McGill
Faculty of Engineering

Course Outline
BIEN 580

Department of Bioengineering
BIEN 580 – Synthetic Biology
Syllabus

Course outline:
Spanning the boundary of biology, engineering, and physical sciences, Synthetic Biology is broadly defined as the construction and reconstruction of biological systems for practical applications in research and industry. Emphasis is placed on fundamental knowledge and central technologies: engineering principles in biology, BioBricks and standardization of biological components, parts registries, advanced molecular biology tools for DNA assembly, genome editing, high-throughput genetic manipulation methods, construction of biological pathways, strategies for transcriptional control, examples of engineered systems.
The course will offer fundamental knowledge of central technologies in Synthetic Biology, advanced tools for integration of basic synthetic units into multi component devices, and modern analytical techniques for designing and testing new systems.

Prerequisites: Permission of instructor

Audience: This course is appropriate for upper-level undergraduate and graduate students.

Instructor: Assist. Prof. Codruta Ignea (codruta.ignea@mcgill.ca)

Office Hours: By appointment.

Course material: There is no required textbook. Required reading materials (consisting of selected original research papers and review articles), lecture slides and assignments will be posted on the McGill myCourses (accessible via www.mcgill.ca/lms).

Course evaluation and grading:

- Active participation during coursework	5%
- Literature presentation	25%
- Written Assignments and Quizzes	10%
- Bioethics roundtable	10%
- Final exam / Case study	50%

Final Exam:

- Type of assessment**:**
  Individual oral examination, 20 min (no preparation time) based on discussion/questions to the presentation of case study, report and to synthetic biology in general.
- Exam registration requirements:
  The exam requires submission of all assignments and laboratory reports and a passing average grade in quizzes.
- Re-exam
  Re-exam as ordinary exam. If the requirements are not met a report on a given topic must be handed in no later than 2 weeks before the re-exam.

Learning Objectives:

Graduate attribute	**KB**	**PA**	**IN**	**DE**	**ET**	**IT**	**CS**	**PR**	**IE**	**EE**	**EP**	**LL**
Level descriptor	D	I	I	A	n/a	D	D	n/a	n/a	n/a	n/a	D

Participants enrolled in this course should:

- Obtain knowledge and understanding about synthetic biology and its importance in modern society, and its current and future applications (KB.4, KB.8, PA.1, PA.4, IT.1, IT.4).
- Learn basic concepts and advanced technologies that facilitate the building of biological parts and systems (KB.4, KB.8, PA.3, PA.4, IT.1).
- Have developed abilities to design biological systems, chassis, devices and parts (PA.1, PA.2, DE.1, DE.2, DE.3)
- Be able to apply modularity, standardization, and abstraction principles in design of biological systems (PA.1, PA.2, DE.1, DE.2, DE.3).
- Be able to integrate the design-build-test-learn cycle in synthetic biology projects (KB.8, PA.1, IT.1).
- Have acquired skills to efficiently engage in interdisciplinary group work (IT.2, DE.4, ET.1, ET.2, ET.3, IT.1, IT.2, IT.3).
- Be able to discuss and debate relevant scientific literature (IT.1, IT.4, CS.1, KB.8)
- Be able to consider ethical decisions and containment strategies in this field (EE.1, EE.3, CS.1, CS.2, CS.4).
- Become familiar with entrepreneurial aspects of using synthetic biology (KB.4, KB.8, CS.1, CS.2, CS.4).

Preliminary Course Schedule:
Week 1 - Synthetic Biology overview. Central Dogma. Concepts & principles. Achievements & perspectives.
Week 2 - Enabling technologies. Next generation sequencing. DNA synthesis. Bioethics.
Week 3 - Biological Parts. Part repositories. Biological circuits
Week 4 - Genome Editing. Gene Expression Fundamentals. Optogenetics
Week 5 - Synthetic Biology for Sustainability Case Studies – Introduction.
Week 6 - Synthetic metabolism. Orthogonality, Compartmentalization, Protein engineering

Week 7 - Modularity & standardization. Construction of synthetic pathways, combinatorial biosynthesis.
Week 8 - Expansion of the genetic code. Artificial life. Bottom-up synthetic biology
Week 9 - Sustainability actions. Sustainability Development Goals from a Synthetic Biology perspective
Week 10 - Entrepreneurship, spin-offs and industrial enterprises. Industry Guest lectures.
Week 11 - Synthetic Biology for Sustainability Case Studies – Feedback on development
Week 12 - Bioethics roundtable
Week 13 - Synthetic Biology for Sustainability Conference Case Studies – presentation

Teaching and learning methods:
Delivery of material in lecture format (40%)
Group work, active learning, seminars (30%)
Demonstrations, experiments, simulations (30%)

Assignments and Quizzes:
There will be literature presentations and written assignments, which should be handed in at an announced due date. Quizzes (15-20 min) will usually be on seminar days covering all material to date. The lowest quiz score will not count towards the student's final grade. There will be no make-ups for missed quizzes. Students are encouraged to work together on assignments; individual solutions must be handed in, however.

Literature Presentation: One research article will be assigned for a team of 2-3 students. The group will be responsible for leading a roughly ~25-minute discussion about a research topic exemplified with a lead article and its relevance to the course, based on a slide presentation. All students are to read these assigned topics and discussion participation will be graded. Team composition and details about presentations will be provided on myCourses.

Case Study Presentation: A team of 2-3 students will be assigned one research topic in week 5 of the course. Students will research this topic/molecule and prepare a prograss presentation of 10 min on the case-study development and discuss their project with the class. Student will prepare a 10 pages proposal a 15 min presentation for the final exam. Due date for handing in for the written summary will be announced on myCourses.

Synthetic Biology for Sustainability Case Study Report – structure
Description of the problem

1. Proposed solution. Objectives
2. Methodology/Implementation
3. Feasibility of the project and alternative plan (what can go wrong/what will you do?)
4. Bioethics, Biosafety, Biosecurity considerations
5. Sustainability relevance
6. Industrial application - product development - business model, if applicable
7. Novelty and Impact (further expansions of the technology)
8. References
9. Figures and legends

Must include the following:

- Considerations about abstraction/modularity
- Description of the chassis, parts and devices used

- Design approaches towards standardization of the parts and (if possible/relevant) design of the biobricks used.

Recommended:

- Build a good story.
- Consider novelty, impact on the society and/or the environment, feasibility
- Utilize contingency plan.

Language of Written Work:
In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

Academic Integrity:
McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see www.mcgill.ca/students/srr/honest/ for more information).

Disabilities:
If you have a disability, please contact the instructor to arrange a time to discuss your situation. It would be helpful if you contact the Office for Students with Disabilities at (514) 398-6009 before you do this.