individual basis via a multiple-choice quiz on Avenue and the anatomy/physiology and biochemistry modules evaluated via a written assignment. You may work in pairs to complete the anatomy/physiology and biochemistry modules, but only one of the students in the pair can be enrolled in the Chemical Engineering and Bioengineering program.

- The research paper will be written on a topic of your choice. Any topic in the general field of applying engineering principles in medicine will be considered. Please note that there are three due dates associated with the research paper: **January 24** (submit at least two proposed topics for your project via e-mail to Dr. Hoare, hoaretr@mcmaster.ca), **February 16** (submit a one-page outline of your proposed paper), and **April 3** (final research paper due). A marking scheme for the final paper is available on Avenue. Assistance with literature and patent searches will be provided via an in-class workshop early in the semester.
- The Biomaterials analysis project will consist of a mix of applying lecture material and self-study of biomaterial characterization techniques. To assist you with understanding the biomaterial characterization techniques covered in the distributed lecture slides, one class (date TBA) will be allotted to address your questions on this topic in a student-driven tutorial format.
- The major in-term evaluation is in the form of design projects, where you will be tasked with designing a new biomaterial or device (or modifying an existing biomaterial or device) to address a particular biomedical engineering challenge. Please be aware that design projects are NOT research projects - you are not expected to completely review the literature on a topic, but rather should identify a unique design and then justify your choice of that design based on the parameters of the problem you are given and the principles discussed in class. There will be two design projects distributed throughout the term; you should complete one in a group (2-3 students) and one individually. You may choose to do your individual project on either the first or second project distributed, as is convenient for your schedule. Design projects consist of a *maximum* of 4 pages of text (12 pt. font, 1" margins), excluding figures, schematics, tables, and references, although shorter reports are encouraged if you can adequately explain your rationale for each design specification in the allotted space.
- Two journal articles and one patent on various topics will be handed out throughout the term. Three lecture periods throughout the term will be devoted to small group and then large group discussions about specific papers on topics covered during the regular lecture slots. Your literature discussion mark will consist of a combination of your participation in the discussion sections and a (maximum) one page summary of your notes and your assessment of each paper, due at the end of the literature discussion periods. Dates for these sessions will be announced during the term.
- A final exam question (with a full solution) worth 10 marks and based on the material covered in class must be developed and submitted (hard copy and electronic copy required). All questions and solutions will be distributed to the class, with one question selected for inclusion on the final exam.
- The final examination will be scheduled during the normal exam period. The exam will be open-book and will focus on the latter half of the course material, although material from the first half of the course will also be covered. Any calculator may be used on the final examination.
- Guest lecturers from academia and industry will be invited throughout the term to give you a broader view on the diversity and challenges of bioengineering. Attendance at these lectures is expected, and questions regarding their lectures may appear on the final examination.
- The end-of-term presentation will focus on your own research project and how the principles of biomaterials and chemical engineering are applied in your work to address a medical challenge. If your research topic is not related to bioengineering, please speak to Dr. Hoare to identify an appropriate presentation topic. Presentations should be 15-20 minutes in length and will be marked according to the marking scheme posted on Avenue.

ASSESSMENT POLICIES:

- Late evaluations will be assessed a penalty of 10% per school day late. If deadlines cannot be met due to sickness or other valid reasons, the student should inform the instructor prior to the deadline to arrange alternate due dates. If a deadline is missed without informing the instructor prior to the deadline, you *must* complete the McMaster Student Absence Form and forward it to the instructor to receive consideration for waived late penalties.
- No make-up tests or repeated projects will be considered under any circumstance.
- The final percentage grades will be converted to letter grades using the Registrar's recommended procedure. Adjustments to the final grades may be done at the discretion of the instructor.

The following Faculty of Engineering and University Senate policies will be followed in this course:

Plagiarism and Academic Dishonesty: *"You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity."*

"Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university."

"It is your responsibility to understand what constitutes academic dishonesty. For information the various types of academic dishonesty please refer to the Academic Integrity Policy, located at http://www.mcmaster.ca/academicintegrity"

The following illustrates only three forms of academic dishonesty:

1. *Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained. **
2. *Improper collaboration in group work. **
3. *Copying or using unauthorized aids in tests and examinations. **

Privacy: *In this course, we will be using Avenue to Learn. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. Continuation in this course will be deemed consent to this disclosure. If you have questions or concerns about such disclosure, please discuss this with the course instructor.*

Disabilities and Adverse Discrimination: *Students with disabilities can receive accommodations to assist them in the completion of their assignments and exams. Please contact the Centre for Student Development for advice and for arranging assistance." Further info at:* ***http://csd.mcmaster.ca***

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem, that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

RESOURCES:

There is no single textbook is available to cover all aspects of the course. In addition to course notes, available online, the sources in the accompanying list may be found generally useful.

S. Ramakrishna, "Biomaterials: a nano approach" (2010)

J. Park, R.S. Lakes, "Biomaterials: an Introduction" (2007) – available as an e-book

J. Enderle, S. Blanchard, J. Bronzino "Introduction to Biomedical Engineering" (2005).

B.D. Ratner, "Biomaterials Science: An Introduction to Materials in Medicine", 2nd Ed. (2004) – particularly useful for biological response to materials section

L. Di Silvio (ed.), "Cellular Response to Biomaterials" (2009)

J.D. Bronzino (ed.), "The Biomedical Engineering Handbook" (1995)

R. Baker, "Controlled Release of Biologically Active Agents" (1987)

D.A. Lauffenburger and J.J. Linderman, "Receptors: Models for Binding, Trafficking and Signaling" (1993).

D.O. Cooney, "Biomedical Engineering Principles" (1976)

A.C. Burton, "Physiology and Biophysics of the Circulation" (1972)

T.E. Creighton, "Proteins: Structure and Function" (1992)

F. Eirich (ed.), "Rheology" vol 4 (Chapter by Goldsmith and Mason) (1967)

G. Cokelet, H.J. Meiselman, D.E. Brooks (eds.), "Erythrocyte Mechanics and Blood Flow" (1980)

L. Dintenfass, "Blood Viscosity" (1985)

J.O. Rowan, "Physics and the Circulation" (1981)

S. Middleman, "Transport Phenomena and the Cardiovascular System" (1972)

R.L. Whitmore, "Rheology of the Circulation" (1968)

D.N. Ghista *et al* (eds.), "Theoretical Foundation of Cardiovascular Processes" (1979)

D.H. Bergel (ed.) "Cardiovascular Fluid Dynamics" (1972)

D.J. Schneck (ed.), "Biofluid Mechanics 2" (1980)

A.C. Guyton, "Textbook of Medical Physiology" latest edition

A.L. Shrier and T.G. Kaufmann (eds.), "Mass Transfer in Biological Systems" CEP Symposium Series No. 99 (1970)

Shitzer and R.C. Eberhart, "Heat Transfer in Medicine" (1987).

R.C. Seagrave, "Biomedical Applications of Heat and Mass Transfer" (1971)

M.S. Lih, "Transport Phenomena in Medicine and Surgery" (1975)

C.W. Patrick, A.G. Mikos, L.V. McIntire (eds) "Frontiers in Tissue Engineering" (1998)

R.P. Lanza, R. Langer and W.L. Chick (eds) "Principles of Tissue Engineering" (1997)