BIOL 309 (Fall)
Mathematical Models in Biology

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Prerequisites: 1 year of calculus; an additional course in Calculus is also recommended; or permission of instructor.

Content:

This course will give you a foundation in how mathematical models are used in biology. We will focus on building simple mathematical representations of biological processes and developing mathematical tools to allow us to determine the behavior of these models. One of the themes we cover is that simple mathematical models can show surprising and complex dynamics - and by the end of the term you should understand why this is and the consequences this has on our understanding of biological systems.

This course has been taught at McGill since 1975 and will be entirely online for the first time this year due to the current shutdown. In order to do so, the course will mostly follow a 'flipped classroom' approach, consisting of reviewing videos and reading at home and focusing primarily on directed problem solving with discussions in class. The course is based on the **class textbook** ("Understanding Nonlinear Dynamics" by Leon Glass and Daniel Kaplan), written specifically for this course by the course's creator Professor Leon Glass. We will cover Chapters 1 through 6 in order.

Another change is that there will be less of a focus on exams this year and more emphasis on the term paper. You can choose to work alone or in teams to either 1) critique a current mathematical biology paper or 2) develop your own mathematical model. In both cases there will be an emphasis not only on the math but also on good scientific writing. This year all students will give a short Zoom presentation about their work which will factor into the final grade. You will be given all the details you will need to get started by the end of the second week of the term.

The grading scheme is:

%50 Critique/Project

%25 Assignments (best 5 out of 6)

%25 Class test

Final letter grades for the course use a formula that rounds to to the nearest integer. If your grade is 84.4 then it rounds to 84 and you get an A-, whereas if it is 84.5 then it rounds to 85 and you get an A.

The assignments are mostly derived from the questions at the end of each chapter. You are usually given a week to complete them, depending on what is covered in class. Late assignments will not be accepted, but we only count the best 5 out 6 toward your final grade.

The class test will have a set time for completion of 3 hours. You will have a 48-hour window which to complete the class test (i.e. you can choose the time you start the test, and once started, you have 3 hours to complete it). Its 'open book', meaning you are free to use your own notes, results from assignments and the class textbook, but you cannot consult with others.

While there is less focus this year on tests, the course still emphasizes mathematical problem solving, and the assignments can be challenging. The course is directed towards students who have interest in mathematics, and who have solid foundations in algebra and differential calculus. Most students enjoy the introduction to current applications of modern mathematics (including the topics of chaos and fractals) to biology and can master the requisite techniques. However, not all students enjoy the challenge of problem solving. Since it is essential to do problems in order to learn the material, if you do not enjoy working on problems you should reconsider taking this course. You can get an idea of the type of math involved by looking at the problems at the end of each chapter in the class textbook.

The **syllabus** will be adjusted before and during the term to account for the online format but should roughly cover the following topics:

1) FINITE DIFFERENCE EQUATIONS IN BIOLOGY (12 lectures) dynamics in 1-dimensional finite difference equations modeling ecosystems including concepts of steady states, cycles and chaos. Boolean switching networks as applied to genetic regulation. Cellular automata and fractals.

2) DIFFERENTIAL EQUATIONS (14 lectures) One dimensional differential equations modeling growth and decay in biology. Second order linear and nonlinear differential equations modeling ecological, biochemical, and compartmental systems in biology. Stability analysis of first and second order nonlinear differential equations. Phase plane analysis of nonlinear second order differential equations

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