BIOPHYSICS

http://biophysics.jhu.edu/

The Department of Biophysics offers programs leading to the B.A., M.A., and Ph.D. degrees. Biophysics is appropriate for students who wish to develop and integrate their interests in the physical and biological sciences.

Research interests in the Department cover experimental and computational, molecular and cellular structure, function, and biology, membrane biology, and biomolecular energetics. The teaching and research activities of the faculty bring its students in contact with biophysical scientists throughout the university. Regardless of their choice of research area, students are exposed to a wide range of problems of biological interest. For more information, and for the most up-to-date list of course offerings and requirements, consult the department web page at biophysics.jhu.edu (http://biophysics.jhu.edu/).

Research Activities of Primary Faculty

Protein Engineering and Biophysics (Dr. Garcia-Moreno)

To understand how biological macromolecules work, or to design and engineer new ones, it is necessary to understand in detail the relationship between structure and energetics. We study this problem in our lab by analysis of the connection between structure, thermodynamic stability, and dynamics of proteins with a combination of computational and experimental methods. The approach depends heavily on the application of NMR spectroscopy, X-ray crystallography, and equilibrium thermodynamics. The experiments contribute the physical insight needed to guide the development of computational methods for structure-based energy calculations, as well as the data required to benchmark these methods. We are focused on problems of protein electrostatics because electrostatic energy is the most useful metric for correlating structure with function in all the most important energy transduction processes in biological systems. We focus on the engineering of proteins with pH sensing.

Biophysics of RNA (Dr. Woodson)

The control of cell growth and type depends on the ability of RNA to fold into complex three-dimensional structures. RNA catalysts are good models for studying the physical principles of RNA folding, and the assembly of protein-RNA complexes such as the ribosome. Changes in RNA three-dimensional structure are monitored by fluorescence spectroscopy, “X-ray footprinting,” and neutron scattering. Bacterial and yeast expression systems are used to study intracellular folding of RNA.

Protein Folding, Notch Signaling (Dr. Barrick)

The folding of proteins into their complex native structures is critical for proper function in biological systems. This spontaneous process of self-assembly is directed by physical chemistry, although the rules are not understood. We are using repeat-proteins, linear proteins with simple architectures, to dissect the energy distribution, sequence-stability relationship, and kinetic routes for folding. We are also using consensus sequence design to explore how sequence statistices represented in multiple sequence alignments can be used to engineer protein stability, structure, and function. In addition, we are studying the molecular mechanisms of Notch signaling, a eukaryotic transmembrane signal transduction pathway. The transmission of information across the membranes of cells is essential for cell differentiation and homeostasis; signaling errors result in disease states including cancer. We are focusing on interactions between proteins involved in Notch signaling using modern biophysical methods. Thermodynamics of association and allosteric effects are determined by spectroscopic, ultracentrifugation, and calorimetric methods. Atomic structure information is being obtained by NMR spectroscopy. The ultimate goal is to determine the thermodynamic partition function for a signal transduction system and interpret it in terms of atomic structure.

NMR Spectroscopy (Dr. Lecomte)

Many proteins require stable association with an organic compound for proper functioning. One example of such “cofactor” is the heme group, a versatile iron-containing molecule capable of catalyzing a broad range of chemical reactions. The reactivity of the heme group is precisely controlled by interactions with contacting amino acids. Structural fluctuations within the protein are also essential to the fine-tuning of the chemistry. We are studying how the primary structure of cytochromes and hemoglobins codes for heme binding and the motions that facilitate function. The method of choice is nuclear magnetic resonance spectroscopy, which we use to obtain detailed structural and dynamic representations of proteins with and without bound heme. The ultimate goal is to understand the evolution of chemical properties in heme proteins and how to alter them.

Structural and Energetic Principles of Membrane Proteins (Dr. K. Fleming)

Membrane proteins must fold to unique native conformations and must interact in specific ways to form complexes essential for life. Currently, the chemical principles underlying these processes are poorly understood. Thermodynamic and kinetic studies on membrane proteins with diverse folds and oligomeric states are carried out with the goal of discovering the physical basis of stability and specificity for membrane proteins. Our research results in a quantitative understanding of sequence-structure-function relationships that can ultimately be used to describe membrane protein populations in both normal and disease states, to design novel membrane proteins, and to develop therapeutics that modulate membrane protein functions in desirable ways.

Chromatin Remodeling (Dr. Bowman)

Chromatin, the physical packaging of eukaryotic chromosomes, plays a major role in determining the patterns of gene silencing and expression across the genome. Chromatin remodelers are multicomponent protein machines that establish and maintain various chromatin environments through the assembly, movement, and eviction of nucleosomes. At present, the molecular mechanisms by which chromatin remodelers alter chromatin structure are not understood. Our long-term goal is to gain a molecular understanding of the remodeling process and in particular how remodeling is coupled to the transcriptional machinery. Our strategy is to couple structure determination with functional studies to determine how different components of a chromatin remodeler cooperate and interact with the nucleosome substrate.

Theoretical Biophysics (Dr. Johnson)

Protein interaction networks capture the cooperation required by proteins to carry out complex functions in the cell. The ability of proteins to assemble to form transient or permanent complexes and transmit signals or nutrients depends on their concentrations, their binding partners, and their spatial and temporal dynamics in the cell. Using computation and theory, we are building models to accurately simulate these multi-protein assembly processes, such as those occurring in endocytosis, that are critical to cell survival. We complement these detailed simulations with coarse-grained models to extend to larger protein interaction networks and characterize the role of network topology on protein binding specificity and dynamics.

Single Molecule Biophysics (Dr. Ha)

Our research is focused on pushing the limits of single-molecule detection methods to study complex biological systems. We develop state-of-the-art biophysical techniques (e.g., multicolor fluorescence, super-resolution imaging, combined force and fluorescence spectroscopy, vesicular encapsulation, single-molecule pull-down) and apply them to study diverse protein–nucleic acid and protein-protein complexes, and mechanical perturbation and response of these systems both in vitro and in vivo.

Quantitative Analysis of Gene Expression in Single Molecule and Single Cell (Dr. Myong)

Our research is focused on dissecting biological pathways that control and modulate gene expression profiles that are pertinent to human diseases. We develop single molecule and single cell platforms to examine potential rate-limiting steps that contribute to modulating transcription and translation. In particular, we investigate RNA interference pathway and G-quadruplex DNA mediated promoter activity. In collaboration, we are also studying telomeric DNA processing and chromatin remodeling. Together, we seek to shed light on molecular orchestration and mechanism that govern the Central Dogma of Biology.

Cellular Physics (Dr. Camley)

I work on the physics of cell biology, trying to understand how cells can respond to signals, crawl through complex environments, and work together to move and measure signals. I am also interested in the dynamics of subcellular processes like the cell membrane's motion and intracellular transport. These problems link the physics of soft, fluctuating materials to biological questions like how a white blood cell can find a wound. My group uses a wide range of computational and analytical methods to model organelles, cells, and tissues, ranging from stochastic hydrodynamics to phase field and reaction-diffusion modeling.

Biophysics Theory and Modeling (Dr. Zhang)

The interior of a cell is organized in both space and time by non-membrane bound compartments, many of which form via liquid-liquid phase separation. These phase-separated condensates play key roles in processes ranging from transcription to translation, metabolism, signaling, and more. Unlike conventional phase separation, e.g. the demixing of oil and water, the underlying interactions that drive biomolecular phase separation are complex, typically involving both specific and non-specific interactions and often among multiple components. These interactions are regulated by the cell in ways that allow condensates to carry out specific biological functions, yet the complexity of these interactions poses challenges to understanding how the microscopic features of biomolecules lead to the macroscopic properties and functions of condensates. We utilize physical, mathematical, and computational tools and work closely with experimental groups to understand such emergent connections. In addition, we are broadly interested in the complex behaviors of biomolecules and their assemblies across scales, from RNA folding and DNA bending, to macromolecular transport through nuclear pore complexes and intracellular space, to genome organization.

Facilities

The department shares state-of-the-art equipment for X-ray diffraction analysis, NMR spectroscopy, solution biophysical studies, and numerically intensive computer simulations with other biophysics units and departments within the University. In addition, the Department houses a full complement of equipment for molecular biological and biochemical work, and for various kinds of spectroscopy.

Undergraduate Program

The undergraduate major in biophysics is intended for the student interested in advanced study of biophysics or the related fields of biochemistry, quantitative or computational biology, molecular biology, physiology, pharmacology, and neurobiology. The biophysics major fulfills all typical science premedical requirements with the exception of Organic Chemistry Lab (AS.030.225 Introductory Organic Chemistry Laboratory or AS.030.227 Chemical Chirality: An Introduction in Organic Chem. Lab, Techniques). The student majoring in biophysics, with the advice of a member of the department, chooses a program of study that will include foundation courses in biology, chemistry, and physics followed by advanced studies in biophysics, and independent research. The biophysics major requires that students earn a grade of "C" or greater for all courses required in the major. A student who earns a grade of "C-" or below must repeat the course and earn a better grade.

Doctoral Programs

The Thomas C. Jenkins Department of Biophysics offers three Ph.D. programs (Jenkins, PMB and CMDB, see below). The annual application deadline is December 1.

Financial Aid

Two National Institutes of Health training grants currently provide stipend and tuition support: one is for students who enroll in PMB and the other is for those who enter CMDB. Students supported by these training grants must be U.S. citizens or permanent residents. In addition, several research assistantships funded by grants and contracts awarded to faculty by outside agencies may be available to qualified students. University fellowships providing remission of tuition are also available. Graduate students in biophysics are eligible for and encouraged to apply for various nationally administered fellowships, such as National Science Foundation fellowships. Information on these and other support mechanisms can be obtained through the fellowship advisor at the applicant's college or from the National Research Council:

Attn: Fellowships
1000 Thomas Jefferson St.
Washington, D.C., 20007.

It is anticipated that financial support covering normal living costs and tuition will be made available to accepted students. Support for foreign students is extremely limited.

Programs

- Biophysics, Bachelor of Arts (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysics-bachelor-arts/)
- Biophysics, Fifth-Year Master's Degree (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysics-fifth-year-masters-degree/)
- Biophysics, PhD - Jenkins Biophysics Program (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysics-phd-jenkins/)

- Biophysics, PhD - Program in Molecular Biophysics (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysics-phd-bmp/)
- Biophysics, PhD - The Program in Cell, Molecular Developmental Biology and Biophysics (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysics-phd-cmdb/)

For current course information and registration go to https://sis.jhu.edu/classes/

Courses

AS.250.105. Science and Film. 2 Credits.
From the origins of cinema to the present, science and technology have remained the most reliably popular subjects for filmmakers and audiences alike. This course will address that enduring fascination, exploring the meanings and uses of science and technology in film through guest lectures and discussion of cinematic examples both recent and historic. Lectures and discussion will focus on a range of questions: How does film both reflect and shape our understanding of scientific concepts and technologies, from artificial intelligence to genetic engineering? How does science fiction reveal contemporary cultural anxieties and address ethical questions? How “fictional” is the science in science fiction film, and how have science fiction films inspired science and technology? What can we learn about “real” science from the movies? In addition to exploring science through film, students will learn the tools of film analysis through lecture, close viewing, and completion of a series of short written responses. In lieu of a short written response, student may choose to work in a team to create a short (1-3 minute) video response. Possible scientific topics: Genetics and Bioethics, Psychological and Brain Sciences, Artificial Intelligence and Robotics, Climate Change and Public Health and Astrophysical and Planetary Sciences. Possible films to be discussed: 2001: A Space Odyssey, Eternal Sunshine of the Spotless Mind, Blade Runner, GATTACA, The Martian, Interstellar, WALL-E, Children of Men and more. Attendance at weekly screenings at the Parkway Theater is required.

AS.250.205. Introduction to Computing. 3 Credits.
This course is useful for many disciplines not only the life sciences. It will introduce students to basic computing concepts and tools useful in many applications. Students will learn to work in the Unix environment, and write bash shells scripts. They will learn to program using the Python programming language, including Python libraries for graphing, fitting and for numerical and statistical computing, such as NumPy, SciPy, and Matplotlib. At the end of the semester, students will complete a project coupling all components of the semester together. Brief lectures followed by extensive hands-on computer laboratories with examples from many disciplines. No prerequisites. Course offered every semester.
Prerequisite(s): You cannot take AS.250.205 if you have already taken AS.250.206.
Area: Natural Sciences, Quantitative and Mathematical Sciences

AS.250.253. Protein Engineering and Biochemistry Lab. 3 Credits.
This laboratory examines the relationship between genes and proteins in the context of disease and evolution. It is a research project lab in which the structural and functional consequences of mutations are determined for a model protein. Students will learn basic protein science and standard biochemical techniques and methods in protein engineering. They will perform experiments in site-directed mutagenesis, protein purification, and structural, functional and physical characterization of proteins. No prerequisites. Courses offered in Fall and Spring semesters.
Prerequisite(s): You cannot take AS.250.253 if you have already taken AS.250.254.;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences
Writing Intensive

AS.250.254. Protein Biochemistry and Engineering Laboratory. 4 Credits.
A project laboratory where students will use the techniques of protein engineering to attempt to modify existing proteins to endow them with new structural or physical properties. This course will provide an introduction to standard biochemistry laboratory practice and to protein science, including experiments in site-directed mutagenesis, protein purification and characterization of proteins in regard to structure, function and stability.
Prerequisite(s): You cannot take AS.250.254 if you have already taken AS.250.253.
Area: Natural Sciences

AS.250.302. Modeling the Living Cell. 4 Credits.
Previously titled "Models and Algorithms in Biophysics." Introduction to physical and mathematical models used to represent biophysical systems and phenomena. Students will learnalgorithms for implementing models computationally and perform basic implementations. We will discuss the types of approximations made to develop useful models of complex biological systems, and the comparison of model predictions with experiment.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Engineering, Natural Sciences

AS.250.310. Exploring Protein Biophysics using Nuclear Magnetic Resonance (NMR) Spectroscopy. 3 Credits.
NMR is a spectroscopic technique which provides unique, atomic level insights into the inner workings of biomolecules in aqueous solution and solid state. A wide variety of biophysical properties can be studied by solution state NMR, such as the three dimensional structures of biological macromolecules, their dynamical properties in solution, interactions with other molecules and their physical and chemical properties which modulate structure-function relationships (such electrostatics and redox chemistry). NMR exploits the exquisite sensitivity of magnetic properties of atomic nuclei to their local electronic (and therefore, chemical) environment. As a result, biophysical properties can be studied at atomic resolution, and the global properties of a molecule can be deconstructed in terms of detailed, atomic level information. In addition, interactions between nuclei can be exploited to enhance the information content of NMR spectra via multidimensional (2D and 3D) spectroscopy. Since these properties can be studied in solution, NMR methods serve as an effective complement to X-Ray crystallography and electron microscopy. In this course, we will learn about the basics of NMR spectroscopy, acquire 1D and 2D NMR spectra and use various NMR experiments to characterize and probe biophysical properties of proteins at an atomic level.
Prerequisite(s): ((AS.030.101 AND AS.030.105) OR (AS.030.103 OR AS.030.204)) AND (AS.030.370 OR AS.250.372) AND (AS.020.305 OR AS.030.315 OR AS.250.315) AND AS.030.205 or permission of the instructor.;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.

AS.250.315. Biochemistry I. 3 Credits.
Foundation for advanced classes in Biophysics and other quantitative biological disciplines. This class is the first semester of a two semester course in biochemistry. Topics in Biochemistry I include chemical and physical properties of biomolecules and energetic principles of catabolic pathways. Co-listed with AS.030.315
Prerequisite(s): If you have completed AS.250.307 you may not register for AS.250.315.;(AS.030.206 OR AS.030.212) AND (AS.250.372 OR AS.030.301)
Area: Natural Sciences

AS.250.316. Biochemistry II. 3 Credits.
Biochemical anabolism, nucleic acid structure, molecular basis of transcription, translation and regulation, signal transduction with an emphasis on physical concepts and chemical mechanisms. Format will include lectures and class discussion of readings from the literature.
Prerequisite(s): (AS.250.315 OR AS.030.315 OR AS.020.305) AND (AS.030.206 OR AS.030.212) or permission of the instructor.

AS.250.320. Macromolecular Binding. 3 Credits.
All biological processes require the interactions of macromolecules with each other or with ligands that activate or inhibit their activities in a controlled manner. This course will discuss theoretical principles, logic, approaches and practical considerations used to study these binding processes from a quantitative perspective. Topics will include thermodynamics, single and multiple binding equilibria, linkage relationships, cooperativity, allostery, and macromolecular assembly. Some biophysical methods used in the study of binding reactions will be discussed. Computer simulation and analysis of binding curves will be used to analyze binding data, and binding schemes and examples from the scientific literature will be reviewed and discussed.Recommended Course Background: AS.250.372 Biophysical Chemistry
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Writing Intensive

AS.250.335. Single Molecule & Cell Biophysics. 3 Credits.
This (elective) course offers an introduction to the field of single molecule and single cell biophysics to second and third year undergraduate students in biophysics. We will examine technologies such as single molecule fluorescence, force measurements and single cell fluorescence detections that enable high precision molecular visualizations in vitro and in cells. In addition, we will cover topics of genome engineering, cell mechanics and optogenetics toward the end of the semester. Each student is expected to read two articles assigned for each week and submit a written summary. All students will take turns presenting the assigned articles to class.

AS.250.351. Reproductive Physiology. 2 Credits.
Focuses on reproductive physiology and biochemical and molecular regulation of the female and male reproductive tracts. Topics include the hypothalamus and pituitary, peptide and steroid hormone action, epididymis and male accessory sex organs, female reproductive tract, menstrual cycle, ovulation and gamete transport, fertilization and fertility enhancement, sexually transmitted diseases, and male and female contraceptive methods. Introductory lectures on each topic followed by research-oriented lectures and readings from current literature.
Area: Natural Sciences

AS.250.372. Biophysical Chemistry. 4 Credits.
Course covers classical and statistical thermodynamics, spanning from simple to complex systems. Major topics include the first and second law, gases, liquids, chemical mixtures and reactions, partition functions, conformational transitions in peptides and proteins, ligand binding, and allostery. Methods for thermodynamic analysis will be discussed, including calorimetry and spectroscopy. Students will develop and apply different thermodynamic potentials, learn about different types of ensembles and partition functions. Students will learn to use Pythonand will use it for data fitting and for statistical and mathematical analysis. Background: Calculus, Introductory Organic Chemistry, and Introductory Physics.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences

AS.250.381. Spectroscopy and Its Application in Biophysical Reactions. 3 Credits.
Continues Biophysical Chemistry (AS.250.372). Fundamentals of quantum mechanics underlying various spectroscopies (absorbance, circular dichroism, fluorescence, NMR); application to characterization of enzymes and nucleic acids.
Prerequisite(s): AS.250.372
Area: Natural Sciences

AS.250.383. Molecular Biophysics Laboratory. 3 Credits.
An advanced inquiry based laboratory course covering experimental biophysical techniques to introduce fundamental physical principles governing the structure/function relationship of biological macromolecules. Students will investigate a “model protein”, staphylococcal nuclease, the “hydrogen atom” of biophysics. Using a vast library of variants, the effect of small changes in protein sequence will be explored. A variety of techniques will be used to probe the equilibrium thermodynamics and kinetic properties of this system; chromatography, spectroscopy (UV-Vis, fluorescence, circular dichroism, nuclear magnetic resonance), calorimetry, analytical centrifugation, X-ray crystallography, mass spectroscopy, and computational methods as needed for analysis. These methods coupled with perturbations to the molecular environment (ligands, co-solvents, and temperature) will help to elucidate protein function. Prerequisite: Introduction to Scientific Computing (250.205) or equivalent. Biophysical Chemistry (250.372 or 020.370) or equivalent. Course taught in Fall and Spring.
Prerequisite(s): (AS.250.372 OR AS.030.370) AND AS.250.205;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Writing Intensive

AS.250.403. Advanced Seminar in Bioenergetics. 3 Credits.
The trait shared by all living systems is the capacity to perform energy transduction. This biophysics/biochemistry course examines the physico-chemical and structural basis of biological energy transduction. Emphasis is on understanding the molecular and cellular logic of the flow of energy in living systems. The course explores the connection between fundamental physical requirements for energy transduction and the organization, evolution and possibly even the origins of biological molecules, cells, and organisms. Implications for planet earth[1]s energy balance and for the design of synthetic organisms and of artificial energy transducing machines will be discussed, time permitting. Recommended Course Background: One semester of Biochemistry. Recommended Course Background: One semester of Biochemistry
Writing Intensive

AS.250.410. Genome Maintenance and Genome Engineering. 3 Credits.
Advanced seminar for biophysics undergraduates. We focus on topics of genome maintenance via telomere regulation and genome engineering by CRISPR-Cas systems. The course will have lecture, scientific article reading, small and large group discussion.

AS.250.411. Advanced Seminar in Structural Biology of Chromatin. 3 Credits.
Focus is on structural and physical aspects of DNA processes in cells, such as nucleosomal packaging, DNA helicases, RNA polymerase, and RNA inhibition machinery. Topics are meant to illustrate how the structural and chemical aspects of how proteins and nucleic acids are studied to understand current biological questions. Recommended Course Background: Biochemistry I (AS.250.315) and Biochemistry II (AS.250.316) or Biochemistry (AS.020.305) and Intro to Biophys Chem (AS.250.372)
Area: Natural Sciences
Writing Intensive

AS.250.420. Advanced Seminar in Macromolecular Binding. 3 Credits.
All biological processes require the interactions of macromolecules with each other or with ligands that activate or inhibit their activities in a controlled manner. This is a literature and skills-based course that will discuss theoretical principles, logic, approaches and practical considerations used to study these binding processes from a quantitative perspective. Topics will include thermodynamics, single and multiple binding equilibria, linkage relationships, cooperativity, allostery, and macromolecular assembly. Some biophysical methods used in the study of binding reactions will be discussed. Simulation and analysis of binding scenarios will be used to analyze illustrate binding schemes, and examples from the scientific literature will be reviewed and discussed. Basic working knowledge of Python is helpful. The writing component will be in one of the common formats employed in the professional biophysics field.Recommended Course Background: AS.250.372 Biophysical Chemistry
Writing Intensive

AS.250.421. Advanced Seminar in Membrane Protein Structure, Function & Pharmacology. 3 Credits.
Topics are meant to illustrate the physical basis of membranes and membrane proteins towards understanding their functions and pharmacological importance including aspects of drug design as it relates to membranes. Contemporary issues in the field will be covered using primary literature articles, structural manipulations in pymol, and computational binding simulations.Recommended Course Background: AS.030.205, AS.250.307, and AS.250.372
Writing Intensive

AS.250.514. Research in Protein Design and Evolution. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Writing Intensive

AS.250.520. Introduction to Biophysics Research. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.250.521. Research in Biophysics. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.;AS.250.520

AS.250.601. Biophysics Seminar.
Graduate students only. Students and invited speakers present current topics in the field.

AS.250.602. Biophysics Seminar.
Graduate students only. Students and invited speakers present current topics in the field.

AS.250.610. Savvy Science Seminars.
Oral presentations are one of the main forms by which scientists communicate their results. Whether in the context of the classroom, the relatively informal lab meeting or as an invited speaker at an international colloquium, the ability to effectively present scientific results is an important skill to master. This course will cover the planning and execution steps necessary to produce an engaging oral presentation. Students will learn to articulate the big biological questions, tell a story that stimulates interest in their chosen subject, and effectively convey their experimental findings. Key methodological steps in planning will guide students on how to create slides with compelling visuals, and how to use technology to their advantage. Students will each prepare, present, and receive feedback on a 15-minute talk on their thesis project in the style of the Biophysical Society short talks. In addition, each student will receive and evaluate a video of their presentation so they can see themselves through the eyes of others.

AS.250.615. Biophysics Writing Workshop.
A series of writing workshops designed to help Biophysics Graduate Students develop a proposal of thesis work. Each student will write a specific aims page and a full (6 page) proposal.

AS.250.620. Optical Spectroscopy.
Basics of absorbance, CD, and fluorescence spectroscopy; calorimetric methods.

AS.250.621. X-ray Diffraction.
Basics of X-ray diffraction methods

AS.250.622. Statistics and Data Analysis.
Basics of statistics and data analysis

AS.250.623. Macromolecular Simulation.
Basics of molecular dynamics

AS.250.624. NMR Spectroscopy.
Basics of NMR spectroscopy

AS.250.625. Single Molecule Measurements.
Basic Principles of Single Molecule Measurements
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.

AS.250.648. Physics of Cell Biology: From Mechanics to Information.
Cells are actively-driven soft materials but also efficient sensors and information processors. This course will cover the physics of those cellular functions, from the mechanics of DNA to the sensing of chemical signals. Questions answered include: How does polymer physics limit how quickly chromosomes move? Why do cells use long, thin flagella to swim? What limits the accuracy of a cell's chemotaxis?Some experience with partial differential equations required. No biology knowledge beyond the high school level necessary. Some problem sets will require minimal programming.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences

AS.250.649. Introduction to Computing in Biology.
In this four week, intensive introductory course, students will gain a practical working knowledge of UNIX and Python programming languages and packages for analyzing data from biochemical and biophysical experiments. Brief daily lectures are followed by extensive hands-on experience in the computer laboratory.

AS.250.685. Proteins & Nucleic Acids.
The structure of proteins, DNA and RNA, and their functions in living systems. Students are required to participate in class discussions based on readings from the primary scientific literature. Co-requisite: AS 250.649 Introduction to Computing in Biology. Instructor permission for undergraduates.
Prerequisite(s): Prerequisite: AS.250.649,may be taken concurrently.

AS.250.689. Physical Chemistry of Biological Macromolecules.
Introduction to the principles of thermodynamics and kinetics as applied to the study of the relationship between structure, energy dynamics, and biological function of proteins and nucleic acids. Topics include of classical, chemical, and statistical thermodynamics, kinetics, theory of ligand binding, and conformational equilibria.

AS.250.801. Dissertation Research.

AS.250.802. Dissertation Research.

AS.250.803. Summer Dissertation Research.
Graduate Independent Academic Work

ME.100.300. Research Practicum. 0 Credits.
N/A

ME.100.600. Scientific Foundations of Medicine-Macromolecules. 0 Credits.

ME.100.699. Biophysics Elective. 0 Credits.
For Medical Students only. Specialized Topics in Biophysics.
Refer to Medical Student Electives Book located at https://www.hopkinsmedicine.org/som/students/academics/electives.html.

ME.100.705. Computer Modeling Of Biological Macromolecules: Lecture. 0 Credits.
Lecture will offer an introduction to the mathematical aspects of computer representation and manipulation of macromolecules

ME.100.706. Fundamentals Of Protein Crystallography. 0 Credits.
An introductory course designed to present the core knowledge and theoretical underpinnings of protein crystallography necessary to function in the laboratory. Assigned readings and problem sets will be given.

ME.100.707. Advanced Topics in Protein Crystallography. 1 Credit.
An introductory course designed to present the core knowledge and theoretical underpinnings of protein crystallography necessary to function in the laboratory. Assigned readings and problem sets will be given.

ME.100.708. Proteins and Nucleic Acids. 0 Credits.

ME.100.709. Macromolecular Structure and Analysis. 1.5 Credits.
The course will cover the structure and properties of biological macromolecules and the key methods used to study them, including X-ray crystallography, nuclear magnetic resonance, spectroscopy, microscopy, and mass spectrometry.

ME.100.710. Biochemical and Biophysical Principles. 1.5 Credits.
The physical and chemical principles underlying biological processes are presented and discussed. Topics include thermodynamics, chemical equilibrium, chemical and enzymatic kinetics, electrochemistry, physical chemistry of solutions, and structure and properties of water. Elementary concepts of statistical thermodynamics will be introduced as a way of correlating macroscopic and microscopic properties.

ME.100.712. Computer Modeling Of Biological Macromolecules: Lab. 3 Credits.
The laboratory course will familiarize students with practical aspects of molecular modeling. It teaches the necessary tools to create and manipulate computer generated models of biological-interest molecules. Techniques such as comparative modeling will be introduced.

ME.100.713. Using Structure to Understand Biology. 1 Credit.
The goal of this course is to teach students how to make use of structural information in the PDB using commonly available tools that are accessible to the non-expert. Students will learn how to read a structure paper, understand structure quality and limits of interpretation, and use coordinates from the Protein Data Bank to explore a structure and make figures. Topics covered will include non-covalent interactions, modeling point mutants, identifying binding pockets, making homology models, and calculating electrostatic surface potentials. Classes will combine lectures, hand-on computer demonstrations and critical reading of papers. A final project will require a short write-up and presentation that implements the programs and principles learned in the class

ME.100.714. Single-Molecule Single-Cell Biophysics. 1 Credit.
This elective course offers an introduction to the field of single molecule and single cell biophysics to graduate students in Johns Hopkins University and will be delivered in the School of Medicine. We will examine technologies such as single molecule fluorescence and force measurements, super-resolution imaging and single cell fluorescence detections that enable high precision molecular visualizations in vitro and in cells.

ME.100.715. Proteins and Nucleic Acids II. 3 Credits.
Critical reading and analysis of primary source literature is vital to scientific discourse and discovery. Students will be responsible for analyzing and critiquing papers in diverse topics and systems ranging from replication, transcription, and translation to enzyme mechanism, drug resistance, innate immunity, and signaling. Methods covered will include structural, biochemical, single-molecule, single-cell, and genomic approaches. Students will deliver analytic presentations on at least two ground-breaking papers relevant to these areas, and will be expected to actively participate in class discussion of experimental methodology and logic of other papers assigned in the course.

ME.100.716. Analysis of Macromolecules. 2 Credits.
The course will cover (1) macromolecules, (2) physical chemical principles dictating their biological behavior, and (3) methods to study them. Lectures will focus on practical application of the methods, experimental design, data collection, and elementary aspects of data analysis.

ME.100.801. Research. 0 Credits.
Thesis research

ME.100.804. Topics in Macromolecular Structure and Function I. 0 Credits.
This is the first part of a seminar course covering a variety of topics involving the structure and function of proteins and nucleic acids. Recent topics have included: protein folding, evolutionary significance of introns, protein-DNA interactions, solution structure of peptides, prospects for designing novel proteins, and two-dimensional NMR.

ME.100.807. Research. 0 Credits.
Thesis Research

ME.100.808. Topics in Macromolecular Structure and Function II. 0 Credits.
This is the second part of a seminar course covering a variety of topics involving the structure and function of proteins and nucleic acids. Recent topics have included: protein folding, evolutionary significance of introns, protein-DNA interactions, solution structure of peptides, prospects for designing novel proteins, and two-dimensional NMR.

Cross Listed Courses

Biology

AS.020.674. Quantitative Biology and Biophysics.
Students will be given instruction in the concepts of physical and quantitative biology. Students will learn to simulate biological processes, identify the relationship between data and models, and will learn to fit biological data. Note: Friday classes will be held in UTL 398.

First Year Seminars

AS.001.119. FYS: The Nature of Nature. 3 Credits.
To understand nature, we normally apply the scientific method to dissect complexity and to identify general principles and natural laws. Fortunately, science is not the only avenue for understanding and appreciating the fundamental character of the natural world and the logic of life. This is precisely how the Greeks, without the benefit of the technological and mathematical armamentarium at our disposal today, simply by identifying critical questions, laid the foundation for modern science and contributed insight that has stood the test of time. In this First-Year Seminar, we will emulate the Greeks. We will examine the nature of nature by asking questions about phenomena we experience in our daily lives. We will read brief sources from popular science and engage in weekly conversations. For the students with backgrounds in science, these conversations are an opportunity to discover the elusive continuity and connectivity between elements in nature that siloed science education all too often obfuscates. The students without science in their background will come to understand the forces that shape our world and our lives, and discover rich links between science and humanistic thinking.
Area: Humanities, Natural Sciences

Physics & Astronomy

AS.171.648. Physics of Cell Biology: From Mechanics to Information.
Cells are actively-driven soft materials – but also efficient sensors and information processors. This course will cover the physics of those cellular functions, from the mechanics of DNA to the sensing of chemical signals. Questions answered include: How does polymer physics limit how quickly chromosomes move? Why do cells use long, thin flagella to swim? What limits the accuracy of a cell’s chemotaxis?Some experience with partial differential equations required. No biology knowledge beyond the high school level necessary. Some problem sets will require minimal programming.
Area: Natural Sciences

For current faculty and contact information go to http://biophysics.jhu.edu/people/