

## Representative timeline for a Molecular Biophysics PhD

Year	Term	Half/Full	Title	Credit Hour	Total Credit Hrs/Term	
First Year	Fall	Full	Core Curriculum - Proteins	2	Semester Total: 10	
			Core Curriculum - Genes	2		
			Core Curriculum- Cell	2		
			Professionalism, Responsible Conduct of Research, and Ethics I	1		
			Laboratory Rotations	3		
	Spring	1 <sup>st</sup> Half	Full	Macromolecule I: Energetic Foundation	2	Semester Total: 11
				Modern Methods in Structural Biology	1.5	
		2 <sup>nd</sup> Half	Full	Macromolecules II: Structural Foundation	2	
				Using Light in Biology (previously titled: Spectroscopy)	1.5	
		Full	Full	Professionalism, Responsible Conduct of Research, and Ethics II	1	
	Laboratory Rotations/Research			3		
	Summer			Research	6	Semester Total: 6
<b>21 course credits plus 6 summer research credits fulfill the MB first year requirements</b>						
Second Year	Fall	Full	Introduction to Biostatistics and Bioinformatics	2	Semester Total: 10.5	
			Research	6		
			Elective Coursework*	1.5		
			Work-In-Progress (WIP) Seminar	1		
	Spring	Full	Full	Research	8	Semester Total: 10.5
				Elective Coursework*	1.5	
				Work-In-Progress (WIP) Seminar	1	
				Qualifying Exam		
Summer			Dissertation Research	6	Semester Total: 6	
Third Year	Fall	Full	Dissertation Research	8	Semester Total: 9	
			Work-In-Progress (WIP) Seminar	1		
	Spring	Full	Full	Dissertation Research	8	Semester Total: 9
				Work-In-Progress (WIP) Seminar	1	
	Summer			Dissertation Research	6	Semester Total: 6
Fourth Year & Beyond	Fall	Full	Dissertation Research	8	Semester Total: 9	
			Work-In-Progress (WIP) Seminar	1		
	Spring	Full	Full	Dissertation Research	8	Semester Total: 9
				Work-In-Progress (WIP) Seminar	1	
	Summer			Dissertation Research	6	Semester Total: 6
<b>Minimum Credit Hours for PhD</b>				<b>102</b>		

\*Any elective can fulfill this requirement. Option to take electives in first year, pending approval.

Recommended Advanced Elective Courses	Credit Hour	Term Offered	
Experimental Biophysics <sup>2</sup>	1.5	Fall	1 <sup>st</sup> half
Quantitative Biology <sup>1</sup>	1.5	Spring	1 <sup>st</sup> half
Advanced NMR Spectroscopy <sup>2</sup>	1.5	Fall	1 <sup>st</sup> half
Practical X-Ray Crystallography <sup>2</sup>	1.5	Fall	2 <sup>nd</sup> half
Logic and Persuasion in Scientific Communication	1.5	Fall	2 <sup>nd</sup> half

<sup>1</sup> Students are strongly encouraged to complete Mathematical Foundations of Quantitative Biology (Fall, 2nd half, 2.0 credit hours) prior to taking Quantitative Biology.

<sup>2</sup> Requires a prerequisite of Modern Methods in Structural Biology. Offered on demand.

# Molecular Biophysics Course Descriptions

## Required Courses

### Core Curriculum – Proteins

Fall (full semester)

2 credit hours

Instruction includes the energetic basis of protein structure; stability; ligand binding and regulation; enzyme mechanics and kinetics; methods of purification; and analysis by spectroscopic methods.

### Core Curriculum – Genes

Fall (full semester)

2 credit hours

Instruction includes molecular genetics of model organisms; DNA replication, repair, and recombination; transcription; RNA catalysis, processing, and interference; translation; protein turnover; developmental biology; and genomics.

### Core Curriculum – Cells

Fall (full semester)

2 credit hours

Cell structure; membrane biology; intracellular membrane and protein trafficking; energy conversion; signal transduction and second messengers; cytoskeleton; cell cycle; and introductory material in microbiology, immunology, and neurobiology.

### Professionalism, Responsible Conduct of Research, and Ethics I

Fall (full semester)

1 credit hour

Topics covered through lectures and small group discussions: goals of education in RCR; professionalism; collaboration; teambuilding and professional behavior; everyday practice of ethical science; mentorship; data management and reproducibility; animal research; genetics and human research.

## **Macromolecules I: Energetic Foundations**

Spring (1st half)

2 credit hours

This course covers diverse aspects of physical chemistry, including general concepts in thermodynamics and kinetics as well as topics more specific to biological macromolecules. All aspects will be presented from the point of view of statistical mechanics to provide a connection from microscopic behavior to macroscopic properties. Specific topics include diverse types of non-bonding interactions, cooperativity, phase transitions, and polymeric behavior.

## **Modern Methods in Structural Biology**

Spring (1st half)

1.5 credit hours

Much of modern structural biology is based on results obtained with two high-resolution methods (X-ray crystallography, NMR spectroscopy), often complemented by several lower-resolution approaches (EM, scattering, FRET, among others). We assert that the successful union of these general approaches is absolutely critical in modern structural biology, particularly as biophysical methods are applied to larger, multicomponent systems that are often dynamic in their composition. This course provides the foundation for students to understand these techniques, extending the introduction provided in the first year core course. A central focus of the course is discussions of both the theory and application of X-ray crystallography and NMR spectroscopy, with the aim to establish the physical bases of both methods using instruction that covers theory and application. Combined with introductions into the lower-resolution methods, this course provides students with the ability to critically evaluate the relative strengths and weaknesses of each technique and how they can be combined to provide insight into biological systems.

## **Macromolecules II: Structural Foundations**

Spring (2nd half)

2 credit hours

Overview of the basic principles governing protein structure and folding. Topics include stereochemical mechanisms by which protein secondary and tertiary structures are generated and stabilized, methods of prediction of tertiary structure from amino acid sequence, and the organization of folding motifs into protein structures. Instruction is based on didactic material, discussion of the primary literature, and student projects utilizing computer graphics.

## **Using Light in Biology**

Spring (2nd half)

1.5 credit hours

Overview of optical spectroscopic approaches to biological systems, both in vitro and via light microscopy of cells. Begins with discussion of the interaction of light with matter, and extension to absorption spectroscopy, and UV, both visible and IR. Circular dichroism of proteins and other chromophores. Fluorescence and fluorescence-based techniques. Static and dynamic light scattering. The course intends to develop physical principles to support rigorous biophysical applications and experimental design.

## **Professionalism, Responsible Conduct of Research, and Ethics II**

Spring (full semester)

1 credit hour

Topics covered through lectures and small group discussions: codes of ethics and misconduct; building interprofessional teams; conflict of interest; sexual boundaries and professional behavior; applications of

genetic testing; technology transfer and intellectual property; plagiarism, authorship, and citation; peer review; image and data manipulation.

## Elective Courses

### Quantitative Biology

Spring (1st half)

1.5 credit hours

Introduction to quantitative approaches to “complex” systems in biology. The course comprises a mixture of didactic lectures that provide a review of basic concepts, theories, and tools of quantitative science, and also a number of case studies in which deep understanding of biological systems has emerged through the application of this approach. An overall theme is to define complexity in a more rigorous way and to learn about strategies to rationally address complexity.

The course begins with the study of linear systems and the rich mathematical foundations for understanding and predicting their behaviors. The course then moves non-linear systems: What makes them complex and difficult, and why is the mathematical treatment of these systems so much harder? We will explore several biological examples of non-linearity in fields ranging from structural biology to evolution, ending ultimately with a general definition of complexity in biology and an operational strategy for studying such systems.

The syllabus includes a combination of analytical and computational exercises to solve as we go through the course; we will use MATLAB as our primary computing platform.

The course is open to all graduate students and postdocs.

### Advanced NMR Spectroscopy

Fall (1st half)

1.5 credit hours

This course is designed to provide a strong background on biomolecular NMR spectroscopy. Topics covered include diverse practical aspects on the application of one-dimensional and multidimensional NMR techniques, protein structure determination, analysis of protein dynamics, product operator formalism, design of pulse sequences and studies of large proteins/systems.

Prerequisite: Modern Methods in Structural Biology

### Experimental Biophysics

Fall (1st half)

2.0 credit hours

This course is designed to give students a solid theoretical and experiential background in several biophysical techniques that are available at UT Southwestern. The topics covered are dynamic light scattering, analytical ultracentrifugation, isothermal titration calorimetry, circular dichroism spectroscopy, and microscale thermophoresis. Through lectures, students are exposed to the theoretical underpinnings of the methods.

The students also participate in laboratory exercises in which they conduct experiments using instruments available in the Macromolecular Biophysics Resource. After collecting data, the students are then guided through analyzing and presenting their data.

Prerequisite: Modern Methods in Structural Biology

### **Logic and Persuasion in Scientific Communication**

Fall (2nd half)

1.5 credit hours

The course aims to improve participants' presentation skills by providing structured instructions on how to build strong arguments, both written and oral. By combining original lectures and practical exercises on: (a) formal and informal logic, including detection of logical fallacies in scientific presentations, and (b) elements of critical thinking, students will learn skills and practice constructing arguments, engaging an audience, and recognizing and responding to problems in communication.

### **Practical X-Ray Crystallography**

Fall (2nd half)

1.5 credit hours

Lectures and hands-on tutorials, with the goal of providing beginners in the discipline the tools to move forward confidently on crystallographic projects of their own. In the tutorial section, students will grow protein crystals, collect and process X-ray diffraction data, solve the phase problem using both molecular replacement and anomalous diffraction, build protein models, refine the model, analyze the model, and learn effective model presentation. Students will be tutored in the use of state-of-the-art crystallographic software. In the lectures, the principles behind the methods will be discussed.

Prerequisite: Modern Methods in Structural Biology. Recommended prerequisite: Protein Structure and Folding