Department of Bioengineering
BIEN 540
Information storage and processing in biological systems
Term Winter 2021

Instructor:
Prof. Dan V Nicolau (dan.nicolau@mcgill.ca)
Office Hours: by appointment, as requested
Office Location: Remote teaching (Zoom)

Teaching Assistant: Michael Phelan

Lecture Schedule:
Day (Tuesday and Thursday); Time (8:35 – 19:55); Remote teaching (Zoom)

Tutorial Schedule:
Day (Friday); Time (11:05 – 12:55); Remote teaching (Zoom)

Course Information:
Audience: Undergraduate and graduate engineering, science, and/or biomedical students
Prerequisites: Determined by instructor
Website: McGill MyCourses

Course Description:
The course will review the storage and the processing of information in biological systems, both natural and artificially-created, ranging from biomolecules, cells, and populations of cells, information storage in DNA and DNA computation; protein molecular surfaces; computation with motile biological agents in networks; and biological and biologically-inspired algorithms.

Course Material:
Lecture notes, scientific articles uploaded on MyCourses

Supplemental course materials, including lecture notes, will be distributed during the semester via MyCourses.

Course Assignments and Grading:

Assignments	**Points**	**Percentage**
Team project (individual presentation)	100	50
Midterm individual presentation of project progress	100	50

Team project assessing the feasibility of computing combinatorial problems by various biocomputation approaches vs. classical computing based on silicon technology:
Students will work in groups of 3 to 5 and prepare competitive projects assessing the technological and economic feasibility (with an emphasis on energy consumption and scaling)

of a biocomputation technique, OR an information storage system, both compared with the present classical, silicon devices-based system. The assessment of the ethical implications of proposed solutions will be part of the project.

Midterm presentation of the project progress:
Students will be required to present, individually, as part of the team project, their assumptions and methodology regarding the feasibility of implementation of a new design of a device, or a software addressing the information storage or processing, in or with biological systems.

Objectives: [Relevant GAs: KB: A, PA: A, IN: D, DE: I, ET: I. IT: D, CS: D]

- Introduce the fundamental concepts regarding information theory, the storage of information in biomolecules, and the processing of information by cells, and multi-cellular assembles, and population of organisms. KB (KB.1 to KB.4). Lectures 1, 2, 3, 5, and 6.

- Familiarize students with the technologies, devices and algorithms using, or inspired by the storage and processing of information by biological systems, or using them for computational-related artificial applications. KB (KB.5 to KB.8) Lecture 7, and 8.

- Describe the current progress in information biomimetics. KB (KB.1 to KB.4). Lecture 9 and 10.

- Analyze the design of classical computation and information storage systems and propose new designs for alternative systems based on biological entities, or inspired by them. PA (PA.1 to PA.4) DE (DE.1 to DE.3) IN (IN.1 to IN.3) ET (ET.1. and ET.2) IT (IT.1. to IT.4) Achieved via the Project (and Lectures above, where applicable).

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) 398-8261 before you do this.

Course Schedule

Week	Date	Assignments /Quizzes	Lecture	Topic
1	7 Jan		Introduction	Structure of the course, project descriptions
2	12-14 Jan		1. Information theory	Context of biological information; elements of information theory
3	19-21 Jan		2. Information storage in DNA	Basics of DNA information storage and replication
4	26-28 Jan		3. Signal processing with DNA	Genetic noise, genetic signals
5	2-4 Feb		4. DNA computation	Concepts and technologies in DNA computing
6	9-11 Feb		Recapitulation of DNA-based information storage and transfer	
7	16-18 Feb		5. DNA-to-Protein information transfer	Protein errors and mutations, protein synthesis
8	23-25 Feb		6. Protein information on molecular surface	Surface mapping at geometrical, physico-chemical resolutions
9	2-4 March	Mid term project presentations		
10	9-11 March		7. Biological algorithms - bacteria	Bacterial space searching and partitioning: the “software” and the “hardware”
11	16-18 March		8. Biological algorithms - fungi	Fungal space searching and partitioning: the “software” and the “hardware”
12	23 March – 25 April		9. Biosimulation with biological agents	Traffic optimization using amoeboid, bacteria
13	30 March 1 April		11. Biocomputation with biological networks	Network computing using cytoskeletal proteins, microorganisms
14	6-8 April	Final project presentations		