

## Syllabus BISC/QBIO 481 Fall 2021

### Structural Bioinformatics from Atoms to Cells

**Time and Location:** T/Th 11:00 am - 12:20 pm

**Instructors:**

Dr. Jared Sagendorf (1 <sup>st</sup> part)	RRI-413M;	<a href="mailto:sagendor@usc.edu">sagendor@usc.edu</a>
Dr. Adam MacLean (2 <sup>nd</sup> part)	RRI-403H; (213) 740-7055	<a href="mailto:macleana@usc.edu">macleana@usc.edu</a>

**Teaching Assistants:**

TBA		
TBA		

**Description:**

This course will introduce the principles of computational structural and systems biology, ranging in scope from the molecular structures of biological macromolecules and their structural organization at the cellular level to dynamical systems modeling of cells and tissues. Structural bioinformatics methods are introduced for the analysis and structural prediction of proteins, nucleic acids and their assemblies. The principles of molecular interactions and recognition are illustrated. The principles of modeling in systems biology will be introduced using differential equations as a foundation. We will exemplify all computational and theoretical approaches with practical examples, and introduce related software packages and databases.

**Goals:**

The students shall obtain necessary skills to analyze and predict structural properties of biological macromolecules and complexes, which includes proteins and nucleic acids. Our students shall gain a good understanding of key concepts of structure and dynamics of biological assemblies at the atomic, molecular, and cellular level.

**Required reading:**

The Molecules of Life – Physical and Chemical Principles. First Edition, 2012. John Kuriyan, Boyana Konforti, and David Wemmer. Garland Science. Taylor & Francis. The book can be rented or purchased on amazon.com, or required Chapters can be purchased directly from Garland Science.

Nonlinear Dynamics and Chaos. Second Edition, 2015. Steven H. Strogatz. CRC Press. The eBook is available online via USC libraries.

**Course contents:**

Biological web resources, structure databases, structure alignment, protein, DNA, and RNA structure, molecular recognition, structural analysis and molecular simulation algorithms.

**Grade:**

Course grade will be based on homework, a mid-term and final examination as follows:

Percentage of final grade:

Homework Projects:	50 %
Mid-term Examination:	25 %
Final Examination:	25 %

The final and mid-term examinations will be comprehensive written tests. The homework assignments from each half of the course will contribute to half of the total homework grade. You should hand in your projects by the due date specified by the instructors. Points will be subtracted for projects submitted after the due date.

**Tentative Schedule:**

**Weekly discussion sections will be held every Friday 4-5pm (led by TA).** These discussion sections are not obligatory but rather offered to complement the lectures. We also plan to provide a Q&A Forum for accessibility of the course.

**Week 1: Lectures 1 and 2 (Sagendorf) 08/24/21-08/26/21**

Topics: Introduction to molecular structure / Energy and intermolecular forces / Visualization of molecular structures / Protein Data Bank/ Protein structure  
Reading: Molecules of Life, Ch. 1

**Week 2: Lectures 3 and 4 (Sagendorf) 08/31/21-09/02/21**

Topics: Protein structure / Calculation of bond and torsion angles / Secondary structure elements / Ramachandran plot  
Reading: Molecules of Life, Ch. 4A-B

**Week 3: Lectures 5 and 6 (Sagendorf) 09/07/21-09/09/21**

Topics: Hierarchy of protein structure / Nucleic acid structure / Computational structure analysis  
Reading: Molecules of Life, Ch. 6C

**Week 4: Lectures 7 and 8 (Sagendorf) 09/14/21-09/16/21**

Topics: Nucleic acid structure / Calculation of helical parameters / RNA vs. DNA / Electrostatics  
Reading: Molecules of Life, Ch. 2

**Week 5: Lectures 9 and 10 (Sagendorf) 09/28/21-09/30/21**

Topics: Electrostatics calculations and solvation models / Poisson-Boltzmann equation / Force fields / Structure prediction / Molecular dynamics and Monte Carlo simulations

Reading: Rohs et al. *Nature* 461, 1248-1253, 2009 (will be on Blackboard)

**Week 6: Lectures 11 and 12 (Sagendorf) 10/05/21-10/07/21**

Topics: Structure determination / X-ray crystallography and Cryo EM / Affinity and specificity in molecular interactions / Cooperativity through co-factors and oligomerization / Protein-nucleic acid recognition / review for Midterm

Reading: *Molecules of Life*, Ch. 13A+13C

**Midterm Exam (Sagendorf): 10/12/21**

**Week 8: Lectures 14 and 15 (MacLean) 10/19/21-10/21/21**

Topics: Introduction to systems biology / Dynamical models of biological systems / Biological rates of change / Review of derivatives and differential equations

Reading: Kitano (2002), "Systems Biology: A Brief Overview" *Science*, 295 (will be on Blackboard)

**Week 9: Lectures 16 and 17 (MacLean) 10/26/21-10/28/21**

Topics: Ordinary differential equation (ODE) models in biology / Developing models from building blocks / Solving ODE models at steady state / Fixed points / Numerical methods for solving ODEs

Reading: Strogatz, Ch. 2

**Week 10: Lectures 18 and 19 (MacLean) 11/02/21-11/04/21**

Topics: Stable states and attractors / Analysis of ODE models at steady state: linear stability analysis / Multistability / Analysis of ODE models: bifurcations

Reading: Strogatz, Ch. 3

**Week 11: Lectures 20 and 21 (MacLean) 11/09/21-11/11/21**

Topics: Modeling biological noise / Stochastic gene expression / Stochastic differential equations / Linear noise approximation

Reading: Elowitz et al. (2002) "Stochastic Gene Expression in a Single Cell" *Science*, 297 (will be on Blackboard)

**Week 12: Lectures 22 and 23 (MacLean) 11/16/21-11/18/21**

Topics: Fitting models to data / Parameter estimation and model selection / maximum likelihood estimation / Bayes rule and Bayesian inference for systems biology / Model identifiability

Reading: Kirk et al. (2013) "Model selection in systems and synthetic biology" *Curr Opin Biotech*, 24(4) (will be on Blackboard)

**Week 13-14: Lecture 24 and Lecture 25 (MacLean) 11/23/21-11/30/21**

Topics: Modeling cell heterogeneity / Single-cell biology / Dimensionality reduction / Methods for multiscale modeling in biology

Reading: Wagner et al. (2016) "Revealing the vectors of cellular identity with single-cell genomics" *Nat Biotech*, 34(11) (will be on Blackboard)

**Final Exam (MacLean): 12/07/21**

Please note that some reading assignments and homework due dates will be announced at a later time.

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**Statement for Observance of Religious Holidays:**

The university's policy grants students excused absences from class to observe religious holidays (<http://orl.usc.edu/religiouslife/holydays/absences.html>). In this case, please contact your instructor in advance to agree on alternative course requirements.

**Statement for Students with Disabilities:**

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your instructor as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

**Statement on Academic Integrity:**

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: <http://www.usc.edu/dept/publications/SCAMPUS/gov/>. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: <http://www.usc.edu/student-affairs/SJACS/>.

## 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](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [policy.usc.edu/scientific-misconduct](http://policy.usc.edu/scientific-misconduct).

### Support Systems:

*Student Health Counseling Services - (213) 740-7711 – 24/7 on call*

[engemannshc.usc.edu/counseling](http://engemannshc.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](http://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) 740-4900 – 24/7 on call*

[engemannshc.usc.edu/rsvp](http://engemannshc.usc.edu/rsvp)

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

*Office of Equity and Diversity (OED) | Title IX - (213) 740-5086*

[equity.usc.edu](http://equity.usc.edu), [titleix.usc.edu](http://titleix.usc.edu)

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

*Bias Assessment Response and Support - (213) 740-2421*

[studentaffairs.usc.edu/bias-assessment-response-support](http://studentaffairs.usc.edu/bias-assessment-response-support)

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

*The Office of Disability Services and Programs - (213) 740-0776*

[dsp.usc.edu](http://dsp.usc.edu)

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

*USC Support and Advocacy - (213) 821-4710*

[studentaffairs.usc.edu/sssa](http://studentaffairs.usc.edu/sssa)

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

*Diversity at USC - (213) 740-2101*

[diversity.usc.edu](http://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](http://dps.usc.edu), [emergency.usc.edu](http://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](http://dps.usc.edu)

Non-emergency assistance or information.