**Department of Electrical & Computer Engineering and Department of Biology**
**Concordia University**

# BIOLOGICAL COMPUTING & SYNTHETIC BIOLOGY

**Winter Term of Academic Year 2021/22**

**>> Course Outline <<**

## ➢ Course Instructor

Nawwaf Kharma, MSc (Biology), PhD (Machine Learning)
Lectures: Tuesdays 14:45 – 17:30
Office Hours: Fridays 12-1 (on-line)
E-mail: nawafkharma@gmail.com

## ➢ Office Hours

I expect students to contact me by E-mail to schedule a ZOOM session during my office hours to ask their questions related to the course material or their assignments. Please type COEN433 in the message subject line.

## ➢ Brief Description & Objectives

This course is an interdisciplinary course with 2.5 class hours of lectures scheduled every week. This course is, in essence, about designing computational machines that can be implemented in biological media, mainly cells. Typically speaking, a computational functionality is required. A target implementation platform (e.g. *E. coli* bacteria) is decided upon, and a network of interacting genes is designed. That network, which is called a Gene Regulatory Network (GRN), is modeled using available simulation software. If the simulation is satisfactory, then actual physical genes can be synthesized using recombinant DNA techniques, and then added to the genome of a cell. The result is a cell (or, in some cases a sheet of cells) that implements, as part of its overall functionality, a designed computational ability. The modified cell, as a whole, may be viewed as a biologically engineered robot with sensing (e.g. arsenic concentration), information processing and output capabilities (e.g. fluorescence). Applications range widely, from bio-sensing to gene silencing.

You will learn how to design your own GRN, and in a multidisciplinary team of 2-4 students (min of 1 bio and 1 comp student per team), you will propose a design to the instructors. In preparation for this, you will be given a ~3-week crash course in Molecular Biology, Digital Logic and some Modeling, followed by mainly research-paper-based lectures on fundamental and recent works in Synthetic Biology. Modeling is returned to later in the course and will be part (though not necessarily big) of your project. The aim of the course is to empower and inspire inquisitive minds to want to learn more and do research in computational Synthetic Biology.

## ➢ Textbook & Papers

This course has no textbook. All the slides used in the lectures will be made available to you through Moodle. Also, all the research papers used for the latter part of the course will be available to you in PDF format. You are expected to attend every lecture, participate in it, and take your own notes.

- **Detailed Course Plan**

**Lecture Topics (by week) *with* tests, unmarked assignments, project report and final assay:**

W01. Introduction to Molecular Biology (MB) and Digital Logic (DL)
W02. Introduction to MB and DL continued
W03. Qualifying Test (on MB and some DL)
W04. DL material concluded + Assignment (published) #1
W05. *Combinational* Genetic Regulatory Networks
W06. *Sequential* Genetic Regulatory Networks
W07. Cloning Methods: *how to build it?* (Guest Lecture)

W08. Spring Break

W09. Midterm Test (on Genes, GRNs, Cloning)
W10. Modeling Lecture + Intro to Project + Assignment (published) #2
W11. Connecting to the World;
W12. Connecting to Each Other
W13. Cell-Free synthetic biology
W14. Synthetic Biology: *what next?* Possible Futures

Team Project (report)
Final Exam (take-home assay)

- **Grades Breakdown**

In terms of grading, the course will involve assessment via a Qualifying Exam on the material of the first 3 weeks (>=70 ➔ Pass +10%; <70 ➔ 0% and a *Strong* Withdraw Recommendation), a Midterm Exam worth 25%, and a Final Exam assay, given during normal exam period (35%). The 2-4 person mixed (bio+comp students) Team Project is worth 25% for graduate students (10% for undergraduate students). The project's deliverables will consist of a properly researched, argued and presented GRN design proposal, probably including some modeling results. Graduates are required to submit a final project report, while undergraduates are awarded a bonus (of up to 10%) if they do.

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|---|---|---|
| 1. Qualifying Test | Pass (10)/ Withdraw (0) | marks |
| 2. Midterm Test | 25 | marks |
| 3. Team Project Report | 25 PG; 10 bonus for UG | marks |
| 4. Final Exam Assay | 35 | marks |
| 5. Participation in Classes | 05 | marks |

- **Extraordinary Circumstances**

In the event of extraordinary circumstances and pursuant to the Academic Regulations the University may modify the delivery, content, structure, forum, location and/or evaluation scheme. In the event of such extraordinary circumstances, students will be informed of the changes.

- **Intellectual Property**

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