Dalhousie University

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.[1]

Faculty of Computer Science

Syllabus

CSCI 4181/6802: Algorithms in Bioinformatics

Winter 2025-2026

Lecture: Mon/Wed 1435-1555, 2176 McCain Arts and Social Sciences Building

COURSE INFORMATION

Instructor Information

- **Instructor:** Finlay Maguire (finlay.maguire@dal.ca)
- **Office:** 4242 Mona Campbell Building, Studley Campus
- **TA:** Sneha Murthy (sn559585@dal.ca)
- **TA Office Hours:** On request
- **Course Website:** https://maguire-lab.github.io/bioinformatics_algorithms_2026/
- **Submission Site:** https://dal.brightspace.com/d2l/home/418935

Course Description

Bioinformatics uses computational and statistical approaches to tackle questions of biological function and evolution. The goal of Algorithms in Bioinformatics is to introduce key applications of algorithms, data structures, and encodings to the analysis of large biological data sets. A recurring theme throughout the course will be the disconnect between algorithmic beauty and the horrifying realities of biological data. Every statistical model is violated and every classification comes with an asterisk, as we struggle with even the most basic concepts of 'gene' and 'species', and the challenges of understanding events that happened 500 million years ago. Despite these challenges, in this age of massive data sets we stand to learn a good deal if the computational tools we use are efficient, robust, properly validated, and correctly applied.

This course covers major challenge areas in bioinformatics, each focused on an aspect of DNA or protein sequence analysis. The goal in each case is to define an overarching problem, and then explore different approaches that have been applied to solving that problem, with an emphasis on the match (or mismatch) between the algorithm and the underlying biological system.

Class Format

The course consists of two lectures per week. These will be delivered in person; lectures will be recorded and available afterward via the course website. All assignments will be submitted via the **Course Brightspace** (where grades will also be managed).

[1] For more information about the purpose of territorial acknowledgements, or information about alternative territorial acknowledgements if your class is offered outside of Nova Scotia, please visit https://native-land.ca/.

We do not have set office hours; we will respond to emails and in-person meetings can be arranged on an *ad hoc* basis.

Course Learning Outcomes

There are three main learning objectives for the course. By the end you should have knowledge of the following:

1. Key biological concepts such as genomics and evolution - *largely the focus of the introduction but with some new material introduced throughout the course.*
2. How different types of algorithms are appropriate to biological data analysis, and their shortcomings - *the focus of the lectures.*
3. The use of widely adopted bioinformatics software tools - *the focus of the assignments*.

The assignments will give you experience with specific tools that support the following activities:

1. Sequence data retrieval
2. Homology search
3. Multiple sequence alignment
4. Phylogenetic analysis
5. Machine-learning analysis of genomic data

We will likely use a Linux cluster for the sequence-assembly project, so you will gain experience with using bioinformatics software in an HPC environment.

Important Dates

- Classes begin: **January 7th**
- Last day to register or add/drop without penalty: **January 22nd**
- Last day to drop without a "W": **February 5th**
- Munro Day - University Closed**: February 6th**
- Nova Scotia Heritage Day - University Closed**: February 16th**
- Winter Study Break**: February 16-20th**
- Last day to drop with a "W": **March 9th**
- Last class**: April 9th**

Tentative Course Schedule

Module	Week	Date	Topic	Deadlines
Introduction	*1*	2026-01-07	Overview & Life at Resolution	
	2	2026-01-12	Pathway & Central Dogma	
		2026-01-14	Molecular Evolution	
Homology	*3*	2026-01-19	Sequence Representation: Text	
		2026-01-21	Sequence Representation: Structural	
	4	2026-01-26	Sequence Alignment: Scoring	
		2026-01-28	Sequence Alignment: Dynamic Programming	
	5	2026-02-02	Homology Search: BLAST	

		2026-02-04	Homology Search: Burrows-Wheeler Transform	Assignment 1 Release
	6	2026-02-09	Multiple Sequence Alignment	
		2026-02-11	Hidden Markov Models	Assignment 1 Due & Assignment 2 Release
Winter Study Break	*7*	**2026-02-16**	**No Lecture**	
		2026-02-18	**No Lecture**	
Assembly	*8*	2026-02-23	Assembly: Overlap Layout Consensus	Assignment 2 Due
		2026-02-25	Assembly: de Bruijn Graphs	Assignment 3 Release
Phylogenetics	*9*	2026-03-02	Introduction to Phylogenetics	
		2026-03-04	Distance Inference	Assignment 3 Due
	10	2026-03-09	Maximum Likelihood Inference	
		2026-03-11	Bayesian Inference	Paper Selection Deadline
	11	2026-03-16	Statistical Support & Testing	
		2026-03-18	Pangenomics & Outbreaks	
	12	2026-03-23	Phylodynamics	
Machine Learning		2026-03-25	Introduction to Machine Learning for Biological Data	
	13	2026-03-30	Feature Representations	
		2026-04-01	Applications of Classifiers	Assignment 4 Release
	14	2026-04-06	Oral Presentations	
		2026-04-08	Oral Presentations	Assignment 4 & Paper Review Due

Course Assessments
We use the standard Dalhousie grading scheme. Note that the minimum passing grade in a graduate course is a B-, so any graduate student mark under 70% will be converted to an F.

Assignments must be submitted via **Brightspace**. Late assignments will be penalized at 20% per day. Assignments submitted after five days will still be evaluated if you would like feedback, although the final grade will still be zero.

Practical Assignments (60% total)
- Four assignments, each worth 15%
- No collaboration is permitted on the assignments.
- Each assignment is due before midnight 1 week after release (deadline extended over winter study break).

Each of the four tutorial assignments will draw material from course modules and will involve the application of one or more methods to a problem data set. The challenge to the student will be to generate, evaluate and

interpret the results obtained when different approaches are used.

Paper review (40% total)
- ◦ List of selected paper(s) are due 2026-03-11
- ◦ Written review (25%) - due 2026-04-08
- ◦ Oral presentation (15%) - due during final lecture slots (2026-04-06 & 2026-04-08)

Undergraduate students *will choose a recent (since 2019) research paper from the bioinformatics literature and produce a written review and oral presentation.*
Graduate students *will choose 3-5 recent, related papers on a specific topic in bioinformatics and write a report that synthesizes the results. For example, your report might explore the contrasting results obtained when similar methods are run on different types of data, or when different methods are run on the same or similar datasets. You can also do a comparison of the principles behind different methods. The review will include written and oral components.*

Grading: This course uses the standard Dalhousie grading scheme: (https://www.dal.ca/campus_life/academic-support/grades-and-student-records/grade-scale-and-definitions.html)

Submission: Assignments must be submitted via Brightspace in PDF format. Incorrect submission formats will receive a 0 after the first assignment.

Late Policy: Late assignments will be penalised at 20% per day. Assignments submitted more than 5 days late can still be evaluated for feedback on request but the grade will be 0. Late submissions without penalty will be considered **only for** reasons of recognised accommodation.

You may:
- Refer to different sources of information in your assignments, where appropriate. It is fine to use generative AI to explore different concepts and test yourself, but remember that tools such as ChatGPT get less and less accurate as the available online material dwindles, and there are many documented instances where ChatGPT has been confidently wrong about even core concepts in bioinformatics.
- Use a variety of tools to conduct your literature search (PubMed, Google Scholar, Elicit)
- Include images from publications in your final project report. You must cite the source, and the license must permit you to re-use the image (generally OK for educational purposes, but you should check!)

You must not:
- Submit anything that was not written by you. This includes fee-for-service report mills, copying and pasting from the internet, or using generative AI. I am a big fan and user of generative AI, but its use is not justifiable for any of the course components.
- Collaborate with others on the assignment or final project report.

Student declarations of absence: These will not be accepted for this course.

TA Office Hours: The primary time to get help from the TAs is during the 2 practical sessions each week, if you attend these and still have issues there will be office hours immediately following the Thursday practical. In order to get access to regular TA office hours or email responses from the TAs it is **required** that you attend the practicals.

UNIVERSITY STATEMENTS

Territorial Acknowledgement:

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We

are all Treaty People[2]

Internationalization

At Dalhousie, "thinking and acting globally" enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders."

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect. As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation.

If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion please contact:

- the Student Accessibility Centre (for all courses offered by Dalhousie with the exception of Truro)
- the Student Success Centre in Truro for courses offered by the Faculty of Agriculture

Your classrooms may contain accessible furniture and equipment. It is important that these items remain in place, undisturbed, so that students who require their use will be able to fully participate.

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2).

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aCode of Student Conduct
Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Fair Dealing policy
The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie.

Originality Checking Software
The course instructor may use Dalhousie's approved originality checking software and Google to check the originality of any work submitted for credit, in accordance with the Student Submission of Assignments and Use of Originality Checking Software Policy. Students are free, without penalty of grade, to choose an alternative method of attesting to the authenticity of their work, and must inform the instructor no later than the last day to add/drop classes of their intent to choose an alternate method.

UNIVERSITY POLICIES, GUIDELINES, AND RESOURCES FOR SUPPORT
Dalhousie courses are governed by the academic rules and regulations set forth in the Academic Calendar and the Senate.

University Policies and Programs
- Important Dates in the Academic Year (including add/drop dates)
- Classroom Recording Protocol
- Dalhousie Grading Practices Policy
- Grade Appeal Process
- Sexualized Violence Policy
- Scent-Free Program

Learning and Support Resources
- Academic Support - Advising Halifax, Truro
- Student Health & Wellness Centre
- On Track (helps you transition into university, and supports you through your first year at Dalhousie and beyond)
- Indigenous Student Centre. See also: Indigenous Connection.
- Elders-in-Residence: The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit the office in the Indigenous Student Centre or contact the program at elders@dal.ca or 902-494-6803.
- Black Student Advising Centre
- International Centre
- South House Sexual and Gender Resource Centre
- LGBTQ2SIA+ Collaborative
- Dalhousie Libraries
- Copyright Office
- Dalhousie Student Advocacy Service (DSAS)

- Dalhousie Ombudsperson
- Human Rights & Equity Services
- Writing Centre
- Study Skills/Tutoring