Molecular Evolution, Syllabus

Department of biology

BIOL 3046 Fall 2023

Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.

Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

Course Instructor

Name	Email	Office Hours
Joseph P. Bielawski	j.bielawski@dal.ca	LSC 7056, by appointment unless specified otherwise

Course Description

This course examines the process of evolutionary change at the molecular level. It begins with the sources of mutation, and moves on to dynamics of population variation. The course culminates with a macro-evolutionary perspective on topics such as adaptive evolution and genetic co-option. This course is complementary to BIOC 4010.03 (Bioinformatics).

Course Prerequisites

BIOL 2030
BIOL 2040

Course Materials & Student Resources

Regarding the in-class exam content:

> *There is no required textbook for this course. Lecture notes will be posted on Brightspace*. *The lecture notes and slides are the primary resource you will need to study for the exams.*
>
> In addition, key scientific papers and/or review articles relevant to the lecture material might be posted on Brightspace. Students are advised to download these materials and review them, when applicable.
>
> Several textbooks cover the course topics that can be used as *supplemental resources* for the course content. These books are available in the Killam Library: (1) D. M. & E.C. Holmes. Molecular Evolution: A Phylogenetic Approach. 1998; (2) Li, Wen-Hsiung. Molecular Evolution.1997; (3) Avise, John C. Molecular Markers, Natural History & Evolution . 1994; (4) Nei, Masatoshi. Molecular Evolution and Phylogenetics. 2000; (5) Felsenstein, Joseph. Inferring Phylogenies. 2003; (6) Daniel L. Hartl and Andrew G. Clark. Principles of population genetics (1997).

Regarding the course projects:

> The following scientific journals provide an excellent source for additional information and are available either in print or electronically through the Dalhousie Libraries: *Genome Research*, *Journal of Molecular Evolution*, *Molecular Biology and Evolution*, *Molecular Phylogenetics and Evolution*, *Trends in Ecology and Evolution*, *Bioinformatics, Development Genes and Evolution, Evolution, Genetics, Nature, PNAS(USA), Science and Systematic Biology*. Students can search the journal literature via databases such as BIOLOGICAL ABSTRACTS, PUBMED and WEB OF SCIENCE. The library also makes available a document delivery service that permits students to order journal articles for a nominal fee.

Course Structure

Course delivery: In-person

Lectures: 2:35 – 3:55, LSC Room C220 (M/W)

Laboratories: none

Tutorials: none

Assessment

Component	*Weight (% of grade)*	*Date*
Tests (60%)		
Exam 1	*15%*	*October 4TH (in class)*
Exam 2	*30%*	*November 8TH (in class)*
Exam 3	*15%*	*December 6TH (in class)*
Assignments (science communication)		
Project 1	*10%*	*November 20TH (M)*
Project 2	*30%*	*Topic due: October 16th (M)*
		"Hard" deadline: December 7TH (Th)

Other course requirements

Science communication *Project 1*: Science info-graphic

This is a new activity that will be introduced in 2023, and the details are still being developed. We will discuss and finalize the details, as a group, as the course progresses.

The activity involves choosing a scientific paper that has some connection to either (1) molecular evolution or (2) some aspect of equity, diversity & inclusion (EDI) relevant to STEM and producing a 1-page "info-graphic" based on (1) or (2).

In the meantime, see https://pineapplesandwhales.wordpress.com/infographics/ for good examples.

Additional information and guidelines will be posted on Brightspace and discussed in class.

The deadline for submission for project 1 is **November 20TH**.

Project submission: Project 1 will be submitted by copying a compressed archive containing BOTH the infographic and the original source material (a scientific paper, or a suitable alterative approved by the instructor). **Only the version of the infographic deposited in the Dropbox will be graded. Any project submitted only as a URL rather than as files deposited in the designated Dropbox will NOT be graded**!

Science communication *Project 2*: video podcast/video blog

The web has become an extremely important source for dissemination of molecular data, scientific knowledge and analytical resources related to the discipline of molecular evolution. By completing this video project, a student will demonstrate a proficiency to use multi-media resources to address topics in molecular evolution.

You will select a topic that interests you. You will conduct a survey of the literature using web-based resources and produce a video podcast. **Students will submit BOTH the video (mp4 file), and a text document that summarizes their scholarship** directly to the instructor.

The text of document must contain references to the primary scientific literature, formatted using any one of the conventional citation systems. **You should think of the total amount of work as analogous to the traditional "term paper"**. **However, in this case, the primary medium of delivery is the video.** The written text provides the means to formally link the video content to the scientific literature via standard scientific citation practices. Do NOT simply mimic, or paraphrase, any information from a pre-existing website; this is plagiarism and will not be tolerated.

Note: Students may request to do project 1 in an alternative format [a functional HTML website]. This requires prior permission of the instructor. The request MUST be made within the first two weeks of class. There will be very specific criteria for submission of a project as an HTML website. Students that have permission to submit a website project must make an appointment with the instructor to review the requirements associated with an alternative project format.

Project submission: Video projects will be submitted by copying a compressed archive containing BOTH the mp4 and text files (e.g., via a zip archive) to a specified Dropbox. **Only the version of the video podcast deposited in the Dropbox will be graded. Any video posdcast submitted only as a URL (e.g., via YouTube) rather than as files deposited in the designated Dropbox will get ZERO points**!

You should have fun with this project, it's not all that hard! Potential topics are wide open, and can relate to evolutionary theory, a biologically motivated problem, a new method of data analysis, a particularly useful database, etc. After deciding on a topic, you must receive approval of your topic from the instructor. The deadline to obtain approval for a topic is **16th of October**.

The deadline for final submission of the project is **December 07TH**. This is a "*hard deadline*". No projects will be accepted after this date. *Students can submit earlier if they want the instructor to check for video functionality and assess levels of scholarship. The instructor will NOT forecast grades based on any early submissions.* Any early submission checks are qualitative, and feedback is coarse-grained.

The relationship between *Project 1* and *Project 2*

The topic of the project 2 (video) can be related to project 1 (infographic), or the two projects can be done on independent topics. *This is your choice.*

IFF the projects are done on related topics, then project 2 **MUST** cover *a more general overview* of a topic that includes the topic of project 1 as a special case. The video (project 2) **MUST NOT** be a mere re-packaging project 1.

Conversion of numerical grades to final letter grades follows the Dalhousie Grade Scale

A+ (90-100)	**B+** (77-79)	**C+** (65-69)	**D** (50-54)
A (85-89)	**B** (73-76)	**C** (60-64)	**F** (0-49)
A- (80-84)	**B-** (70-72)	**C-** (55-59)	

Course Policies on Missed or Late Academic Requirements

Requests for an alternative exam time due to extenuating circumstances:

A student requesting an alternative time for an examination will be granted that request only in exceptional circumstances where notification is provided at least **1 week prior to the start of the exam**. Such circumstances include having another Dalhousie synchronous lecture or exam scheduled at the same time, or other mitigating circumstances *outside the control of the student*. Elective arrangements (such as travel plans) are **NOT** considered acceptable grounds for granting an alternative examination time.

Special arrangements for missed exams due to illness or other exceptional circumstances:

Alternate arrangements will be considered provided that:

A student who misses class work (project, midterm or exam) because of illness/medical reason:

1. Notifies the Instructor prior to, or on, the day in question
2. Completes the Student Declaration of Absence, and/or provides other appropriate supporting documentation within three (3) days following the last day of absence. **An SDA can be used once per term** for absences of **3 days or less** only. For more info https://www.dal.ca/dept/university_secretariat/policies/academic/missed-or-late-academic-requirements-due-to-student-absence.html.

3. For absences of **4 days or longer**, students cannot submit a Student Declaration of Absence Form. Please contact the Instructor. Absences of **5 days or longer** will require a physicians note.

Students who miss an exam (including the final exam), and provided the appropriate notice and/or supporting documentation are provided, can fulfill course requirements by one of several means, including:

1. A make-up exam offered on another date
2. An alternate assignment that can be completed in lieu of an exam
3. A re-weighting of assessment components that applies to students who miss an exam

N.B. - The decision on when special arrangements can be made, and the form of those arrangements, will be at the discretion of the Instructor.

Course Policies related to Academic Integrity

CLASS CODE OF CONDUCT: We expect all classroom participants to treat each other with dignity and to conduct themselves in a proper and professional manner. Harassment and sexist, racist, homophobic, or exclusionary jokes will not be tolerated.

You are expected to work independently on all assignments, projects, and exam-related activities.

Use of any online "homework" sites like Chegg or CourseHero are strictly prohibited, and student information will be released if asked by academic integrity officers in the course of an investigation.

Generative AI and large language models (*e.g.*, ChatGPT) can be used to supplement your learning. However these models can generate biased, and sometimes incorrect, results. Above all, students must (1) never present information obtained via generative AI as their own work [*this will be treated as a form of plagiarism*], and (2) students will be held responsible for any errors in fact, or conceptional, that originate from the use of generative AI.

Course Objectives & Learning Outcomes

- Comprehend different evolutionary models for genetic load and how these led to the neutral theory of molecular evolution. Understand and describe the "Neutral theory" and the "nearly neutral theory". Know the major predictions of neutral theory and give examples where predictions have been validated with real molecular data. Comprehend both the benefits and pitfalls of neutral theory.

- Comprehend the complexity of homology relationships under a variety of different molecular evolutionary processes.
- Demonstrate the relationship between critical thinking and good scholarship within a course project.
- Know mechanisms for functional divergence at the molecular level that span a wide range of biological complexity. Understand how specific models of adaptive evolution explain real examples of functional divergence.
- Know the historical, cultural, and social framework that lead to the Darwinian theory of evolution
- Know updates and extensions to Darwinian theory that led to modern theory. Comprehend and explain principles arising from the neo-Darwinian synthesis and neutral theory.
- Understand how explicit models of population genetic processes serve as the theoretical foundation for microevolution. Apply these models to understand different mechanisms of evolution acting on real biological data.
- Understand how molecular evolutionary processes give rise to patterns of genetic diversity that we observe in the natural world, and how to use those patterns to make inferences about different processes.
- Understand the evolutionary significance of mutations at different levels of complexity. Apply evolutionary theory to understand impacts of mutations on fitness, rates of molecular evolution and genetic control of mutation.
- Understand the importance of molecular evolution in the post-genomic era, and be able to explain this to non-specialists.
- Use knowledge of molecular evolution for clear and explicit communication and exchange of ideas about the topic within a course project.

Course Content

On the following page is an outline of the lecture topics organized into seven modules. The outline provides an approximate (tentative) schedule of the lecture delivery. A full course schedule with both lecture and exam dates will be provided in the first week of class (posted on Brightspace). **Note** *that all schedules are tentative and subject to change, so please re-check the course schedule on Brightspace throughout the term for updates and changes.*

Course Outline

1. Foundations
    - 1.1 Introduction to Molecular Evolution
    - 1.2 The Synthetic Theory of Evolution (i.e., “The Modern Synthesis”)
    - 1.3 Mutation and recombination

2. Population genetics
    - 2.1 Introduction
    - 2.2 Hardy-Weinberg equilibrium
    - 2.3 Linkage disequilibrium
    - 2.4 Inbreeding
    - 2.5 Mutation
    - 2.6 Assortative mating
    - 2.7 Natural selection
    - 2.8 Genetic Drift
    - 2.9 Equilibrium polymorphism

3. Neutral evolution
    - 3.1 Genetic load
    - 3.2 Neutral theory
    - 3.3 Nearly Neutral theory

4. Selfish gene theory and “gene-centrism”

5. Phylogenetics
    - 5.1 Introduction to phylogenetic homology
    - 5.2 Homology evolving

6. Functional divergence
    - 6.1 FFTNS and Shifting Balance
    - 6.2 Sickle Cell as a case study
    - 6.3 Evolution of novel genetic and molecular complexity
    - 6.4 Multi-Level Selection Theory (MLST) and ESS
    - 5.5 Forms of “aptation” (pre-aptation, ex-aptation, ad-aptation)

7. Situating science in society: Truth and Responsibility

University Policies and Statements

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding the Indigenous Student Centre can be found at: https://www.dal.ca/campus_life/communities/indigenous.html

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." Additional internationalization information can be found at: https://www.dal.ca/about-dal/internationalization.html

Academic Integrity

At Dalhousie University, we are guided in all 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 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. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

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 (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/about-dal/agricultural-campus/student-success-centre.html)

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). Additional diversity and inclusion information can be found at: http://www.dal.ca/cultureofrespect.html

Student Code of 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. The full Code of Student Conduct can be found at: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

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. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/dept/university_secretariat/policies/academic/fair-dealing-policy-.html

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. Additional information regarding Originality Checking Software can be found at:
https://www.dal.ca/dept/university_secretariat/policies/academic/student-submission-of-assignments-and-use-of-originality-checking-software-policy-.html

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.