03-511/711 Computational Molecular Biology and Genomics Fall 2026

Instructors:

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Course description

An advanced introduction to computational molecular biology, using an applied algorithms approach. The course will survey established algorithmic methods. The course web site provides a detailed view of course materials: https://www.cs.cmu.edu/~durand/03-711/. Here is a tentative schedule of topics covered.

1. Pair-wise sequence alignment
2. Multiple Sequence alignment
3. Sequence evolution models
4. Phylogenetics
5. Amino acid substitution matrices
6. Modeling motifs, PSSMs, Hidden Markov Models
7. Database searching, Blast, alignment statistics

Objectives

Upon completion of this course, students will

1. have a working knowledge of algorithms for global, semi-global, and local alignment and be able to apply those algorithms to concrete examples;
2. understand how parameter selection in a scoring function influences the results obtained using an alignment algorithm;
3. understand Markov models of sequence evolution;
4. be familiar with the problems of sequence motif discovery, representation, and recognition in a probabilistic framework;
5. understand the application of Hidden Markov Models in this framework, including the Viterbi, Forward, and Backward algorithms;
6. understand the Baum Welch algorithm and the Gibbs Sampler in terms of sequence analysis;
7. understand the purpose of amino acid substitution matrices that are parameterized by evolutionary distance;
8. have an in-depth knowledge of the BLAST database search heuristic and its parameters; be able to select appropriate parameter values for a given query sequence and retrieval goal; and be able to interpret the statistical output of BLAST.

Prerequisites

Research in bioinformatics requires an interdisciplinary effort between molecular biologists and computer scientists, and students from both disciplines are encouraged to participate in the course. A variety of backgrounds will bring different strengths to the course.

To succeed in this course, you will need a solid introductory background in biology (molecular, cell and genetics), data structures and algorithms, and discrete math (probability, graphs, trees). There are *no programming assignments* in this course and the ability to program is not evidence that you have the right foundation.

To take this course you must have taken the following CMU courses or have the permission of the instructor.

- Modern Biology (03-121),
- Programming for Scientists (02-601) or Principles of Imperative Computation (15-122),
- Concepts of Mathematics (21-127). Note that 21-127 is a co-requisite of 15-122.

Students in 03-511/711 tend to come from diverse disciplinary and institutional backgrounds, making it difficult to determine whether they have the requisite knowledge to succeed in the course. To address this, we will administer an **in-class readiness quiz** on **August 27th, the first Thursday** of the semester. The objective is to help you (and me) assess your comfort with the prerequisite material coming into the course. The quiz will be graded on Friday, so that you will have a week before add date (Friday, September 4th) to switch to a different course, if we determine that that would be a better fit for you.

The quiz will consist of a few questions that are representative of the material covered in the prerequisite courses. It is closed book and closed notes. You will not need a calculator and no electronic devices may be used during the quiz. Your score on the readiness quiz will not count towards your final grade.

Course organization

The course website (https://www.cs.cmu.edu/~durand/03-711/) is the primary vehicle for communicating with you about the progression of the course. Lecture topics, reading assignments, lecture notes, assignments, and work sheets will be posted there.

Canvas will be used for you to submit completed assignments and for us to return graded assignments to you. Canvas will *not* be used to calculate grades. Please enable Canvas notifications to receive announcements about assignment releases in a timely fashion. Canvas will be used for handing in completed assignments and returning graded assignments with comments. We will not use Canvas' native messaging system. *Do not send me messages on Canvas;* they will not be read.

Piazza will be used as a class bulletin board and communication system. Any questions you have about course organization or course material should be posted to Piazza. If you have a question about the course or content, at least two other students will have the same question and will be delighted that you asked. Matters of a private nature should be sent to the instructors by email or via face-to-face communication (in-person or virtual).

Office hours will be held via zoom. We will have a poll to determine the best times for weekly office hours. In addition, I will be available for half an hour after every lecture to answer questions in person.

Reading

You do not need to purchase a textbook for this course.

Comprehensive lecture notes (~150 pages) in pdf format are provided on the course website: https://www.cs.cmu.edu/~durand/03-711/2026/Lectures/computationalBiology.pdf. The lecture notes are the best source of information on up-coming lectures and the best way to catch up, if you must miss class. In addition, reading materials drawn from several textbooks, as well as the primary literature, are provided through the course web site.

For supplementary reading, the following textbooks are recommended:

- Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, R. Durbin et al (electronic version).
- Introduction to Computational Molecular Biology, J.C. Setubal and J. Meidanis (available at the Mellon Institute Library)
- Statistical Methods in Bioinformatics: An Introduction Ewens and Grant (electronic version).

The Cartoon Guide to Genetics, by Larry Gonick and Mark Wheelis, is recommended for those needing additional biological background. The paperback edition is available via the Mellon Institute Library and on Amazon for about $15, new; used copies start below $10.

Course work

Course work for all sections includes 7 to 9 homework assignments, two in-class exams and a final exam. Homework assignments focus on problem solving and do not require programming. Students taking the 12-unit version of the course (711) will complete 6 to 8 additional assignments that extend the course material to topics in genomics and involve problem solving in more complex or open-ended scenarios.

The final exam is cumulative, although there will be greater emphasis on material covered in the second half of the course.

Grading policy:

- Participation: 5%
- Homework: 15%
- Midterm Exams: 44% (two exams, 22% each)
- Final: 36%

Because students in 03-511/711 enter the course with diverse disciplinary backgrounds, I adjust the emphasis and presentation of material each year to meet the needs of the current cohort. I use a grading policy that allows me to tailor my teaching strategy and learning assessments to the current cohort, while meeting the overarching goals of assigning grades that reflect the students' mastery of the material and that are consistent across all students in the class. To allow for this flexibility, this course does not have pre-set grade points (e.g., A=90-100%, B=80-89%, ...). Nor do I grade on a curve (e.g., top

2.1% of students receive an A, the next 13.6% of students receive a B, ...). Final letter grades will be assigned based on your mastery of the material and your performance relative to the class as a whole.

Lectures

Most lectures will be presented at the chalkboard. Occasionally, lectures will include PowerPoint presentations and software demonstrations. The course lecture notes, while quite extensive, are not guaranteed to cover all the material discussed in class. You are responsible for taking notes in class and learning the material from your notes and reading assignments.

Attendance

Attendance is not mandatory. However, attending class is the best way to gain a deep understanding of the material. It is an also an excellent way to meet your participation requirement (see below).

If you are feeling unwell, please stay home. This will protect the welfare of other students and you will recover more quickly.

Electronic Devices

The use of laptops and phones in class is prohibited. A growing body of evidence from learning research shows that the use of laptops and other devices in the classroom has a negative impact on the retention of knowledge and subsequent exam performance for both the user of the laptop *and* for students sitting near them. Personally, I am distracted when students use laptops and other electronic devices in class. When I am distracted, I am a poor lecturer. For this reason, I ask you to turn off your mobile devices and close your laptops during class. Exceptions will be made for students with disabilities.

Classroom Recording Allowed for Personal Educational Use: Classroom activities may be recorded by the lecturer or a student for the personal, educational use of that student or for all students presently enrolled in the class only, and may not be further copied, distributed, published, or otherwise used for any other purpose without the express written consent of Dr. Durand. Recordings of class sessions are covered under the Family Educational Rights and Privacy Act (FERPA) and must *not* be shared with anyone outside your course-section. All students are advised that classroom activities may be taped.

Participation

Class participation makes up 5% of your grade. The participation requirement can be satisfied through interaction in-class, office hours or via Piazza.

Participation makes class more valuable for everyone. During class, I expect students to be attentive and actively engaged in the learning process. Asking questions will help you, me, and the rest of the class. If something is not clear to you, chances are that someone else finds it confusing, too. Your neighbor will be delighted that you asked.

I will ask questions of the class and ask for participation in walk-through examples. This helps me assess whether a concept has been effectively conveyed and identify areas that need more discussion. To make sure that everyone has a chance to participate, I will direct questions to specific students. If I call

on you to answer a question, a good faith attempt to answer the question counts towards your participation score, regardless of whether your answer is correct or not.

You do not have to participate in the same way each week. In any given week, participation could include:

- Attending class and asking or answering a question or participating in the discussion.
- Attending office hours and/or asking questions after class.
- Posting a substantive question on the course bulletin board on Piazza. ("When is the homework due?" is not a substantive question.)
- Providing a substantive answer to a question posted by someone else on the course bulletin board. ("Friday" is not a substantive answer.)

Exam policy:

There will be two exams and a final exam, in addition to the readiness quiz. The mid-semester exams will cover the first and second third of the semester, respectively. The final exam will be cumulative. You are responsible for all material covered during the semester. Exams are closed book. You may bring two 8.5"x11" pages (or one page, front and back) of your own notes. Preparing your notes is an excellent way to study for the exams. You will not need a calculator. No electronic devices may be used during the exams.

The two mid-semester exams will be held at:

Exam 1: 7:30pm to 9:30pm, Wednesday, September 30th
Exam 2: 7:30pm to 9:30pm, Thursday, November 12th

Make-up exams will not be offered, except in the case of conflict with an exam in another class, documented illness, or family emergency. This policy applies to both mid-semester exams and the final exam. If you anticipate a conflict with another class, you should inform me now.

The time and date of the final exam are determined by the registrar's office and are beyond my control. Until the date of the final is determined, you should not make plans to leave for winter vacation before the end of the exam period. **No student will be permitted to take the final exam early.**

CMU policy states that no student is required to take more than two scheduled examinations that start within a 25-hour period. If you have more than two final examinations scheduled within a 25-hour period or another examination scheduled at the same time as the exam for this course, please see me immediately to discuss how to resolve this conflict.

Homework assignments

Deadlines: Homework will typically be assigned on a weekly basis, except for exam and vacation weeks, and will be due 7 to 10 days later. Please turn your assignments in on time. Late homework inconveniences your instructors and other students in the course. Late homework also puts you at a disadvantage because problem sets are designed to help you stay up to date on the material.

Late homework will not be accepted once graded homework has been returned to the class and solutions have been posted. If late homework is accepted, the penalty is 10% per day. Extensions will be granted only in extraordinary circumstances (for example, an extended illness). *There will be no "makeup" homework assignments*. *Please let me know as soon as possible*, preferably through email, if you will require an extension.

To offset these draconian rules and give you some flexibility, I will drop your lowest homework assignment grade when calculating your final score, *with the proviso* that all assignments have been submitted by the last day of classes. Your mid-term grade will be based on the first mid-term examination and all homework assignments administered before mid-semester. No homework scores will be dropped at midterms.

Authorized and unauthorized assistance on homework assignments: The table below summarizes which sources of information you may use in preparing homework assignments and which you may not. The column on the right gives permitted and unauthorized sources for assignments. When using permitted sources, **include a list of the reference materials you used when you hand in your assignment.** Verbatim quotes should be clearly attributed to the source and used sparingly, if at all. You *may not* quote verbatim or paraphrase material from any source without attribution.

Information sources (permitted and forbidden)	**Problem sets**
Discussion with other students	Limited
Refer to textbooks, your own class notes from prior courses	Yes
Refer to 03-711 solution sets from prior years or solution sets from other courses, within CMU or elsewhere (with the exception of materials from courses you have already taken and passed.)	No
Information from the internet	Limited
Generative AI (e.g., chatGPT)	Limited

The overarching *rationale* for these rules is to guide you towards learning strategies that will help you gain a deep understanding of the material and the ability to apply your problem solving skills in diverse and unexpected contexts. Relying too heavily on pre-solved problems and/or collaboration with your peers, without investing in understanding and problem solving, may lead to poorer performance in the course and poorer knowledge mastery --- the ultimate goal of education.

Details on each of these sources are provided below:

Discussion and collaboration on homework problems between students are allowed with limitations. You may not hand in jointly prepared assignments. Students may not copy any portion of a homework assignment from another student, nor may they jointly prepare all or part of an assignment. Students who collaborate on homework assignments **must write the names of their collaborators on the front of their homework assignments, with a short explanation of what was discussed.** This information is to help me understand each individual student's comprehension of the material.

An example of acceptable collaboration would be the discussion of strategies for a particular task, followed by each student implementing the strategy independently. Examples of unacceptable collaboration are:

- jointly doing an analysis and then handing in multiple copies of the results;
- following a method suggested by someone else without being able to explain the method;
- getting help from a classmate or source without acknowledgement; or
- receiving answers from students who have taken the course in previous years.

Be careful. Collaboration is a useful tool for increasing your knowledge and understanding of the subject. However, when working in a group, it is easy to fool yourself into thinking you understand the material better than you do.

Use of information on the internet: Unless explicitly stated otherwise, you *may* use resources that provide knowledge, such as Wikipedia, and tutorials that give general background on a subject, such as Monte Carlo Markov Chain (MCMC), Explained and How to Interpret a ROC Curve. These are resources that provide knowledge, which you can then apply to solving specific problems.

You *may not* use resources that contain repositories of solved homework and exam questions and/or that are designed to answer specific questions from a problem set. Examples of sites you may not use are Chegg, Quizlet, stack exchange. These are resources that solve problems for you, denying you the opportunity to build your problem solving skills.

A great deal of educational material is available online from institutions of higher learning and some of this material is very good. You may listen to recorded lectures or read notes from other courses posted on university websites, but you may not consult the solution sets of homework assignments from other courses, offered here or elsewhere.

Use of generative AI tools: Students are strongly advised against using Generative AI (GenAI) tools, like ChatGPT, in problem solving on homework assignments. There are two reasons for this:

1. Use of GenAI on problem sets is likely to reduce your performance in the class. Multiple studies carried out by learning scientists demonstrate that broad use of GenAI tools undermines learning. For example, in a recent study, students in upper level CS courses who used generative AI as an aide in problem solving, had the subjective experience that their understanding of the material was improved. However, objective assessment of the skills and knowledge of the same students showed that the opposite was true: their performance was *lower*.
2. Second, AI generated content is not necessarily accurate or contextually appropriate. In our experiments, GenAI tools frequently gave incorrect answers to problems typical of the assignments in this course. You will not earn credit if your assignments contain incorrect, invalid, or irrelevant information.

To maximize your performance in the course, you should solve homework problems on your own. You should not copy the text of a problem into a GenAI tool or ask the tool how to solve a problem. Once you have solved a problem and written up the solution, GenAI can be helpful for improving your spelling, syntax and grammar. Students who use Generative AI ***must*** **write the source (e.g., ChatGPT) and version number on the front of their homework assignments and explain how the tool was used.**

Use of Generative AI on homework assignments without acknowledgement constitutes a violation of CMU's academic integrity policy.

Our policy on generative AI is similar to our policy on collaboration. AI is a useful tool, but you are ultimately responsible for understanding this material. Using the tool without understanding the reasoning for the answer will lead to poorer performance on exams, as this cannot be considered a substitute for developing fundamental skills and expertise.

Academic Integrity

Integrity and honesty are integral aspects of good science. *Whether you use collaboration, AI, or other outside material, your ethical responsibilities as a student remain the same.* Cutting and pasting content from any source without citation is plagiarism. Likewise, paraphrasing content without citation is plagiarism. Deviations from these guidelines constitute a violation of CMU's academic integrity policy.

All students are responsible for familiarizing themselves with the Carnegie Mellon policies on Academic Integrity, Cheating and Plagiarism and adhering to those policies. In order to deter and detect plagiarism, online tools and other resources may be used in this class.

You should be aware that plagiarism, cheating and other violations of the academic integrity policy are considered to be serious infractions at Carnegie Mellon. Any act of cheating or plagiarism will be treated in accordance with Carnegie Mellon's Policy on Academic Integrity. Depending upon the individual violation, students could face penalties ranging from failing the assignment to a penalty as severe as failure in the course for a single violation.

Note that expectations for "plagiarism, cheating, and acceptable assistance" on student work may vary across your courses and instructors. If you have any questions about using collaboration, generative AI, or any other aspect of how you may prepare assignments in this course, please message or talk to me.

Accommodations for Students with Disabilities

If you have a disability and have accommodations approved by the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you have a disability and require accommodations but do not already have them approved by the Office of Disability Resources, please apply for accommodations through the Application section of the Disability Resources Online Portal.

Study Tips

These are some tips and tricks on how to do well in class. (These are general tips that can help you succeed in learning!)

1. Come to class prepared with paper and writing implement for note taking.
2. Lecture notes and/or slides are posted to the syllabus page on the course website. Read over these notes and your class notes before the next lecture. This will only take a short amount of time but can yield great benefits in transferring material to your memory and highlighting areas of confusion, which can be clarified in class.

- Highlight important concepts and/or make marginal notes.
- Re-do in-class examples, without looking at your answer. When going through examples in class, it may seem easy. Doing the example yourself can highlight areas that need clarification.
- Write down your questions and bring them to the next lecture. If you're uncomfortable asking a question in class, give it to me on a piece of paper at the start of class or email me the night before.

3. Do the homework. Doing the problems is like training for your brain.
   - Start early.
   - Ask me for clarification on any questions that are unclear.
   - Attempt to solve the problems before collaborating with other students or coming to office hours.
   - Do the problems again, after the solutions have been posted. Be sure you understand how to solve the problem.
4. Come to office hours and use the time productively.
5. Read the assigned readings. As with lecture notes, you should highlight, make marginal notes, do the examples, and write down questions you may have.

Student Health & Well-being

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep, and taking some time to relax. *This is especially important given the uncertainty and isolation many of us face.*

All of us benefit from support during times of stress or struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Take the time to learn about all that's available and take advantage of it. Ask for support sooner rather than later – this always helps.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Consider reaching out to a friend, faculty, or family member you trust for assistance in obtaining support that can help. Counseling and Psychological Services (CaPS) is here for you: call 412-268-2922 and visit their website http://www.cmu.edu/counseling/. Over 25% of students reach out to CaPS at some point during their time at CMU.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

CaPS: 412-268-2922

Re:solve Crisis Network: 888-796-8226

If the situation is life threatening, call the police.

On campus: CMU Police: 412-268-2323

Off campus: 911

Food Insecurity: If you are worried about affording food or feeling insecure about food, there are resources on campus that can help. Email the CMU Food Pantry Coordinator to schedule an appointment:

Pantry Coordinator
cmu-pantry@andrew.cmu.edu
412-268-8704 (SLICE office)

Academic Resources

- The Student Academic Success Center offers many services and resources to students in need of academic help, including academic counseling and individual tutoring. They can also help you improve general learning strategies, such as note-taking, time-management, exam preparation, and stress management. Services are free to all Carnegie Mellon students.
- Communication Support provides free communication instruction and support to help CMU students, faculty, and staff convey their ideas logically, clearly, and effectively. Services include one-on-one tutoring and campus workshops.
- Language and Cross-cultural Support offers services and resources to students from other cultural backgrounds to help with developing language skills and adjusting to the culture of the American classroom.

Diversity and Inclusion

We must treat every individual with respect. We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Each of these diverse identities, along with many others not mentioned here, shape the perspectives our students, faculty, and staff bring to our campus. We, at CMU, will work to promote diversity, equity, and inclusion not only because diversity fuels excellence and innovation, but because we want to pursue justice. We acknowledge our imperfections while we also fully commit to the work, inside and outside of our classrooms, of building and sustaining a campus community that increasingly embraces these core values.

Each of us is responsible for creating a safer, more inclusive environment.

Unfortunately, incidents of bias or discrimination do occur, whether intentional or unintentional. They contribute to creating an unwelcoming environment for individuals and groups at the university. Therefore, the university encourages anyone who experiences or observes unfair or hostile treatment on the basis of identity to speak out for justice and support, within the moment of the incident or after the incident has passed. Anyone can share these experiences using the following resources:

- Center for Student Diversity and Inclusion: csdi@andrew.cmu.edu, (412) 268-2150
- Report-It online anonymous reporting platform: reportit.net username: *tartans* password: *plaid*

All reports will be documented and deliberated to determine if there should be any following actions. Regardless of incident type, the university will use all shared experiences to transform our campus climate to be more equitable and just.