Biophysics

Courses offered by the Biophysics Program are listed under the subject code BIOPHYS (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=BIOPHYS&filter-catalognumber-BIOPHYS=on) on the (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=BIOPHYS&filter-catalognumber-BIOPHYS=on) Stanford Bulletin's (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=BIOPHYS&filter-catalognumber-BIOPHYS=on) ExploreCourses web site (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=BIOPHYS&filter-catalognumber-BIOPHYS=on).

The Biophysics Program offers instruction and research opportunities leading to the Ph.D. in Biophysics. Students admitted to the program may perform their graduate research in any appropriate department.

The Stanford Biophysics Program is an interdisciplinary, interdepartmental training program leading to the Ph.D. Degree in biophysics. The program centers on understanding biological function in terms of physical and chemical principles. The Program comprises faculty from 16 departments in the Schools of Humanities and Sciences, Medicine, Engineering, and the Stanford Synchrotron Radiation Laboratory. Research in the Program involves two overlapping branches of biophysics: the application of physical and chemical principles and methods to solving biological problems, and the development of new methods.

The Biophysics Program aims to train students in quantitative approaches to biological problems, while also developing their perspective in choosing forefront biological problems. A balanced academic program is tailored to the diverse backgrounds of the students. The program requires graduate-level coursework in physical and biological sciences, participation in seminar series, and most importantly achievement of a high level of proficiency in independent research.

Learning Outcomes (Graduate)

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research and analysis in Biophysics. Through completion of advanced course work and rigorous skills training, the doctoral program prepares students to make original contributions to the knowledge of Biophysics and to interpret and present the results of such research.

Graduate Program in Biophysics

For information on the University's basic requirements for the Ph.D. degree, see the "Graduate Degrees (http://www.stanford.edu/dept/registrar/bulletin/4901.htm)" section of this bulletin.

A small number of qualified applicants are admitted to the program each year. Applicants should present strong undergraduate backgrounds in the physical sciences and mathematics. The graduate course program, beyond the stated requirements, is worked out for each student individually with the help of appropriate advisers from the Committee on Biophysics.

The requirements and recommendations for applying to the Ph.D. Program in Biophysics include:

		Units
CHEM 131	Organic Polyfunctional Compounds	3
CHEM 171	Physical Chemistry I	3
CHEM 173	Physical Chemistry II	3
CHEM 175	Physical Chemistry III	3
BIOC 200	Applied Biochemistry	2

Ph.D. students in the Program in Biophysics are required to complete the following course requirements:

		Units
BIOPHYS 241	Biological Macromolecules	3-5
or BIOE 300A	Molecular and Cellular Bioengineering	
BIOPHYS 242	Methods in Molecular Biophysics	3
BIOPHYS 250	Seminar in Biophysics	1
MED 255	The Responsible Conduct of Research	1
AND, 4 graduate level courses in physical or biological science, with		
at least 1 course in physical science		
at least 1 course in literature-based biological science		

1. Training in a major with connections to biophysics such as physics, chemistry, or biology, with a quantitative background equivalent to that of an undergraduate physics or chemistry major at Stanford.
2. Opportunities for teaching are available during the first nine quarters, at the discretion of the advising committee.
3. The student must prepare a dissertation proposal defining the research to be undertaken, including methods of procedure. This proposal should be submitted by Autumn Quarter of the second year, and it must be approved by a committee of at least three members, including the principal research adviser and at least one member from the Biophysics Program. The candidate must defend the dissertation proposal in an oral examination. The dissertation reading committee normally evolves from the dissertation proposal review committee.
4. The student must present a Ph.D. dissertation as the result of independent investigation that expresses a contribution to knowledge in the field of biophysics.
5. The student must pass the University oral exam, taken only after the student has substantially completed the dissertation research. The examination is preceded by a public seminar in which the research is presented by the candidate.

Director: Vijay Pande (Chemistry)

Professors:

- Russ Altman (Genetics, Medical Informatics)
- Steve Block (Applied Physics, Biology)
- Steven Boxer (Chemistry)
- Axel Brunger (Molecular and Cellular Physiology)
- Gilbert Chu (Oncology)
- Steven Chu (Physics, Molecular and Cellular Physiology)
- Mark Davis (Microbiology and Immunology)
- Sebastian Doniach (Physics, Applied Physics)
- James Ferrell (Chemical and Systems Biology)
- Daniel Fisher (Applied Physics)
- Judith Frydman (Biology)
- K. Christopher Garcia (Molecular and Cellular Physiology, Structural Biology)
- Gary Glover (Radiology)
- Philip C. Hanawalt (Biology)
- Daniel Herschlag (Biochemistry)
- Keith O. Hodgson (Chemistry)
- Theodore Jardetzky (Structural Biology)
- Chaitan Khosla (Chemical Engineering, Chemistry)
- Peter S. Kim (Biochemistry)
- Brian Kobilka (Molecular and Cellular Physiology)
- Eric Kool (Chemistry)

- Ron Kopito (Biology)
- Roger D. Kornberg (Structural Biology)
- Craig Levin (Radiology)
- Michael Levitt (Structural Biology)
- Richard Lewis (Molecular and Cellular Physiology)
- Sharon Long (Biology)
- Tobias Meyer (Chemical and Systems Biology)
- W. E. Moerner (Chemistry)
- Vijay Pande (Chemistry)
- Peter Parham (Structural Biology, Microbiology and Immunology)
- Norbert Pelc (Bioengineering, Radiology)
- Joseph D. Puglisi (Structural Biology)
- Stephen Quake (Bioengineering)
- Stephen J. Smith (Molecular and Cellular Physiology)
- Edward I. Solomon (Chemistry)
- James A. Spudich (Biochemistry, Developmental Biology)
- Julie Theriot (Biochemistry)
- Soichi Wakatsuki (Photon Science, Structural Biology)
- William I. Weis (Structural Biology, Molecular and Cellular Physiology)
- Richard N. Zare (Chemistry)

Associate Professors:

- Annelise Barron (Bioengineering)
- Zev Bryant (Bioengineering)
- Jennifer Cochran (Bioengineering)
- Ron Dror (Computer Science)
- Miriam Goodman (Molecular and Cellular Physiology)
- Pehr Harbury (Biochemistry)
- KC Huang (Bioengineering)
- Jan Liphardt (Bioengineering)
- Merritt Maduke (Molecular and Cellular Physiology)
- Beth Pruitt (Mechanical Engineering)
- Jianghong Rao (Radiology)
- Mark Schnitzer (Biology, Applied Physics)
- Andrew Spakowitz (Chemical Engineering)

Assistant Professors:

- Manish Butte (Pediatrics)
- Lynette Cegelski (Chemistry)
- Ovijit Chaudhuri (Mechanical Engineering)
- Bianxiao Cui (Chemistry)
- Rhiju Das (Biochemistry)
- Adam de la Zerda (Structural Biology)
- Alexander Dunn (Chemical Engineering)
- Liang Feng (Molecular and Cellular Physiology)
- Polly Fordyce (Genetics)
- William Greenleaf (Genetics)
- Manu Prakash (Bioengineering)
- Ingmar Riedel-Kruse (Bioengineering)
- Jan Skotheim (Biology)
- Sindy Tang (Mechanical Engineering)
- Mary Teruel (Chemical and Systems Biology).

Courses

BIOPHYS 196. INTERACTIVE MEDIA AND GAMES. 1 Unit.
Interactive media and games increasingly pervade and shape our society. In addition to their dominant roles in entertainment, video games play growing roles in education, arts, and science. This seminar series brings together a diverse set of experts to provide interdisciplinary perspectives on these media regarding their history, technologies, scholarly research, industry, artistic value, and potential future.
Same as: BIOE 196

BIOPHYS 227. Functional MRI Methods. 3 Units.
Basics of functional magnetic resonance neuroimaging, including data acquisition, analysis, and experimental design. Journal club sections. Cognitive neuroscience and clinical applications. Prerequisites: basic physics, mathematics; neuroscience recommended.
Same as: RAD 227

BIOPHYS 228. Computational Structural Biology. 3 Units.
Interatomic forces and interactions such as electrostatics and hydrophobicity, and protein structure in terms of amino acid properties, local chain conformation, secondary structure, domains, and families of folds. How protein motion can be simulated. Bioinformatics introduced in terms of methods that compare proteins via their amino acid sequences and their three-dimensional structures. Structure prediction via simple comparative modeling. How to detect and model remote homologues. Predicting the structure of a protein from knowledge of its amino acid sequence. Via Internet.
Same as: SBIO 228

BIOPHYS 232. Advanced Imaging Lab in Biophysics. 4 Units.
Laboratory and lectures. Advanced microscopy and imaging, emphasizing hands-on experience with state-of-the-art techniques. Students construct and operate working apparatus. Topics include microscope optics, Koehler illumination, contrast-generating mechanisms (bright/dark field, fluorescence, phase contrast, differential interference contrast), and resolution limits. Laboratory topics vary by year, but include single-molecule fluorescence, fluorescence resonance energy transfer, confocal microscopy, two-photon microscopy, microendoscopy, and optical trapping. Limited enrollment. Recommended: basic physics, Biology core or equivalent, and consent of instructor.
Same as: APPPHYS 232, BIO 132, BIO 232, GENE 232

BIOPHYS 241. Biological Macromolecules. 3-5 Units.
The physical and chemical basis of macromolecular function. Topics include: forces that stabilize macromolecular structure and their complexes; thermodynamics and statistical mechanics of macromolecular folding, binding, and allostery; diffusional processes; kinetics of enzymatic processes; the relationship of these principles to practical application in experimental design and interpretation. The class emphasizes interactive learning, and is divided equally among lectures, in-class group problem solving, and discussion of current and classical literature. Enrollment limited to 50. Prerequisites: Background in biochemistry and physical chemistry recommended but material available for those with deficiency in these areas; undergraduates with consent of instructor only.
Same as: BIOC 241, GENE 241, SBIO 241

BIOPHYS 242. Methods in Molecular Biophysics. 3 Units.
Experimental methods in molecular biophysics from theoretical and practical standpoints. Emphasis is on X-ray diffraction, nuclear magnetic resonance, and fluorescence spectcroscopy. Prerequisite: physical chemistry or consent of instructor.
Same as: SBIO 242

BIOPHYS 244. Mechanotransduction in Cells and Tissues. 3 Units.
Mechanical cues play a critical role in development, normal functioning of cells and tissues, and various diseases. This course will cover what is known about cellular mechanotransduction, or the processes by which living cells sense and respond to physical cues such as physiological forces or mechanical properties of the tissue microenvironment. Experimental techniques and current areas of active investigation will be highlighted.
Same as: BIOE 283, ME 244

BIOPHYS 250. Seminar in Biophysics. 1 Unit.
Required of Biophysics graduate students. Presentation of current research projects and results by faculty in the Biophysics program. May be repeated for credit.

BIOPHYS 279. Computational Biology: Structure and Organization of Biomolecules and Cells. 3 Units.
Computational approaches to understanding the three-dimensional spatial organization of biological systems and how that organization evolves over time. The course will cover cutting-edge research in both physics-based simulations and computational analysis of experimental data, at scales ranging from individual molecules to multiple cells. Prerequisites: elementary programming background (106A or equivalent) and an introductory course in biology or biochemistry.
Same as: BIOMEDIN 279, CME 279, CS 279

BIOPHYS 294. Cellular Biophysics. 3 Units.
Physical biology of dynamical and mechanical processes in cells. Emphasis is on qualitative understanding of biological functions through quantitative analysis and simple mathematical models. Sensory transduction, signaling, adaptation, switches, molecular motors, actin and microtubules, motility, and circadian clocks. Prerequisites: differential equations and introductory statistical mechanics.
Same as: APPPHYS 294, BIO 294

BIOPHYS 297. Bio-Inorganic Chemistry. 3 Units.
Overview of metal sites in biology. Metalloproteins as elaborated inorganic complexes, their basic coordination chemistry and bonding, unique features of the protein ligand, and the physical methods used to study active sites. Active site structures are correlated with function. Prerequisites: 153 and 173, or equivalents.
Same as: CHEM 297

BIOPHYS 300. Graduate Research. 1-18 Unit.
Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

BIOPHYS 311. Biophysics of Multi-cellular Systems and Amorphous Computing. 2-3 Units.
Provides an interdisciplinary perspective on the design, emergent behavior, and functionality of multi-cellular biological systems such as embryos, biofilms, and artificial tissues and their conceptual relationship to amorphous computers. Students discuss relevant literature and introduced to and apply pertinent mathematical and biophysical modeling approaches to various aspect multi-cellular systems, furthermore carry out real biology experiments over the web. Specific topics include: (Morphogen) gradients; reaction-diffusion systems (Turing patterns); visco-elastic aspects and forces in tissues; morphogenesis; coordinated gene expression, genetic oscillators and synchrony; genetic networks; self-organization, noise, robustness, and evolvability; game theory; emergent behavior; criticality; symmetries; scaling; fractals; agent based modeling. The course is geared towards a broadly interested graduate and advanced undergraduates audience such as from bio / applied physics, computer science, developmental and systems biology, and bio / tissue / mechanical / electrical engineering. Prerequisites: Previous knowledge in one programming language - ideally Matlab - is recommended; undergraduate students benefit from BIOE 41, BIOE 42, or equivalent.
Same as: BIOE 211, BIOE 311, DBIO 211

BIOPHYS 342A. Mechanobiology and Biofabrication Methods. 3 Units.
Review of current cell mechanobiology topics and methods for controlling and assessing the biomechanics of living systems. Practice and theory of design and fabrication of devices for cell mechanobiology. Limited enrollment. NOTE: Compressed schedule starts 7/21 with Tu/Th lecture 10-12 in Weeks 1 and 3, and labs 9-5 (with lunch break) in Weeks 2 and 4.
Same as: ME 342A

BIOPHYS 371. Computational Biology in Four Dimensions. 3 Units.
Computational approaches to understanding the three-dimensional spatial organization of biological systems and how that organization evolves over time. The course will cover cutting-edge research in both physics-based simulation and computational analysis of experimental data, at scales ranging from individual molecules to entire cells. Prerequisite: CS 106A or equivalent, and an introductory course in biology or biochemistry. Recommended: some experience in mathematical modeling (does not need to be a formal course).
Same as: BIOMEDIN 371, CME 371, CS 371

BIOPHYS 392. Topics in Molecular Biophysics: Biophysics of Functional RNA. 3 Units.
Survey of methods used to relate RNA sequences to the structure and function of transcribed RNA molecules. Computation of contributions of the counter-ion cloud to the dependence of free energy on conformation of the folded RNA. The relation of structure to function of riboswitches and ribozymes.
Same as: APPPHYS 392

BIOPHYS 393. Biophysics of Solvation. 3 Units.
Statistical mechanics of water-protein or water-DNA (or RNA) interactions; effects of coulomb forces on molecular hydration shells and ion clouds; limitations of the Poisson-Boltzmann equations; DNA collapse, DNA-protein interactions; structure-function relationships in ion channels.
Same as: APPPHYS 393

BIOPHYS 399. Directed Reading in Biophysics. 1-18 Unit.
Prerequisite: consent of instructor.

BIOPHYS 801. TGR Project. 0 Units.
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BIOPHYS 802. TGR Dissertation. 0 Units.
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