Syllabus BISC 481 Fall 2017

Structural Bioinformatics from Atoms to Cells

Time and Location: TTh 11:00 am - 12:20 pm Room: RRI 101

Instructors:

Dr. Vsevolod Katritch (1st part)	TRF-118; 213-821-1488	katritch@usc.edu
Dr. Frank Alber (2nd part)	RRI-413E; 213-740-0778	alber@usc.edu

Teaching Assistants:

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Note that the prerequisite has been removed. You can register without satisfying the prerequisite by contacting your student advisor.

Description:
This course will introduce the principles of computational structural biology ranging in scope from the molecular structures of biological macromolecules to their structural organization at the cellular level. 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. 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. Certain chapters are required and can be purchased at http://www.garlandscience.com

Recommended reading:
Introduction to Proteins – Structure, Function, and Motion. First Edition, 2011. Amit Kessel and Nir Ben-Tal. Chapman &Hall/CRC. Francis & Taylor Group.

Structural Bioinformatics, Vol. 44, Series: Methods of Biochemical Analysis; 2005, Editor(s): Philip E. Bourne, Helge Weissig. Print ISBN: 9780471202004; Online ISBN: 9780471721208; DOI: 10.1002/0471721204

Course contents:
Biological web resources, structure databases, structure alignment, protein, DNA, and RNA structure, molecular recognition, threading methods for protein structure modeling, protein dynamics, 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:	33 %
Mid-term Examination:	33 %
Final Examination:	33 %

The final and mid-term examinations will be comprehensive written tests. Six homework projects will be assigned by the instructors. 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.

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/.

Tentative Schedule:

Week 1: Lectures 1 and 2 Katritch)
Topics: Introduction to molecular structure / Energy and intermolecular forces / Visualization of molecular structures / Protein Data Bank
Reading: Molecules of Life, Ch. 1

Week 2: Lectures 3 and 4 (Katritch)
Topics: Protein structure / Calculation of bond and torsion angles / Secondary structure elements / Ramachandran plot/Membrane proteins
Reading: Molecules of Life, Ch. 4A-B,4D

Week 3: Lectures 5 and 6 (Katritch)
Topics: Nucleic acid structure / Computational structure analysis / Calculation of helical parameters
Reading: Molecules of Life, Ch. 2

Week 4: Lectures 7 and 8 (Katritch)
Topics: Molecular dynamics simulations / Monte Carlo simulations / Electrostatics calculations and solvation models
Reading: Molecules of Life, Ch. 6C; Rohs et al. Nature 2009
Homework 1 due 09/14/17

Week 5: Lectures 9 and 10 (Katritch)
Topics: Methods of structure determination and prediction / X-ray crystallography and NMR spectroscopy / High-throughput experiments for probing protein-DNA binding Reading: Introduction to Proteins, Ch. 3.1-3.3

Week 6: Lectures 11 and 12 (Katritch)
Topics: Affinity and specificity in molecular interactions / Protein-drug binding / Cooperativity through co-factors and oligomerization / Protein-nucleic acid recognition / Transcription factors / Nucleosome
Reading: Molecules of Life, Ch. 12, 13A+13C
Homework 2 due 10/03/17

Week 7: Lectures 13 and 14 (Katritch)
Topics: Data mining and high-throughput DNA shape prediction / Machine learning techniques for binding specificity predictions

Week 8: Midterm Exam 10/10/17 (Katritch)

Week 8: Lectures 15 (Alber)
Topics: Overview structural biology of the cell – historic perspective - breakthrough discoveries

Week 9: Lectures 16 and 17 (Alber)
Topics: Protein folding problem

Week 10: Lectures 18 and 19 (Alber)
Topics: Protein sequence similarity / Sequence alignment and dynamic programing

Week 11: Lectures 20 and 21 (Alber)
Protein structure motifs / protein structure variation and structure space / protein classification / protein structure modeling (Comparative modeling and ab initio methods)

Week 12: Lectures 22 and 23 (Alber)
Topics: Protein interactions: Detection of interactions and principles of protein recognition / Structure determination of protein complexes / Principles of cryo electron microscopy

Week 13: Lectures 24 and Lecture 25 (Alber)
Topics: Modeling of protein complexes / Prediction of protein interactions / Protein docking methods / Molecular organization of the cell / Protein crowding

Week 14: Lecture 26 (Alber) and Thanksgiving holiday.
Topics: / Methods for determining the ultra structures of cells and the cellular distribution of proteins and complexes / Cryo electron tomography

Week 15: Lecture 27 (Alber) and Lecture 28 (Alber)
Topics: Structure organization of the genome / structure function correlations of genomes

Study Break: 12/02/17 – 12/05/2017

Week 16: Final Exam 12/07/17 (Alber) RRI: 101, 8am-10am.

Please note that reading assignments and homework due dates for the second half of the course will be announced at a later time.