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 the Ph.D. degree include:

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<tr>
<th>Course</th>
<th>Title</th>
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<tr>
<td>CHEM 131</td>
<td>Organic Polyfunctional Compounds</td>
<td>3</td>
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<tr>
<td>CHEM 171</td>
<td>Physical Chemistry I</td>
<td>3</td>
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<td>CHEM 173</td>
<td>Physical Chemistry II</td>
<td>3</td>
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Select one of the following:

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<tr>
<th>Course</th>
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<tr>
<td>BIOPHYS 241</td>
<td>Biological Macromolecules</td>
<td>3-5</td>
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<tr>
<td>or BIOE 300A</td>
<td>Molecular and Cellular Bioengineering</td>
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<tr>
<td>BIOPHYS 242</td>
<td>Methods in Molecular Biophysics</td>
<td>3</td>
</tr>
<tr>
<td>BIOPHYS 250</td>
<td>Seminar in Biophysics</td>
<td>1</td>
</tr>
<tr>
<td>MED 255</td>
<td>The Responsible Conduct of Research</td>
<td>1</td>
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At least four additional graduate level courses in physical or biological science, with at least one in physical science and one as a literature-based biological science course.

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. Completion of the following background courses or their equivalents at other institutions:
3. Completion of the following courses or their equivalents:
4. Opportunities for teaching are available during the first nine quarters, at the discretion of the advising committee.
5. 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.
6. 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.
7. 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.

**Emeritus:** Harden M. McConnell (Chemistry)

**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), Mark Davis (Microbiology and Immunology), Sebastian Doniach (Physics, Applied Physics), James Ferrell (Chemical and Systems Biology), Daniel Fischer (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), Norbert Pellegrini (Structural Biology), Stephen Quake (Bioengineering), Joseph D. Puglisi (Structural Biology), Stephen J. Smith (Molecular and Cellular Physiology), Edward I. Solomon (Chemistry), James A. Spudich (Biochemistry, Developmental Biology), Julie Theriot (Biochemistry), William I. Weis (Structural Biology, Molecular and Cellular Physiology), Richard N. Zare (Chemistry)

**Associate Professors:**
- Annelise Barron (Bioengineering), Jennifer Cochran (Bioengineering), Miriam Goodman (Molecular and Cellular Physiology),
Courses

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: SBI 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: APPPHY 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 alloster; 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: BIO 241, GENE 241, SBI 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 spectroscopy. Prerequisite: physical chemistry or consent of instructor. Same as: SBI 242

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

BIOPHYS 801. TGR Project. 0 Units.

BIOPHYS 802. TGR Dissertation. 0 Units.

Pehr Harbury (Biochemistry), Merritt Maduke (Molecular and Cellular Physiology), Jianghong Rao (Radiology), Mark Schnitzer (Biology, Applied Physics), Andrew Spakowitz (Chemical Engineering)

Assistant Professors: Zev Bryant (Bioengineering), Lynette Cegelski (Chemistry), Binxiao Cui (Chemistry), Rhiju Das (Biochemistry), Adam de la Zerda (Structural Biology), Alexander Dunn (Chemical Engineering), William Greenleaf (Genetics), KC Huang (Bioengineering), Manu Prakash (Bioengineering), Ingmar Riedel-Kruse (Bioengineering), Jan Skotheim (Biology), Mary Teruel (Chemical and Systems Biology).