



QBIO 578A, Computational Molecular Biology

Units: 3

Spring 2023 - Tuesday, Thursday - 11-12:20

Location: RRI 301

Instructor: Andrew Smith

Office: RRI 408E

Office Hours: 10AM-12PM, Fridays, or by appointment.

Contact Info: andrewds@usc.edu, response within 48 hours.

Instructor: Mark Chaisson

Office: RRI 408H

Office Hours: 10AM-12PM, Wednesday, or by appointment.

Contact Info: mchaisso@usc.edu, response within 48 hours.

Course Description

Modern molecular biology involves unique forms of data. These data are notable for their size: many computational challenges in molecular biology cannot be solved simply by employing more hardware. These data also continually demand novel abstractions, both for data structuring and characterizing the associated algorithmic problems. This course covers algorithmic foundations of sequence analysis including string matching, sequence alignment, genome assembly, phylogenetic analysis, and genome rearrangements. Methods will be related to fundamental concepts from computer science including computational complexity, representation in computer architecture, and data structures.

Learning Objectives

- Introduce the classical problems and fundamental algorithms in computational molecular biology.
- Establish a robust algorithmic toolkit enabling students to efficiently solving computational challenges encountered during data analysis.
- Teach students to recognize which techniques are appropriate for solving particular computational problems, to recognize when obvious approaches will fail, and when approximations should be considered.
- Show students how algorithmic theory meets practical performance through implementation and experimentation on real molecular biology data.
- Provide students with the foundation for conducting research designing novel algorithms for emerging computational problems in molecular biology.

Prerequisite(s): CSCI 570

Co-Requisite(s): None

Concurrent Enrollment: None

Recommended Preparation: Programming in a compiled language, computer architecture,

Course Notes

Letter grade. Extra reading materials placed on blackboard.

Required Readings and Supplementary Materials

“Algorithms on Strings, Trees and Sequences” by Dan Gusfield. Each lecture is also accompanied by at least one original research article that will be posted on Blackboard.

Description and Assessment of Assignments

Assignments are a combination of problem sets and software implementation. Answers to problem sets must be clearly written and show all steps. Assignments must be completed by hand. No credit will be given to typeset assignments that are printed or electronically submitted. No credit will be given for answers that are not legible. The assignment 0 is to be submitted the first week, and will be evaluated for legibility.

Grading Breakdown

| Assessment Tool (assignments) | Points | % of Grade |
|--------------------------------------|---------------|-------------------|
| Assignment 0 | 0 | 0 |
| Assignment 1 | 100 | 10 |
| Assignment 2 | 100 | 10 |
| Assignment 3 | 100 | 10 |
| Assignment 4 | 100 | 10 |
| Midterm | 100 | 30 |
| Final | 100 | 30 |
| TOTAL | 600 | 100 |

Assignment Submission Policy

Assignments are to be submitted in the beginning of class on the Tuesday of the week listed as due.

Grading Timeline

Homework and exams will be graded within one week of the due date or exam.

Additional Policies

No electronic devices are permitted to be out during exams. It is expected that students arrive before class begins.

Course Schedule:

| | Topics/Daily Activities | Readings/Preparation | Deliverables |
|----------------|---|-----------------------------|--|
| Week 1 | Exact string matching. Z-algorithm | Gusfield, chapter 1. | Assignment 0 (Thursday) |
| Week 2 | Exact string matching. Knuth-Morris-Pratt | Gusfield, chapter 2. | Homework 1 assigned. |
| Week 3 | Numerical encodings. Rabin-Karp | Gusfield, chapter 4. | |
| Week 4 | String sort, Suffix trees | Gusfield, chapter 5. | Homework 1 due. Homework 2 assigned. |
| Week 5 | McCreight suffix tree. Suffix arrays. | Gusfield, chapter 6. | |
| Week 6 | Suffix arrays, skew alg. Burrows-wheeler transform | | |
| Week 7 | Pairwise alignment, global, local, affine. | Gusfield, chapter 11. | Homework 2 due. |
| Week 8 | Pairwise alignment, linear space. Midterm | Gusfield, chapter 12. | |
| Week 9 | Convex-gap alignment. Partial order alignment. | Gusfield, chapter 12 | Homework 3 assigned. |
| Week 10 | Spring break | | |
| Week 11 | Sparse-dynamic programming | Gusfield, chapter 13.3 | |
| Week 12 | Multiple sequence alignment | Gusfield, chapter 14 | Homework 3 due. Homework 4 assigned. |
| Week 13 | Genome rearrangements | | |

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|----------------|--------------------|-----------------------|--|
| Week 14 | Genome assembly. | Gusfield, chapter 16. | |
| Week 15 | Phylogenetic trees | Gusfield, chapter 17. | Homework 4 due. |
| FINAL | | | Refer to the final exam schedule in the USC <i>Schedule of Classes</i> at classes.usc.edu . |

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on [Research and Scholarship Misconduct](#).

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University’s educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress
24 hours a day, 7 days a week.

*Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press
"0" after hours – 24/7 on call*

studenthealth.usc.edu/sexual-assault

Free and confidential therapy services, workshops, and training for situations related to
gender-based harm.

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086

eeotix.usc.edu

Information about how to get help or help someone affected by harassment or
discrimination, rights of protected classes, reporting options, and additional resources for
students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298

usc-advocate.symplicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for
Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures,
and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776

osas.usc.edu

OSAS ensures equal access for students with disabilities through providing academic
accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 821-4710

campussupport.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues
adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion
Council, Diversity Liaisons for each academic school, chronology, participation, and
various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety,
including ways in which instruction will be continued if an officially declared emergency
makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds.usc.edu

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-3340 or otfp@med.usc.edu
chan.usc.edu/otfp

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.