BMES375: Computational Bioengineering

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TAs: TBD
Office hours: TBD

Course Description:
This course introduces undergraduate students to the mathematical and computational analysis of biological systems. The systems analyzed include the genome, protein and gene expression, enzymatic pathway, and clinical data. Mathematical tools include matrix algebra, differential equations, cellular pathways, cluster analysis, etc.
This course will cover basic computational biology topics in Matlab, Python, and the relational database. We will emphasize the use of real-world data.

Course Objectives:

- BMES 375-A Provides hands-on experience on contemporary mathematics as applied to high throughput biology.
- BMES 375- A-061 and BMES 375- A-062 Provides background in the main areas in the study of computational biology and bioinformatics. Learn to analyze molecular datasets with unsupervised and supervised classification methods.

Drexel Student Learning Priorities:

- Creative and Critical Thinking
- Self-Directed Learning
- Technology Use

Course Materials - Required & Recommended Resources:

- The most recent version of Matlab.
- Matlab Programming Wikibook: https://en.wikibooks.org/wiki/MATLAB_Programming
- Python: https://www.python.org/
- Project Jupyter: https://jupyter.org/
- Lecture Notes, Recorded Lectures, and other material available from Blackboard Learn

Tentative Course Calendar:
Week 1: Introductory week. During the lab, we will go over the basics of using Matlab and how to slice and analyze data. You will use an HIV therapy dataset to determine which treatments are most effective.
Learning Objectives:

- Using boolean indexing to slice matrices
- Use vectorized functions to generate summary statistics such as min, max, and mean
- Use for-loops.

Week 1: Figure Generation. During the lecture, we will discuss how to make figures both scientifically informative and visually appealing. The lab will focus on re-analyzing the HIV treatment dataset to better answer scientific questions.
Learning Objectives:

- Programmatic control of figure properties such as text-size and line colors.
- Programming environments livescript, jupyter, and SQL database.

Week 2: Co-variates Overview. In the lecture, we will explore how to search your data for co-variates. We will discuss the best ways to visualize the effect of these covariates on your dataset. In the lab, we will explore a much larger HIV treatment dataset that includes potential co-variates such as age, gender, BMI, and years infected.
Learning Objectives:

- Understanding the intricacies of Matlab's sub-plotting system
- Using linear regression to measure the effect of co-variates

Week 3: Introduction to Symbolic Math. "Symbolic" or "algebraic" computations are carried out exactly, expressing the answer to a mathematical problem in a closed formula. The main task of a symbolic math system is to manipulate and simplify mathematical expressions. These computations are carried out according to the rules of algebra, instead of approximate floating-point arithmetic used in "numerical" computations.

Week 4: Introduction to Relational Database and SQL language. Learn the basics of the relational database and database management system, practice queries with SQL language. Learn how to connect to the relational base using the MATLAB database toolbox.

Week 5: Aggregation. Often data is not contained within easy to use matrices but is instead contained as records in a database. We will explore a real-life crowdsourcing user-survey dataset on treatments for migraines.
Learning Objectives:

- Using Matlab's dataset object
- Constructing pivot-tables

Week 6: Pathway modeling. We will discuss methods of modeling biological pathways using Mass Action Laws. In the lab, we will model idealized biological pathways.
Learning Objectives:

- Able to generate simple biological pathways integrated two or more inputs
- Able to use Matlab's ODE solver.

Week 7: Transcriptomics. During the lecture, we will discuss the current techniques for measuring genome-wide expression and how to interpret the results. In the lab, we will get our hands dirty with a real transcriptomics dataset.
Learning Objectives:

- Understand how to find significantly altered genes
- Understand the statistics related to multiple-testing comparisons

Week 8: Introduction to DNA sequencing. During the lecture, we will discuss human genomics and DNA sequencing techniques
In the lab, we will get our hands dirty with a real DNA sequencing dataset.
Learning Objectives:

- Learn the basics of human genomics
- Familiar with the major DNA sequencing technologies
- Understand and code to analyze the fastq data format

Week 9: Analyze the sequencing alignment results. We will understand DNA sequence alignment concept and implement the DNA sequencing alignment analysis in MATLAB.

Learning Objectives:

- Learn the basics of the DNA alignment concept
- Understand and code to analyze the Bam data format

Week 10: Introduction to Python, and DNA sequencing analysis.
Development environment and syntax. Using python for DNA sequence analysis.

Graded assignments, assessments, and evaluations:
In weekly assignments, students will work on solving computational biology problems in Matlab (or other programming languages when specified).

Grading Matrix:
Assignments: 100%

Grading Criteria:

		Level of Achievement		
		Unacceptable	Acceptable	Proficient
Criteria	Weight	0.00%	50.00%	100.00%
Formatting	50.00%	Code is unreadable. Any of the following: no comments, incorrectly indented, single letter variable names.	Code is properly indented	Code is indented, has appropriate comments, variables are named logically
Correctness	50.00%	Code errors-out before completion	Code completes but the answers are wrong.	Code completes and all answers are correct

Late Policy:
Weekly assignments: 1% deduction for each hour late.
Exceptions to the late policy subject to medical excuse or other emergencies.

Grading Scale:

Score %	**<59**	**59**	**63**	**67**	**69**	**73**	**77**	**79**	**83**	**87**	**89**	**92**	**98**
Letter Grade	**F**	**D-**	**D**	**D+**	**C-**	**C**	**C+**	**B-**	**B**	**B+**	**A-**	**A**	**A+**

The grading scale is subject to alterations depending on student performance in the class.

Course policies:
- I will communicate with you via email and Blackboard Discussion Board. You are responsible for reading your Drexel email account and check the discussion board on a daily basis to receive these announcements.
- All items in this syllabus are subject to change as the course progresses. You will be notified in class or via email of any changes in policies or content.

All students are expected to abide by Drexel University's policies. If an act of academic dishonesty is determined to have occurred, for a first offense, one of the following sanctions will be imposed, depending on the severity of the offense:

- Reduction of a course grade
- An "F" for the assignment or exam
- Failure for the entire course with the inability to withdraw.
- Other actions deemed appropriate by the faculty member. Examples include, but are not limited to, requiring the student to re-take the exam, re-complete an assignment, or complete an assigned exercise. The decision of the faculty member and the department head shall be reported to the Office of Judicial Affairs, which is responsible for maintaining student conduct records. The incident will result in an official disciplinary record for the student(s).
- Any academic honesty infraction beyond a first offense is subject to the sanctions described above, as well as to disciplinary sanctions that may be imposed through the University judicial process, administered through the Division for Student Life and Administrative Services/Office of Judicial Affairs. These sanctions may include suspension or expulsion from the University.

Course and University Policies

Course / Syllabus Changes: While the syllabus is intended to be as accurate as possible, the instructor retains the right to make changes to the content or schedule. Students will be notified in advance of any changes via announcements on the course website, e-mail, and in class.

Please refer to the following links regarding important University policies.

Academic Integrity:
http://www.drexel.edu/provost/policies/academic_dishonesty.asp
http://www.drexel.edu/studentlife/judicial/honesty.html

Disability Accommodation:
http://www.drexel.edu/oed/disabilityResources/

Adding a Course:
http://www.drexel.edu/provost/policies/course_add.asp

Dropping a Course:
http://www.drexel.edu/provost/policies/course_drop.asp

Withdrawing from a Course:
http://www.drexel.edu/provost/policies/course_withdrawal_policy.asp