

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, 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 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 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.

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

- 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/>)

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 learn algorithms 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 as 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 458083 in the Search box to locate the appropriate module.; ((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.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.;AS.030.206 OR AS.030.212

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.250.335. 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 Python and will use it for data fitting and for statistical and mathematical analysis. Background: Calculus and Introductory Physics.

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): 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.250.372 OR AS.030.370) AND AS.250.205 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'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.250.520. Introduction to Biophysics Research. 3 Credits.

This course is 3 credits and 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, so you can take it twice, even in the same year. Students are expected to take this course twice (2 semesters, 6 units) 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.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.250.601. Biophysics Seminar. 3 Credits.

Graduate students only. Students and invited speakers present current topics in the field.

AS.250.602. Biophysics Seminar. 3 Credits.

Graduate students only. Students and invited speakers present current topics in the field.

AS.250.610. Savvy Science Seminars. 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.250.615. 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.

Basics of molecular dynamics

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): 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. 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.

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. 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.

Civil and Systems Engineering**EN.560.461. 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. Area: Engineering

First Year Seminars**AS.001.119. FYS: The Nature of Nature. 3 Credits.**

What is the fundamental character of nature? Do all living systems share an underlying logic? What is left to explore? 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; without the benefit of the technological and mathematical armamentarium at our disposal today, driven simply by curiosity and their imagination, they identified fundamental questions and laid the foundation for modern science. Much of their insight has 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 all experience in our daily lives. Our conversations will illustrate continuity and connectivity between aspects of nature that are usually treated separately. You might even discover through our conversations 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 different kinds of sources: popular science writing, fiction, poetry, newspaper articles, and movies. We will even do experiments in my lab (no lab or science experience necessary) to examine the secret of life. Area: Humanities, Natural Sciences

AS.001.220. FYS: Reproduction in the 21st Century: Biology and Politics. 3 Credits.

This First-Year Seminar course will explore biological and philosophical changes in 21st century childbearing conditions, and the relationship of emerging technology, politics and legislation to these changes. Among the topics to be discussed are the impact on male and female infertility of assisted reproductive technologies, including in vitro fertilization and intracytoplasmic sperm injection; how genetic technologies can be used to modify sperm, eggs and embryos and the associated risks, benefits, ethics and politics; how, when and whether stem cells obtained from in vitro fertilization "leftovers" can be used; whether abortion should be allowed, disallowed, or allowed only under particular circumstances such as when there are fetal anomalies or danger to the woman; old and new approaches to female and male contraception; and more. 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. Thus, in addition to the science, this First-Year Seminar will focus on when, how, and by whom decisions are made regarding reproduction.

Area: Natural Sciences

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.

Area: Natural Sciences

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