BIOPHYSICS

http://biophysics.jhu.edu/

The Department of Biophysics offers programs leading to the B.A., M.S., and Ph.D. degrees. Biophysics is appropriate for students who wish to develop and integrate their interests in the physical and biological sciences, and is an excellent major for students interested in medical school, for students interested in graduate studies in the molecular biosciences, and for students interested in positions in biotechnology and the pharmaceutical industry. The small class size and emphasis on classroom instruction by tenure track faculty provides a close-knit environment where undergraduate biophysics majors develop close and lasting relationships with their professors.

Research interests in the Department cover experimental and computational biophysics, with topics that address the function and biology of molecular and cellular structures, membrane organization, biomolecular energetics, and macromolecular physical chemistry. The emphasis on independent research in faculty labs bring undergraduate as well as graduate 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 (https://biophysics.jhu.edu/).

Research Activities of Primary Faculty

Protein Engineering and Biophysics (Dr. Garcia-Moreno)

To understand how biological macromolecules work and to design and engineer new macromolecules, it is important 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. Our research depends heavily on the application of NMR spectroscopy, X-ray crystallography, and equilibrium thermodynamics. These experimental methods contribute the physical insight needed to develop computational methods for structure-based energy calculations, and generate 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 and Design, 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 use repeat-proteins, linear proteins with simple architectures, to dissect the energy distribution, sequence-stability relationships, and kinetic routes for folding. We are also using consensus sequence design to explore how sequence statistics represented in multiple sequence alignments can be used to engineer protein stability, structure, and function in globular proteins. In addition, we are studying the molecular mechanisms of Notch signaling, a eukaryotic transmembrane signal transduction pathway important for human development and disease. 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.

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. Our 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. Our 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.

Cellular Physics (Dr. Camley)

We 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. We are 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.

Structure and Mechanism of How Cells Read and Repair the Genome (Dr. He)

We aim to elucidate the molecular mechanisms through which large, multi-subunit complexes engage in DNA-centric processes, utilizing cryo-electron microscopy (cryo-EM) alongside biophysical and biochemical methods. Our research centers on two main areas: the regulation of eukaryotic gene transcription at various stages, and the repair of different types of DNA damage, exploring how deficiencies in these pathways contribute to cancer predisposition or accelerated aging. Cryo-EM, with its ability to reveal macromolecular assembly structures at atomic resolution using minimal sample sizes, overcomes the challenges of system size and heterogeneity. Enhanced by ongoing technical developments, cryo-EM significantly advances our understanding of complex cellular processes.

Biochemical Reactions on Cell Membranes (Dr. Huang)

The cell membrane hosts a myriad of biochemical reactions critical to cellular functions. The coupling of reactions with a physical surface enables a rich array of unique mechanisms in space and time that are rarely encountered in solution biochemistry. We explore this theme in the case of signal transduction, the process by which chemical information is integrated in living cells. The research approach combines optical methods, including single-molecule imaging and spectroscopy, and kinetic modeling to analyze biochemically reconstituted systems and living cells. The natural integration between physical methods, biochemistry, and cell biology stimulates the invention of imaging assays that advance the degree to which complex signaling processes can be resolved in real time. With the advent of quantitative descriptions of signal transduction, the overarching goal is to formulate a physical understanding of biochemical reactions in living systems.

Facilities

The Department of Biophysics 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, calorimetry, and hydrodynamic studies.

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 trains students in two Ph.D. programs, the Jenkins Biophysics Program and the Program in Molecular Biophysics. The annual application deadline for both programs is typically 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.

The Jenkins graduate program is open to all students including international students. Students in this program are supported, in part, through TA-ships.

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

Programs

- Biophysical Chemistry and Design for Biotechnology, Master of Science (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysical-chemistry-design-biotechnology-master-science/)
- Biophysics, Bachelor of Arts (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/biophysics/biophysics-bachelor-arts/)
- 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/)

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 Foundational Abilities: Science and Data (FA2), Culture and Aesthetics (FA3)
EN Foundational Abilities: Creative Expression (FA3)

AS.250.205. Introduction to Computing. 3 Credits.
This course is helpful 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 shell scripts. They will learn to program using Python and explore graphing, numerical analysis, and statistical computing libraries, such as NumPy, SciPy, pandas, and Matplotlib. The course will also include an introduction to Machine Learning and will conclude with a Python project focused on data analysis. No previous programming knowledge is required. This course is designed for beginners.
Prerequisite(s): You cannot take AS.250.205 if you have already taken AS.250.206.
Distribution Area: Natural Sciences, Quantitative and Mathematical Sciences
AS Foundational Abilities: Science and Data (FA2), Ethics and Foundations (FA5), Projects and Methods (FA6)

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 Laboratory Safety Introductory Course in the Search Box to access the proper course. Click here to access the Laboratory Safety Introductory Course (https://johnshopkins.csod.com/ui/lms-learning-details/app/curriculum/66847e20-c695-4e54-a6be-8c94465b8a70/)
Distribution Area: Natural Sciences
AS Foundational Abilities: Writing and Communication (FA1), Ethics and Foundations (FA5), Projects and Methods (FA6)
Writing Intensive

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): Click here to access the Laboratory Safety Introductory Course (https://johnshopkins.csod.com/ui/lms-learning-details/app/curriculum/66847e20-c695-4e54-a6be-8c94465b8a70/)
Distribution Area: Engineering, Natural Sciences
AS Foundational Abilities: Science and Data (FA2), Projects and Methods (FA6)

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): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter ASEN in the Search Box to access the proper course. Click here to access the Laboratory Safety Introductory Course (https://johnshopkins.csod.com/ui/lms-learning-details/app/curriculum/66847e20-c695-4e54-a6be-8c94465b8a70/);((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.
AS Foundational Abilities: Science and Data (FA2)

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.
Prerequisite(s): If you have completed AS.250.307 you may not register for AS.250.315.;Students must have completed the following courses to enroll in AS.250.315: AS.030.206 OR AS.030.212
Distribution Area: Natural Sciences
AS Foundational Abilities: Science and Data (FA2)

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): Students who have taken AS.030.316 are not eligible to take AS.250.316.;(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 Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2), Ethics and Foundations (FA5)

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.
Distribution Area: Natural Sciences
AS Foundational Abilities: Science and Data (FA2), Projects and Methods (FA6)

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 and Introductory Physics.
Distribution Area: Natural Sciences
AS Foundational Abilities: Science and Data (FA2), Ethics and Foundations (FA5)

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
Distribution Area: Natural Sciences
AS Foundational Abilities: Science and Data (FA2)

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): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter ASEN in the Search Box to access the proper course. Click here to access the Laboratory Safety Introductory Course (https://johnshopkins.csod.com/ui/lms-learning-details/app/curriculum/66847e20-c695-4e54-a6be-8c94465b8a70/);(AS.250.372 OR AS.030.370) AND AS.250.205
AS Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2), Projects and Methods (FA6)
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 earth¹s 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
AS Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2)
Writing Intensive

AS.250.405. Systems Genome Biology. 3 Credits.
Systems Genome Biology uses predictive mathematical models to describe the physical principles behind biological function in the cell’s genome, including the nucleus and cellular and nuclear organelles, the chromatin and its folding structures, biomolecular complexes, and the individual molecules. Students will learn our current understanding at the systems level of biomolecular condensates, how omics data is analyzed and how it is used to understand cellular regulation and cell fate transitions, how epigenetics is coded in the genome, how DNA repairs its damages, and how all these phenomena are altered in cancer and neurodegenerative diseases as well as in rare diseases. The course will include guest lectures by leading scientists in these areas.
Prerequisite(s): AS.250.372 AND AS.250.302
Distribution Area: Natural Sciences
AS Foundational Abilities: Science and Data (FA2)

AS.250.406. Physical Principles of Signal Transduction. 3 Credits.
The goal of this course is to introduce concepts and analyses relevant to a quantitative understanding of cellular signaling, covering length scales from reaction networks to single molecules. The course focuses on the dynamics of signal transduction processes, including analyses of nonlinear and stochastic kinetics drawn from physical sciences. Some topics will be covered in detail, while others will be introduced primarily for exposure.
AS Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2)
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)
Distribution Area: Natural Sciences
AS Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2)
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
AS Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2)
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
AS Foundational Abilities: Writing and Communication (FA1), Science and Data (FA2)
Writing Intensive

AS.250.520. Introduction to Biophysics Research. 2 Credits.
This course is taken S/U (i.e. it does not get letter grades). The course will be offered in Fall, Spring and Summer, with the same number. It is repeatable; students can take it twice, even in the same year. Students are expected to take this course twice (2 semesters) to satisfy the research requirement of the Biophysics major.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.
AS Foundational Abilities: Science and Data (FA2), Projects and Methods (FA6)

AS.250.521. Research in Biophysics. 3 Credits.
This course is for Biophysics students who have already satisfied their the research requirement by having taken 2 semesters (6 units) of AS.250.520 - Introduction to Biophysics Research. Students who decide to continue doing research can do so by enrolling in this course. The course is 3 credits and is graded. This course will be offered in Fall, Spring and Summer, with the same number, and is repeatable.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration, Online Forms.;In order to register for this course, you must first take TWO semesters of AS.250.520 - Introduction to Biophysics Research
AS Foundational Abilities: Science and Data (FA2), Projects and Methods (FA6)

AS.250.601. Biophysics Seminar. 1 Credit.
Graduate students only. Students and invited speakers present current topics in the field.

AS.250.610. Savvy Science Seminars I. 1 Credit.
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.250.611. Savvy Science Seminars II. 1 Credit.
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.
Prerequisite(s): AS.250.610

AS.250.615. Biophysics Writing Workshop. 1 Credit.
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. 2 Credits.
Basics of absorbance, CD, and fluorescence spectroscopy; calorimetric methods.

AS.250.621. Cryo-EM Module. 1 Credit.
In this module students will learn the basic theory behind Cryo-EM, including sample preparation, data collection, data processing, and map/model interpretation with an emphasis on hands on experience. As such, students will collect data on a JHU electron microscope, process this data themselves and perform several exercises interpreting maps and building models.

AS.250.622. Statistics and Data Analysis. 1 Credit.
Basics of statistics and data analysis

AS.250.623. Macromolecular Simulation. 1 Credit.
This five-day, hands-on course introduces students to molecular dynamics (MD) simulations of macromolecular systems. Students will learn how to set up and carry out MD simulations and analyze the data.

AS.250.624. NMR Spectroscopy. 1 Credit.
Basics of NMR spectroscopy

AS.250.625. Single Molecule Measurements. 1 Credit.
Basic Principles of Single Molecule Measurements
Prerequisite(s): Click here to access the Laboratory Safety Introductory Course (https://johnshopkins.csod.com/ui/lms-learning-details/app/curriculum/66847e20-c695-4e54-a6be-8c94465b8a70/)

AS.250.640. How to be an Effective STEM JEDI. 1 Credit.
Students will read, review, and discuss the social psychology literature on bias in science practices. Topics to be discussed include gender and racial biases in faculty and students, imposter syndrome, how stereotypes influence the demographics of scientists, consequences of emotion in the workplace, bystander intervention skills, and the importance of diversity and inclusion. Students will complete a capstone project in the area of improving graduate climate in the STEM fields.
Distribution Area: Social and Behavioral Sciences

AS.250.649. Introduction to Computing in Biology. 2 Credits.
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. 3 Credits.
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. 3 Credits.
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. 9 - 20 Credits.
This course is used for PhD Students conducting research with a Principal Investigator (PI) who has an appointment with the Jenkins or PMB Program. Research is conducted under the supervision of this faculty member and often in conjunction with other members of the research group.

AS.250.803. Summer Dissertation Research. 9 Credits.
Graduate Independent Academic Work

AS.250.820. Laboratory Rotation. 3 Credits.
A full emersion into a potential thesis lab. By the end of the rotation period, students should expect to understand the primary questions and techniques used in the lab and have gained some expertise in acquiring and analyzing data. At the end of the rotation period, students give a 10 min rotation talk to the biophysics community.

AS.250.821. Teaching Assistantship. 3 Credits.
As TAs, students provide key support by helping students with course concepts and techniques, holding office hours, and grading assignments.

Cross-Listed Courses

Biology

AS.020.674. Quantitative Biology and Biophysics. 4 Credits.
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.

Chemical & Biomolecular Engineering

EN.540.461. Future Food Manufacturing. 3 Credits.
Future Food Manufacturing will cover the engineering principles, motivations, and scientific obstacles behind foods that are to replace traditionally animal-derived ingredients such as meat and dairy. Concepts include 3D printing and extrusion of plant-based proteins, biophysics of proteins and fats, fermentation of genetically engineered microbes, and tissue engineering in cultured meat applications. This interdisciplinary course will consist of guest lecturers from multiple departments to encompass the multiple manufacturing angles by which to ensure food security in decades to come. This class will have no exams, instead students will be connected to existing alt protein companies and they will propose solutions for a major pain point in their manufacturing process.
Distribution Area: Engineering
AS Foundational Abilities: Science and Data (FA2)

First Year Seminars

AS.001.119. FYS: The Nature of Nature. 3 Credits.
How well do we understand the natural world? Are there common principles that can explain everything about it? What remains to be understood? Do we understand our past well enough to predict our future? Can I really take this seminar even if I don't have a background in science or math? Yes you can! In this seminar we are going to emulate the Greeks, who without the benefit of the technological and mathematical armamentarium available today, driven simply by curiosity and their imagination, identified some of the fundamental questions that still puzzle us today. In the process they laid the foundation for modern science. Many of their insights have stood the test of time. We will examine the nature of nature by asking deep questions about the world around us and by examining phenomena we experience in our daily lives. We'll try to identify continuity and connectivity between aspects of nature that are usually treated separately. Perhaps you'll discover that science and religion, and scientific and humanistic inquiry, are more similar than you might think. Our seminar is organized around weekly conversations informed by all manner of sources: popular science writing, newspaper articles, fiction, poetry, and film. We will even do simple experiments in my lab (no lab or science experience necessary) to illustrate the logic of life.

AS.001.220. FYS: Reproduction in the 21st Century: Biology and Politics. 3 Credits.
This First-Year Seminar course will explore how 21st century childbearing conditions have changed, and the relationship of politics to these changes. Among the topics to be discussed are the impact on male and female infertility of assisted reproductive technologies that promote birth, including in vitro fertilization and intracytoplasmic sperm injection. But beyond how these technologies function, such topics as how decisions are/should be made about issues such as the acceptability of using genetic material from someone other than the hopeful parents to aid couples in having children will be addressed. Also to be discussed are how genetic technologies can be used to modify sperm, eggs and embryos, including risks, benefits, ethics and politics, and how, when and whether stem cells obtained from in vitro fertilization "leftovers" can be used. The ways in which these new approaches are perceived by the general public and by politicians, and how these perceptions affect the use of the new approaches, will be explored. Topics also will include whether abortions should be disallowed, allowed only under specific circumstances such as fetal anomalies observed during prenatal screening, or available as a women's (or couple's) right to choose. Contraception, both female and male, also will be explored. Thus, in addition to the science, this course will focus on when and how decisions are made regarding issues related to childbearing, including the roles of politics and social media.

Physics & Astronomy

AS.171.648. Physics of Cell Biology: From Mechanics to Information. 3 Credits.

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.
Distribution Area: Natural Sciences

AS.171.671. Advanced Topics in Astrobiology. 3 Credits.

This is an advanced course discussing mainstream and frontier topics in the five areas of: 1. Cosmology and galaxy, star, black hole and planet formation. 2. Discussions on the astrophysics of (exo-)planets including atmospheres, non-equilibrium atmospheres and biosignatures. 3.Future missions including the Habitable Worlds Observatory. 4. The hazards of space flight and how to overcome them 5. Significant existential questions for life's continuance over the vast timeline of the Universe.
Distribution Area: Natural Sciences
AS Foundational Abilities: Science and Data (FA2)

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