CHEMICAL ENG 4T03/6T03: Applications of Chemical Engineering in Medicine

January – April 2020

INSTRUCTOR: Dr. Boyang Zhang
JHE A416
Email: zhangb97@mcmaster.ca

TEACHING ASSISTANT: Eva Mueller (muellee@mcmaster.ca)
Mohammad Akhtar (akhtam5@mcmaster.ca)

LECTURE HOURS, LOCATION: Thursday 11:30-1:20pm and Friday 11:30-12:30pm, HH302

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:

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, "personalized medicine"

Unit 5: Special Topics – microsystems for healthcare, introduction to microfluidics and microphysiological systems for drug discovery

ASSESSMENT:

In-class workshops	30%
Design assignment pre-interview	5%
Design assignment pitch (oral + one-pager)	10%
Design assignment report	15%
Midterm test and Final examination	(15% + 25%) = 40% TOTAL

NOTES ON ASSESSMENTS:

- In-class workshops are **mandatory** and are intended to give practical experience in understanding professional issues in biomedical engineering (patents, ethics, reading literature, regulatory) as well as making design decisions (biomaterial choice and characterization, tissue engineering, drug delivery). Assignments will consist of a mix of group and individual evaluation and will be detailed throughout the semester. Attendance will be taken at each workshop, with consideration for missed workshops only evaluated upon presentation of a McMaster Student Absence Form (MSAF). The weighting for excused absences will be transferred to other workshops, not the final exam. A maximum of two excused absences (of the nine workshops presented) will be considered for accommodation via an MSAF except in exceptional circumstances; further missed workshops will result in a mark of zero being applied to that workshop.

- The midterm test and the final exam will be **run in class**. Both the midterm and final exams will be **fully open book** (i.e. you may bring notes and any other reference material you wish to bring). You can also bring your **laptop, but no internet access**. The midterm test is *optional*, with no make-up tests to be arranged (and no MSAFs considered). If you write the midterm test and do better on the final exam, your final mark will be calculated ignoring the midterm mark (i.e. the final exam will account for 40% of the course mark). Alternately, if you do better on the midterm test than the final exam, the midterm test will count for 15% of your mark and the final exam will count for 25% of your mark.

- In the design assignment, you will be responsible for developing a novel biomedical product to address a clinical challenge using concepts from any part of the course (biomaterials, tissue engineering, drug delivery, microsystems, or biomedical devices). You are **strongly suggested** to run your topic past TAs and/or Dr. Zhang prior to starting work on your design to ensure it fits within the scope of the course and is appropriate in scope. This assignment will be done in groups of four students (with at least one student in each group *not* enrolled in the Chemical Engineering and Bioengineering program) and will include three components:

    - A group pre-interview (10-15 minutes long) will be scheduled the week of **March 16-20** in Dr. Dr. Zhang's office in which the group will present its technical design idea within 3 minutes (visual aids are allowed). Technical questions will follow on the idea, with the ultimate goal to ensure the topic is appropriate and the design is technically feasible.

    - A pitch of your design as a new biomedical product, consisting of an oral presentation *no more than three minutes* long (in the style of Dragon's Den) involving any kind of visual aid(s) you wish to use and a *one-page* technology summary (to be distributed immediately before your pitch). The pitch should explicitly cover (1) the problem you are trying to solve, (2) the solution you have proposed (to the level of detail that an investor would be interested in, not necessarily a scientist), (3) the advantages of your solution compared to others (cost, efficacy, robustness, ease of use, etc.) and (4) a preliminary (and brief) estimate of your target market (patient population). Your mark will be weighted equally based on the quality of your pitch (content and delivery) and your responses to questions from the "Dragons", who will be both entrepreneurship experts and industry representatives, as well as your classmates. All students will present during class in the week of **April 6-10**.

    - A written report focused on the scientific design of the product, although also considering practical translational aspects of the design (including market potential, anticipated regulatory pathway, intellectual property, etc.) Reports should consist of a *maximum* of 10 pages of text

(12 pt. font, 1" margins, including figures, schematics, or tables but excluding references), although shorter reports are encouraged if the requirements are met. The report is due on the last day of classes. A full project description and marking scheme are 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, you *must* complete the McMaster Student Absence Form and forward it to the instructor to receive consideration for waived late penalties and/or arrange alternate due dates. Please note that the requirement for an MSAF also pertains to requests for consideration for missed mandatory workshops, as per the guidelines outlined earlier.
- In the event of a snow day, all deadlines will be pushed to the next class unless otherwise announced via Avenue.
- 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 Student Success Centre for advice and for arranging assistance." Further info at:*
https://studentsuccess.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.

D. Williams, "Essential Biomaterials Science" (2014)

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)

W. Mark Saltzmann, "Drug Delivery: Engineering Principles for Drug Therapy" (2001)

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

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

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

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

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

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)

The P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.

Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries (oil/gas, financials, *etc*.) were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- **P**rofessionalism
- **R**esponsibility
- **O**wnership
- **C**uriosity
- **E**mpathy
- **S**elflessness
- **S**ervice

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.