

OFFICE OF THE VICE-DEAN AND CHAIR, FIRST YEAR



FACULTY OF APPLIED
SCIENCE AND ENGINEERING

UNIVERSITY OF TORONTO

November 25, 2005

Professor Edith M. Hillan
Vice-Provost, Academic
Simcoe Hall, Room 221

Dear Edith:

Attached please find the description of a new minor in bioengineering that we would like to publish in our 2006-2007 academic Calendar.

Creation of this minor will be an important step for our faculty in two ways. First, during our recent strategic planning process, Bioengineering was identified as one of the four strategic directions that our Faculty wanted to pursue. Secondly, creation of minors was one of the mechanisms we identified so as to add more flexibility, breadth, and inter-departmental or inter-Faculty teaching to our curriculum. Bioengineering will be the first APSC minor that we would like to establish and add to our Calendar. Creation of this minor will be possible through existing resources within the Faculty, funding awarded by the Provost to the Faculty from the Academic Initiative Fund in particular.

The Undergraduate Bioengineering Minor will be collaborative across the Faculty of Applied Science and Engineering and open to Engineering students interested in learning more about how biology interfaces with engineering. Initially, students in Chemical Engineering, Mechanical & Industrial Engineering, Electrical and Computer Engineering, Materials Science and Engineering, and Civil Engineering will be permitted to participate in the program. This program will be separate from the Engineering Science biomedical engineering option.

Our definition of bioengineering is broad, including all research at the interface of engineering and biology - this includes bioprocesses, environmental microbiology, biomaterials and tissue engineering, bioelectricity, biomechanics, biomedical imaging, nanotechnology in medicine and the environment and engineering design for human interfacing.

The goals of the minor will be to develop students' skills in engineering in the context of bioengineering. The interdisciplinary program will build on the excellence of the professors in the Faculties of Applied Science & Engineering, Medicine and Arts and Science at the University of Toronto. Students will be taught by leading-edge faculty from across the University of Toronto and encouraged to participate in interdisciplinary research collaborations in fourth year thesis and design projects and during the summer prior to fourth year studies.

Pedagogical and other Academic Issues

The educational outcomes of the Minor will be:

1. *Understand the underlying principles at the interface of biology and engineering.*
2. *Use engineering principles to understand, define and solve biological problems.*
3. *Understand and be able to use the math and science underlying bioengineering.*
4. *Apply the principal assumptions, methodologies, and applications of bioengineering to design solutions*
5. *Apply his/her understanding of bioengineering in order to devise and sustain arguments, solve problems, and incorporate knowledge derived from current research, advanced scholarship and professional practice.*
6. *For those pursuing a thesis or design project, solve bioengineering design problems working effectively on an interdisciplinary team and / or independently*
7. *Master sufficient knowledge of bioengineering for continued lifelong learning in the discipline.*

Students in the Bioengineering Minor will achieve these outcomes by taking a total of 6 “bioengineering” courses, from a list of approved courses. The Bioengineering Minor will provide students with greater depth in bioengineering than was previously possible and ensure a multi-disciplinary and enriched academic experience. Moreover, students will have a greater appreciation for the complexity of biology and how this integrates with engineering.

Students completing the minor will be better prepared for careers in the following industries or organizations: pharmaceutical, medical devices, medical diagnostics, health care delivery, agriculture, forestry, management of natural resources (e.g. water, land, oil, minerals), regulatory and policy development, sustainable energy generation, transportation, waste management, bioremediation, biomaterials, bio-mechanical devices, bioinformatics, medicine. Students will also be better equipped for interdisciplinary research for those interested in academic careers.

Projected Student demand

The Bioengineering Minor begins with two pre-requisite courses, the first of which is CHE353F, Engineering Biology. This course is being taught for the first time this year, as part of the bioengineering streams, and currently has approximately 190 students enrolled. The students come primarily from Chemical Engineering (107), Electrical and Computer Engineering (37) and Mechanical Engineering (40), with a small number of students from Materials Science and Engineering (2).

The second pre-requisite is one of CHE354, Cellular and Molecular Biology or MIE331, Physiological Control Systems. The enrolment in each of these new courses is currently 93 and 47 respectively. These students also come from a range of programs. In CHE354, 63 students come from Chemical Engineering and Applied Chemistry; 10 from Mechanical; 19 from Electrical and Computer Engineering; and 1 from Materials Science. In MIE331, 12 students come from Chemical Engineering and Applied Chemistry, 5 from Electrical and Computer Engineering; and 30 from Mechanical. The multi-departmental representation among the student

population enrolled in these courses gives a good indication of the intended cross-disciplinary nature of the Bioengineering Minor.

Impact on the program

The Bioengineering Minor will provide students with an enriched academic experience. This will be achieved by adding new courses and enriching current courses with laboratory experiences. Emphasis will be placed on attracting excellent students to both the Faculty and to the Minor after 2nd year. Many high school students are interested in both Life Sciences and Engineering. Hence the availability of the Bioengineering Minor is expected to help recruit top quality high school students to our Faculty and University.

The interaction among Departments within Applied Science and Engineering is expected to increase as efforts are made to open up the Bioengineering related course to students from different departments or programs that meet the pre-requisites and are able to schedule these courses.

Consultation

A steering committee was consulted in designing the Bioengineering Minor that includes both faculty and undergraduate counselors: Ross Ethier (Director, IBBME), Doug Reeve (Chair, Chem Eng), Tony Sinclair (Chair, MIE), Paul Young (Chair, Civ), Doug Perovic (Chair, MSE), Elizabeth Edwards (Associate Professor, Chem Eng), Chris Yip (Associate Professor, Chem Eng. / IBBME), Berj Bardakjian (Professor, IBBME / ECE), Bryan Keith (Lab Tutor, IBBME), Craig Simmons (Assistant Professor, MIE / IBBME), Greg Evans (Vice-Dean), Frank Kschischang (Undergraduate Curriculum Chair, ECE), Mark Kortschot (Undergraduate Associate Chair, Chem Eng), Willy Wong (Associate Professor, ECE/IBBME), Ron Hoffman (Assistant Professor, Civ), Luisa Gomes (Undergraduate Counsellor, Chem. Eng), Ella Lund-Thomsen (Undergraduate Counsellor, ECE), Colleen Kerluk (Undergraduate Counsellor, Civil), Mac-Yu Tan (Undergraduate Counsellor, MIE).

The Minor was thoroughly reviewed by the Faculty's Curriculum Committee that includes representatives from each undergraduate Program and approved by Executive Committee and Faculty Council. While the Bioengineering Minor is open only to Engineering students, there will likely be select courses within the Bioengineering Minor that will be of interest as electives to Arts and Science students.

Consistency with objectives, mission, and academic plans.

The institution's academic plan includes multi-disciplinary training which has some depth associated with it. The bioengineering minor represents these goals well, providing students with 6 courses that build on each other and extend from there.

The learning objectives of the degree are to prepare students for careers in engineering, whether in industry or academia. The Bioengineering Minor prepares students for careers in multi-disciplinary fields as described above.

"Employment of biomedical engineers is expected to grow faster than the average for all occupations through 2012. The aging of the population and the focus on health issues will increase the demand for better medical devices and equipment designed by biomedical engineers. For example, computer-assisted surgery and molecular, cellular, and tissue engineering are being more heavily researched and are developing rapidly. In addition, the rehabilitation and orthopedic engineering specialties are growing quickly, increasing the need for biomedical engineers. Along with the demand for more sophisticated medical equipment and procedures is an increased concern for cost efficiency and effectiveness that also will boost demand for biomedical engineers. However, because of the growing interest in this field, the number of degrees granted in biomedical engineering has increased greatly, leading to the potential for competition for jobs." From the Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2002-03 Edition, <http://www.bls.gov/oco/ocos262.htm>.

Appropriateness of the program's structure and curriculum

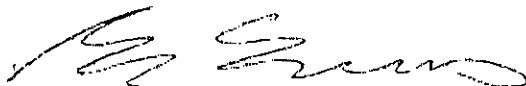
The structure of the Bioengineering Minor was developed so as to be consistent with the Faculty's blueprint for APSC minors. As such, the Minor provides elements of breadth and depth. Consistent with our requirements for an APSC minor, students will be required to complete six half courses related to Bioengineering, with at least two of these being foundational courses. They will also have the opportunity to pursue a Bioengineering thesis or design project, and to pursue a variety of electives. The Curriculum Committee thoroughly reviewed the proposal so as to ensure that the overall structure and courses were appropriate.

Faculty Involvement

Faculty members from each department have been identified as meeting the criteria of having bioengineering research programs and equipped to teach bioengineering curriculum. The Director, Molly Shoichet, is a Professor in Chemical Engineering and Applied Chemistry and Biomaterials and Biomedical Engineering and holds the Canada Research Chair in Tissue Engineering (Tier I). Prof. Shoichet holds numerous other academic awards recognizing excellence in research (NSERC Steacie Fellow, CFI Career Award, CIAR Young Investigator Award, UofT's McLean Award, etc) and is dedicated to making the Bioengineering Minor an excellent and rich academic experience for the undergraduate students.

In summary, we are very excited about this move to incorporate Bioengineering into our undergraduate curriculum in a formal way. We hope that Academic Priorities and Planning will share this enthusiasm and concur with our recommendation that this Minor be implemented effective 2006-07.

Sincerely,



Greg Evans
Vice-Dean, Undergraduate

Report on the Bioengineering Minor Course of Study

The Curriculum Committee of the Faculty of Applied Science and Engineering herewith presents its report and proposal for the establishment of a Bioengineering Minor Course of Study in the Faculty. The Committee acknowledges the indispensable work of Professor Molly Shoichet, the proposed Director of this new initiative, in developing and formulating its objectives and requirements.

The list of bioengineering-designated courses is intended to be an initial collection of approved courses for the successful completion of a bioengineering minor. Additions and deletions are anticipated as warranted.

Respectfully submitted,
Gabriele M T D'Eleuterio
Frank R Kschischang
Cochairs, Curriculum Committee
7 November 2005

Preamble

The Undergraduate Bioengineering Minor Course of Study is a collaborative effort across the Faculty of Applied Science and Engineering and is open to Engineering students interested in learning more about biology and its relation to engineering. Our definition of bioengineering is broad, reaching to all areas at the interface of engineering and biology. This includes bioprocesses, environmental microbiology, biomaterials, tissue engineering, bioelectricity, biomedical imaging, biomechanical engineering, nanotechnology related to medicine and the environment, and engineering design for human interfaces. At present, students in Chemical Engineering, Mechanical and Industrial Engineering, Electrical and Computer Engineering, Materials Science and Engineering and Civil Engineering are eligible to participate in this minor course of study.

Requirements for a Bioengineering Minor

The requirements for a Bioengineering Minor in the Faculty of Applied Science and Engineering are the successful completion of the following courses:

1. CHE353F—Engineering Biology;
2. One of
 - (i) CHE354S—Cellular and Molecular Biology, *or*
 - (ii) MIE331S—Physiological Control Systems;
3. Four (4) other electives from the list of bioengineering-designated courses¹

subject to following constraints:

1. Students must ensure they meet the requirements of their chosen engineering-degree program or Option therein;
2. Not more than one (1) program or Option core course can be counted among the required six (6) courses listed above; a thesis or a design-project course will not be considered a program or Option core course (for the purposes of this definition);

¹ If a student takes both CHE354S *and* MIE331S, one of these courses can be counted as one of the four electives.

3. At least two (2) of the courses must have a foundational course (CHE353F, CHE354S, MIE331S) as a prerequisite or corequisite²;
4. A thesis or design-project course (but not both) can be counted as a required elective (or two required electives if it is a full-year course) provided that the thesis or project focuses on bioengineering; this will require the approval of the Director of the Bioengineering Minor Course of Study.³
5. Availability of the bioengineering-designated courses (including the foundational courses) for timetabling purposes is *not* guaranteed; the onus is on the student to ensure compatibility with their timetable.

List of Bioengineering-Designated Courses

Students must secure approval from their home department before selecting any elective outside their home department.

Course Title	Course Code	Weight
<i>Engineering Biology</i> ⁴	CHE353H1F	0.5
<i>Cell and Molecular Biology</i> ⁵	CHE354 H1S	0.5
<i>Physiological Control System</i> [†]	MIE331H1S	0.5
Food Engineering	CHE462H1S	0.5
Bioprocess Engineering	CHE466H1F	0.5
Chemical Properties of Polymers	CHE461H1S	0.5
Treatment Processes	CIV540H1F	0.5
Cellular Bioelectricity	ECE445H1F	0.5
Sensory Communication	ECE446H1F	0.5
Biomedical Imaging	BME595H1	0.5
Industrial Ergonomics	MIE343H1F	0.5
Biomechanics	MIE439H1S	0.5
Engineering Psychology and Human Performance	MIE448H1F	0.5
Bioinformatics Systems	MIE453H1F	0.5
Biomaterial Processing and Properties	MSE440H1F	0.5
Surgical and Dental Implant Design	MSE442H1S	0.5
Plant Design [‡]	CHE430Y1F	1.0
CHE Thesis ⁶	CHE499Y1Y	1.0
Design Project [‡]	CIV425Y1Y	1.0
CIV Coordinated Program Thesis [‡]	CIV489H1F/S	0.5
CIV Thesis [‡]	CIV499H1F/S	0.5
ECE Design Project [‡]	ECE496Y1Y	1.0
MIE Thesis [‡]	MIE496Y1Y	1.0
MSE Industrial Research Project [‡]	MSE410Y1Y	1.0
MSE Plant Design for Process Industries [‡]	MSE450H1F	0.5
MSE Coordinated Program Thesis [‡]	MSE489Y1Y	1.0
MSE Thesis [‡]	MSE499Y1Y	1.0

² CHE354S and MIE331S themselves satisfy this requirement as they require CHE353F as a prerequisite.

³ Such thesis or design-project courses can also be counted among the two required courses with a foundational prerequisite or corequisite.

⁴ Core for all students undertaking the Bioengineering Minor.

⁵ At least one of CHE354S or MIE331S is required by all students undertaking the Bioengineering Minor.

⁶ A thesis or design-project course (but not both) can be counted as a required elective (or two required electives if it is a full-year course) provided that the thesis or project focuses on bioengineering; this will require the approval of the Director of the Bioengineering Minor Course of Study.