

BMS 502: Macromolecular Structure & Function
Schedule for Fall 2010
9 am – 11 am, David Axelrod Institute, Room 1041

Day	Date	Session	Topic	Professor
Wed	1 Sept	1	Introduction & Overview	Pata
Fri	3 Sept	2	General Properties of Molecules	Pata
Mon	6 Sept		<i>Labor Day</i>	
			Module 1:	
Wed	8 Sept	3	Macromolecular Structure I	Pata
Fri	10 Sept		<i>Rosh Hashanah Break</i>	
Wed	15 Sept	4	Macromolecular Structure II	Pata
Fri	17 Sept	5	Macromolecular Structure III	Pata
			Module 2	
Wed	22 Sept	6	Macromolecular Function I	Pata
Fri	24 Sept	7	Macromolecular Function II	Pata
Wed	29 Sept	8	Macromolecular Function III	Pata
Fri	1 Oct		Exam	
			Module 3	
Wed	6 Oct	9	Quantitative Methods I	Laederach
Fri	8 Oct	10	Quantitative Methods II	Laederach
Mon	11 Oct		<i>Columbus Day (Exam in BMS 500)</i>	
			Module 4	
Wed	13 Oct	11	Proteins & Protein Assemblies I	Banavali
Fri	15 Oct	12	Proteins & Protein Assemblies II	Banavali
Wed	20 Oct	13	Proteins & Protein Assemblies III	Banavali
Fri	22 Oct	14	Proteins & Protein Assemblies IV	Banavali
			Exam and/or Project Due	
			Module 5	
Wed	27 Oct	15	Proteins & Nucleic Acids I	Jaeger
Fri	29 Oct	16	Proteins & Nucleic Acids II	Jaeger
Wed	3 Nov	17	Proteins & Nucleic Acids III	Jaeger
Fri	5 Nov	18	Proteins & Nucleic Acids IV	Jaeger
			Exam and/or Project Due	
			Module 6	
Wed	10 Nov	19	Proteins & Membranes I	Wagenknecht
Fri	12 Nov	20	Proteins & Membranes II	Wagenknecht
Wed	17 Nov	21	Proteins & Membranes III	Wagenknecht
Fri	19 Nov	22	Proteins & Membranes IV	Wagenknecht
			Exam and/or Project Due	
Wed	24 Nov		<i>Thanksgiving Break</i>	
Fri	26 Nov		<i>Thanksgiving Break</i>	
			Module 7	
Wed	1 Dec	23	Pathways & Regulation I	Tenniswood
Fri	3 Dec	24	Pathways & Regulation II	Tenniswood
Wed	8 Dec	25	Pathways & Regulation III	Tenniswood
Fri	10 Dec	26	Pathways & Regulation IV	Tenniswood
			Exam and/or Project Due	

SYLLABUS
BMS 502: Macromolecular Structure & Function
4 credits

SYNOPSIS

This course presents an integrated approach to investigating the structure and function of biological macromolecules. The course is primarily intended for students who are undertaking graduate-level research in the biomedical sciences, and is designed to bridge the gap that frequently exists between classroom lectures and laboratory research.

COURSE DESCRIPTION

The first two modules of the course cover the fundamental aspects of macromolecular structure and function, while the third module introduces students to quantitative methods for data analysis and computational modeling. The next three modules focus on three major types of macromolecular interactions (protein-protein, protein-nucleic acid, and protein-membrane) and the distinctive aspects of each type of interaction. The final module build on all the earlier modules to show how the major constituents of cells function together in pathways and how those pathways can be regulated.

Topics for in-depth study in each module will be determined by the instructor, and may change from year to year, but will be drawn from the wide variety of disciplines encompassed by research in the Department of Biomedical Sciences, including infectious disease and immunology, cancer, neurobiology, molecular genetics, cell biology, biochemistry and structural biology. A significant fraction of in-class time will be devoted to individual and group exercises that will provide students with opportunities to demonstrate their knowledge of macromolecular structure and function by analyzing experimental methods and results from the primary research literature, evaluating alternative approaches, and designing further experiments.

All sessions will be held from 9:00 AM to 11:00 AM in Room 1041 of the David Axelrod Institute at 120 New Scotland Avenue, Albany, NY.

LEARNING OBJECTIVES

After taking this course, students will:

- **know** the fundamental principles of, and experimental methods to study, macromolecular structure and function.
- **understand** these fundamentals and how they can be used to study a wide range of biological questions.
- be able **apply** this knowledge and understanding to investigate how changes in structure (e.g. mutations and modifications) produce changes in function.
- be able to **analyze** data and **interpret** results of experiments relating to macromolecular structure and function.
- be able to **evaluate** the advantages and limitations of different experimental approaches.
- be able to **integrate** the knowledge and skills acquired to design new experimental approaches to study biological problems of interest and relevance to their own research.

An overarching objective is that students will become motivated self-learners with the resources to delve more deeply into the study of macromolecular structure and function as it relates to their own research.

INSTRUCTORS

Course Director: Dr. Janice Pata

Teaching Faculty: (office hours by arrangement)

Dr. Nilesh Banavali	banavali@wadsworth.org	518-474-0569	CMS 2008
Dr. Joachim Jaeger	jjjaeger@wadsworth.org	518-408-2225	CMS 2009
Dr. Alain Laederach	alain@wadsworth.org	518-486-4103	CMS 2003
Dr. Janice Pata	jpata@wadsworth.org	518-402-2595	CMS 2007
Dr. Martin Tenniswood	mtenniswood@albany.edu	518-591-7231	CFG 304
Dr. Terry Wagenknecht	terry@wadsworth.org	518-474-2450	ESP C300

COURSE REQUIREMENTS

Prerequisites: Undergraduate-level courses in biochemistry and molecular biology are helpful, but not required. Students who are not enrolled in a graduate program with the Department of Biomedical Sciences should contact the course director prior to registering for this course.

Reading material: The course will make extensive use of review and primary research articles from the scientific literature and will be provided to the students during the course.

Textbooks: Students should have access to comprehensive textbooks on biochemistry and molecular cell biology, such as those used in advanced undergraduate courses. Since the textbooks will primarily be used for background reading to supplement the other material, students should consult with the course director prior to investing in the purchase of textbooks. The following books will be on reserve in the Wadsworth Center's Library:

Voet & Voet (2004) *Biochemistry*, 3rd Edition. [Wiley]

Alberts *et al.* (2008) *Molecular Biology of the Cell*, 5th Edition. [Garland Science]

Computers & Internet Access: Students will need access to personal computers (Macintosh or Windows operating systems) with software for internet browsing (e.g. Firefox, Safari, or Internet Explorer) as well as basic word processing and spreadsheet applications (e.g. Open Office, Microsoft Office, or iWork). The open-source program PyMol will be used for visualizing and analyzing molecular structures. Other programs will be accessed through web-based interfaces. Internet access will be available when required during class, and is available in the Wadsworth Center libraries outside of class time.

Each student should bring his/her own laptop computer to each session to use for in-class exercises. Students who do not have a laptop computer should notify the course director prior to the first class so that alternate arrangements can be made.

REASONABLE ACCOMODATIONS

Reasonable accommodations will be provided for students with documented physical, sensory, systemic, cognitive, learning and psychiatric disabilities. If you believe you have a disability requiring accommodation in this class, please notify the Director of the Disability Resource Center (Campus Center 137, 442-5490). That office will provide the course instructor with verification of your disability, and will recommend appropriate accommodations. See <http://www.albany.edu/disability/rap.shtml> for more information.

GRADING

The course uses the A-E grading scheme. Each class session (except the first) will be worth 40 points, divided into the following categories:

Readiness Assessments Tests (individual and group)	25%
In-Class Exercises & Participation (individual and group)	25%
Exams & Projects (individual)	50%

Readiness Assessment Tests:

At the beginning of each module, students will take a multiple-choice “Readiness Assessment Test” (RAT) that will cover the background material assigned in advance for that module. These are designed to allow students to review material from their undergraduate courses, which will serve as the foundation for the module, and to allow faculty spend more class time on new concepts rather than going over material that is already familiar to the students. Students will have the opportunity to ask questions about the background reading prior to taking the RAT. Students will first take the RAT individually, then immediately re-take the RAT as a group. Both the individual and group RATs will be graded.

Group work and peer evaluation:

During the first class session, students will be divided into groups of ~5 students that will work together throughout the semester. Groups will be formed to distribute expertise as equitably as possible between the groups.

To ensure that everyone has an incentive to contribute to the group work, each student will assess (at the end of the semester) the contributions made by the other members of his/her group. This assessment will take into consideration the following criteria about group members:

Preparation: were they prepared when they came to class?

Contribution: did they contribute productively to group discussions & work?

Respect for others' ideas: did they encourage others to contribute their ideas?

Flexibility: were they flexible when disagreements occurred?

Each student will have 100 points to distribute between the other members of their group. The final scores on group tests and assignments will be adjusted (up or down) for each student based on the fraction of points (out of 100) that the student received from the other members of their group.

ATTENDANCE

Attendance at all class sessions is expected, and will be recorded by each group. Students should notify the other members of their group if they know they will not be able to attend a session. Because of the group work that is to be done in class, attendance will be taken into account during the peer evaluation as it effects preparation for and contribution to group work.

ACADEMIC INTEGRITY

All students are expected to abide by the UAlbany policies on academic integrity, which can be found at http://www.albany.edu/graduatebulletin/admission_graduate_requirements.htm .

INTRODUCTORY SESSIONS (Sessions 1-2):

Instructor: Pata

Session 1: Introduction & Overview

Domains of life:

- Bacteria, archaea, eukarya
- Similarities & differences
- Evolutionary relationships

Major constituents of life:

- Macromolecules: proteins, nucleic acids, polysaccharides
- Membranes
- Water
- Small molecules

Scale in biological systems:

- From atoms to cells and organisms
- Significance of macromolecular structure & function at all these scales

Relationship between structure and function:

The structure (three-dimensional arrangement of atoms in a molecule), determines function (interactions with other molecules, catalysis, etc.).

Mutations and modifications:

- Changes in: DNA, RNA, proteins and other molecules
- How changes in structure can cause changes in function

Reading & evaluating scientific literature:

Review articles, primary research papers
Other sources of information

Session 2: General Properties of Molecules

Physical properties of molecules that govern their behavior:

- Chemical composition: common atoms & functional groups in biology
- Hydrophobic vs. hydrophilic; chemical reactivity; etc.
- Concentration (law of mass action); diffusion
- Solution conditions (pH, ionic strength, temperature, hydrophobicity, etc.)
- Free energy, enthalpy, entropy
- Importance of ATP
- Chemical & mechanical work

Forces governing non-covalent interactions between molecules:

- Charge-charge interactions
- Van der Waals interactions
- Hydrogen bonding
- Hydrophobic effect

Tools & resources for studying structure:

- Protein Data Bank (PDB)
- Molecular graphics programs
- Web-based tools

Tools & resources for studying function:

- Assay development
- Data analysis, graphing, modeling software
- Web-based tools

MODULE I: MACROMOLECULAR STRUCTURE (Sessions 3-5)

Instructor: Pata

Structures of proteins, nucleic acids, polysaccharides and their monomeric building blocks; non-covalent forces stabilizing macromolecular structures; aqueous vs. hydrophobic environments; conformational changes, especially those induced by nucleotide hydrolysis; purification and characterization of macromolecules; structural methods.

MODULE II: MACROMOLECULAR FUNCTION (Sessions 6-8)

Instructor: Pata

Effects of reaction conditions on activity (pH, ionic strength, solvent polarity, oxidation/reduction, co-factors); influence of mutations and modifications on structure and function; free energy, enthalpy and entropy; energetics of nucleotide hydrolysis; concentration dependence of activity; enzyme kinetics.

MODULE III: QUANTITATIVE METHODS (Sessions 9-10)

Instructor: Laederach

Curve fitting; significance testing; computational modeling.

MODULE IV: PROTEINS & PROTEIN ASSEMBLIES (Sessions 11-14)

Instructor: Banavali

Principles: how proteins function in isolation and as complexes; protein folding & dynamics

Methods: methods for detecting protein-protein interactions, quantitating interaction strength, detecting molecular motion

Example topics: chaperones, proteasomes, ubiquitination; cytoskeletal proteins & molecular motors; multifunctional enzyme complexes; virus assembly

MODULE V: PROTEINS & NUCLEIC ACIDS (Sessions 15-18)

Instructor: Jaeger

Principles: sequence specific & structure specific recognition of nucleic acids by proteins

Methods: methods for detecting protein-nucleic acid interactions & quantitating strength & specificity

Example topics: polymerases; helicases; the ribosome; splicing; viral genome replication & packaging

MODULE VI: PROTEINS & MEMBRANES (Sessions 19-22)

Instructor: Wagenknecht

Principles: lipid and membrane structure & dynamics; transport across membranes; unique properties of membrane proteins.

Methods: special considerations for membrane-associated proteins

Example topics: transporters, ligand-gated and voltage-gated ion channels; virus entry/exit

MODULE VII: PATHWAYS & REGULATION (Sessions 23-26)

Instructor: Tenniswood

Principles: turning pathways off and on; cooperativity and enzyme regulation; coupling of energetically favorable and unfavorable reactions; transmitting an extracellular signal to the nucleus (or other location where the cell responds)

Methods: integration of all of the above; high throughput & “omics” methods

Example topics: signal transduction pathways; biochemical pathways