

# 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://exploreddegrees.stanford.edu/graduatedegrees/>)" section of this bulletin.

## Admissions

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. GRE general score is not required and GRE subject score is optional.

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

		Units
CHEM 123	Organic Polyfunctional Compounds	3
CHEM 171	Foundations of Physical Chemistry	4
CHEM 173	Physical Chemistry II	3
CHEM 175	Physical Chemistry III	3
BIOC 200	Applied Biochemistry	2

## Course Requirements

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

		Units
BIOPHYS 241 or BIOE 300A	Biological Macromolecules Molecular and Cellular Bioengineering	3-5
BIOPHYS 242	Methods in Molecular Biophysics (offered every other year)	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

## Lab Rotation and Settlement

During the first year of graduate school in Biophysics, students are encouraged to complete a minimum two quarters of rotations in any faculty labs of their choice, a third rotation is allowed if necessary. Once the students finish their rotations, they make an official decision on which faculty's lab to settle in. If the faculty is not part of Biophysics, then the student needs to have an additional co-advising faculty member on their committee who is in Biophysics. Once the student settles in a lab, s/he is required to complete the first Individual Development Plan (IDP) and begin forming the reading committee.

## Individual Development Plan (IDP)

In light of the benefits to trainee development and the likelihood that the IDP program will be a factor in NIH funding decisions, the Committee on Graduate Admissions and Policy (CGAP) has adopted a new policy requiring all Biosciences Ph.D. candidates and their mentors in the Schools of Medicine and H&S to create and discuss the Individual Development Plan (IDP) (<https://biosciences.stanford.edu/current/idp/>) on an annual basis.

1. Complete the first IDP meeting with the adviser within 30 days of joining the thesis lab.
2. IDP meetings are required annually, in addition to and separate from thesis committee meetings (see below).

## Reading Committee

See the "Degree-Specific Requirements (Doctoral Degrees) (<http://exploreddegrees.stanford.edu/graduatedegrees/#doctoraltext>)" section of this bulletin for University rules concerning doctoral degrees. See GAP 4.8 (<http://gap.stanford.edu/4-8.html>), for further details on the Doctoral Dissertation Reading Committee.

Once a student have chosen a research adviser and begun thesis-related research, s/he is required to select a reading committee. The student's reading committee should be in place no later than Autumn Quarter of the third year in the program. The individuals selected by the student serve as an advising and consultative group for the duration of their graduate studies. They evaluate the student's dissertation proposal and constitute the core of their the defense committee. Students should consult with their research adviser on the selection of their reading committee.

The doctoral dissertation reading committee consists of the principal dissertation adviser and, typically, two other readers. The doctoral dissertation reading committee must have at least three members and may not have more than five members. All members of the reading committee approve the dissertation. At least one member must be from the student's major department. Normally, all committee members are members of the Stanford University Academic Council or are emeritus Academic Council members.

The reading committee, as proposed by the student and agreed to by the prospective members, is endorsed by the chair of the major department on this Doctoral Dissertation Reading Committee form (<https://stanford.app.box.com/docdiss-reading-committee-form/>). The student's department chair may, in some cases, approve the appointment of a reader who is not a current or emeritus member of the Academic Council (via the Petition for Non-Academic Council Doctoral Committee Members form (<https://stanford.app.box.com/doc-ctte-non-acad-council/>)), if that person is particularly well qualified to consult on the dissertation topic and holds a Ph.D. or equivalent foreign degree. All examiners must hold a Ph.D. degree (or foreign equivalent). Former Stanford Academic Council members and non-Academic Council members may thus on occasion serve on a reading committee.

Any member of the Academic Council may serve as the principal dissertation adviser. If former Academic Council members, emeritus Academic Council members, or non-Academic Council members are to serve as the principal dissertation adviser, the appointment of a co-adviser who is currently on the Academic Council is required. This is to ensure representation for the student in the department by someone playing a major adviser role in completion of the dissertation. However, a co-adviser is not required during the first two years following retirement for emeritus Academic Council members who are recalled to active service. If the reading committee has four or five members, at least three members (comprising the majority) must be current or emeritus members of the Academic Council.

## Qualifying Exam

Once students enter their third year of graduate studies, they are required to arrange a meeting with their committee to present to them a proposed thesis related research project (dissertation proposal). The meeting is called the qualifying exam, and should be completed no later than the end of Autumn Quarter of the student's third year. In anticipation of the exam, the student should prepare an approximately 10-page summary of their proposed research and/or any progress they have made at that time. The precise format (e.g., inclusion of a timeline, methods section, etc.) is flexible, and naturally can conform to the particular style of papers or proposals coming from their thesis lab. The main goal of the written portion is to briefly summarize the student's progress so far and carefully plan out their future thesis research plans with committee feedback and advice.

At the meeting, the student should be prepared to make a 30-45 minute presentation of their research where they discuss their results to date and propose further experiments. Audiovisual aids are not required, but may be useful if available. After completing the qualifying exam, students need to arrange annual thesis committee meetings with their committee members to review academic progress each year. Completing the qualifying exam serves to meet the student's first thesis committee meeting requirement. The thesis committee meetings should be completed once a year during the student's 3rd and 4th years, and twice a year past their fifth year and above.

## Candidacy

Admission to candidacy for the doctoral degree is granted by the major department following a student's successful completion of qualifying procedures. Students are expected to be admitted to candidacy by the

end of the second year of doctoral study. Candidacy is valid for five years, subject to satisfactory academic progress.

## Terminal Graduate Registration (TGR)

Doctoral students who have been admitted to candidacy, completed all required courses and degree requirements other than the University oral exam and dissertation, completed 135 units or 10.5 quarters of residency (if under the old residency policy), and submitted a Doctoral Dissertation Reading Committee form, may request Terminal Graduate Registration (TGR) status to complete their dissertations. Students with more than one active graduate degree program must complete residency units between all active/completed degree programs in order to apply for TGR status. See the "Residency Policy for Graduate Students (<http://exploreddegrees.stanford.edu/graduatedegrees/#residencytext>)" section of this bulletin for additional information.

## Dissertation/Oral Exam

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 third 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.

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. 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.

## COVID-19 Policies

On July 30, the Academic Senate adopted grading policies effective for all undergraduate and graduate programs, excepting the professional Graduate School of Business, School of Law, and the School of Medicine M.D. Program. For a complete list of those and other academic policies relating to the pandemic, see the "COVID-19 and Academic Continuity (<http://exploreddegrees.stanford.edu/covid-19-policy-changes/#tempdeptemplatetabtext>)" section of this bulletin.

The Senate decided that all undergraduate and graduate courses offered for a letter grade must also offer students the option of taking the course for a "credit" or "no credit" grade and recommended that deans, departments, and programs consider adopting local policies to count courses taken for a "credit" or "satisfactory" grade toward the fulfillment of degree-program requirements and/or alter program requirements as appropriate.

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## Graduate Degree Requirements

### Grading

The Program of Biophysics counts all courses taken in academic year 2020-21 with a grade of 'CR' (credit) or 'S' (satisfactory) towards satisfaction of graduate degree requirements that otherwise require a letter grade provided that the instructor affirms that the work was done at a 'B-' or better level.

## Graduate Advising Expectations

Academic advising by our faculty is a critical component of our graduate students' education. The Biophysics Program is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the

adviser and the advisee. Both the adviser and the advisee are expected to maintain professionalism and integrity.

All matriculating students are assigned the program director as a faculty adviser to help them design their academic program. Before advancing to candidacy for the degree, students are expected to identify a group of at least three thesis advisers (also known as the dissertation reading committee), including a primary thesis adviser. The thesis advisers are selected by the student on the basis of expertise relevant to the thesis project, after undertaking two to three rotations of approximately one quarter in length each.

Thesis advisers meet with students at least once each year to discuss students' Individual Development Plan(s) (IDPs). Additionally, students should meet with their adviser(s) on a regular basis throughout each year for guidance in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

Academic progress and student completion of program requirements and milestones are monitored by the program staff and director, and are discussed at meetings of the executive committee.

Requirements and milestones, as well as more detailed descriptions of the program's expectations of advisers and students, are listed in the Student Handbook, found on the program website (<http://med.stanford.edu/biophysics.html>).

Additionally, the program adheres to the advising guidelines and responsibilities listed by the Office of the Vice Provost for Graduate Education (<https://vpge.stanford.edu/academic-guidance/advising-mentoring/>) and in the Graduate Academic Policies (<https://gap.stanford.edu/handbooks/gap-handbook/chapter-3/subchapter-3/page-3-3-1/>).

For a statement of University policy on graduate advising, see the "Graduate Advising (<http://exploreddegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext>)" section of this bulletin.

*Director of Graduate Studies:*

- KC Huang (Bioengineering)

*Emeritus:*

- Philip C. Hanawalt (Biology, Dermatology)
- Harden M. McConnell (Chemistry)
- Stephen J. Smith (Molecular & Cellular Physiology)
- Norbert Pelc (Bioengineering, Radiology)

*Professors:*

- Russ Altman (Bioengineering, Genetics, Medicine - Biomedical Informatics)
- Manuel Amieva (Microbiology & Immunology, Pediatrics)
- Steve M. Block (Applied Physics, Biology)
- Steven Boxer (Chemistry)
- Anne Brunet (Genetics)
- Axel Brunger (Molecular & Cellular Physiology)
- Wah Chiu (Bioengineering)

- Gilbert Chu (Oncology, Biochemistry)
- Steven Chu (Physics, Molecular & Cellular Physiology)
- Jennifer Cochran (Bioengineering)
- Bianxiao Cui (Chemistry)
- Hongjie Dai (Chemistry)
- Mark Davis (Microbiology & Immunology)
- Sebastian Doniach (Physics, Applied Physics)
- James Ferrell (Chemical & Systems Biology, Biochemistry)
- Daniel Fisher (Applied Physics)
- Judith Frydman (Biology, Genetics)
- Chris Garcia (Molecular & Cellular Physiology, Structural Biology)
- Gary H. Glover (Radiology)
- Miriam Goodman (Molecular & Cellular Physiology)
- Daniel Herschlag (Biochemistry)
- Keith O. Hodgson (Chemistry)
- KC Huang (Bioengineering)
- Theodore Jardetzky (Structural Biology)
- Shamit Kachru (Physics)
- Peter S. Kim (Biochemistry)
- Brian Kobilka (Molecular & Cellular Physiology)
- Eric Kool (Chemistry)
- Ron Kopito (Biology)
- Roger D. Kornberg (Structural Biology)
- Craig Levin (Radiology)
- Michael Levitt (Structural Biology)
- Richard Lewis (Molecular & Cellular Physiology)
- Sharon Long (Biology)
- Crystal Mackall (Pediatrics, Medicine)
- Todd Martinez (Chemistry)
- Tobias Meyer (Chemical & Systems Biology)
- W. E. Moerner (Chemistry)
- Vijay Pande (Chemistry)
- Joseph D. Puglisi (Structural Biology)
- Stephen Quake (Bioengineering, Applied Physics)
- Jianghong Rao (Radiology)
- Mark Schnitzer (Biology, Applied Physics)
- Jan Skotheim (Biology)
- Edward I. Solomon (Chemistry)
- James A. Spudich (Biochemistry)
- Alice Y. Ting (Genetics)
- Shreyas Vasanawala (Radiology)
- Anthony Wagner (Psychology)
- Soichi Wakatsuki (Photon Science, Structural Biology)
- Thomas Wandless (Chemical & Systems Biology)
- William I. Weis (Structural Biology, Molecular & Cellular Physiology)
- Richard Zare (Chemistry)

*Associate Professors:*

- Annelise Barron (Bioengineering)
- Zev Bryant (Bioengineering)
- David Camarillo (Bioengineering)
- Jose R. Dinneny (Biology)
- Lynette Cegelski (Chemistry)
- Rhiju Das (Biochemistry)
- Adam de la Zerda (Structural Biology)
- Ron Dror (Computer Science)
- Alexander Dunn (Chemical Engineering)

- William Greenleaf (Genetics)
- Pehr Harbury (Biochemistry)
- Michael Kapiloff (Ophthalmology)
- Jin Billy Li (Genetics)
- Jan Liphardt (Bioengineering)
- Merritt Maduke (Molecular & Cellular Physiology)
- Ashby Morrison (Biology)Mo
- Manu Prakash (Bioengineering)
- Andrew Spakowitz (Chemical Engineering)
- Sindy Tang (Mechanical Engineering)

*Assistant Professors:*

- Monther Abu-Remaileh (Chemical Engineering)
- Raag Airan (Radiology)
- Lacramioara Bintu (Bioengineering)
- Alistair Boettiger (Developmental Biology)
- Onn Brandman (Biochemistry)
- Ovijit Chaudhuri (Mechanical Engineering)
- Gheorghe Chistol (Chemical & Systems Biology)
- Shaul Druckmann (Neurobiology, Psychiatry & Behavioral Sciences)
- Liang Feng (Molecular & Cellular Physiology)
- Polly Fordyce (Genetics)
- Xiaojing Gao (Chemical Engineering)
- Olivier Gevaert (Biomedical Informatics, Biomedical Data Science)
- Benjamin Good (Applied Physics)
- Keren Haroush (Neurobiology)
- Possu Huang (Bioengineering)
- Anshul Kundaje (Genetics, Computer Science)
- Lingyin Li (Biochemistry)
- Jonathan Long (Pathology)
- Julia Palacios (Biomedical Data Sciences, Statistics)
- Johannes Reiter (Radiology, Biomedical Data Science)
- Grant M. Rotskoff (Chemistry)
- Manish Saggarr (Psychiatry & Behavioral Sciences)
- Julia Salzman (Biochemistry)
- Mary Teruel (Chemical & Systems Biology)
- Bo Wang (Bioengineering)
- Roseanna Zia (Chemical Engineering)
- Brad Zuchero (Neurosurgery)

## 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, CS 544

### **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: BIOE 227, RAD 227

### **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, basic cell biology, and consent of instructor.  
Same as: APPPHYS 232, BIO 132, BIO 232, GENE 232

### **BIOPHYS 235. Biotransport Phenomena. 3 Units.**

The efficient transport of energy, mass, and momentum is essential to the normal function of living systems. Changes in these processes often result in pathological conditions. Transport phenomena are also critical to the design of instrumentation and devices for medical applications and biotechnology. The course aims to provide an introduction to the integrated study of transport processes and their biological applications. It covers the fundamental driving forces for transport in biological systems and the biophysics across a range of length scales from molecules, cells, tissues, organs to whole organisms. Topics covered include chemical gradients, electrical interactions, fluid flow and mass transport.  
Same as: ME 235

### **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 among lectures, in-class group problem solving, and discussion of current and classical literature. Enrollment limited to 30. 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, BIOE 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, electron microscopy, nuclear magnetic resonance, and fluorescence spectroscopy. 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. This class is for graduate students only.  
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 250 is a seminar course intended only for first year Biophysics and Structural Biology graduate students, to help them decide on which faculty labs they want to settle in.

**BIOPHYS 279. Computational Biology: Structure and Organization of Biomolecules and Cells. 3 Units.**

Computational techniques for investigating and designing the three-dimensional structure and dynamics of biomolecules and cells. These computational methods play an increasingly important role in drug discovery, medicine, bioengineering, and molecular biology. Course topics include protein structure prediction, protein design, drug screening, molecular simulation, cellular-level simulation, image analysis for microscopy, and methods for solving structures from crystallography and electron microscopy data. Prerequisites: elementary programming background (CS 106A or equivalent) and an introductory course in biology or biochemistry.

Same as: BIOE 279, 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.**

(Formerly Chem 297) 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 (electron transfer; dioxygen binding, activation and reduction to water). Prerequisites: Chem 153 and Chem 173, or equivalents.

Same as: CHEM 257

**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 42, or equivalent.

Same as: BIOE 211, BIOE 311, DBIO 211

**BIOPHYS 315. Methods in Computational Biology. 3 Units.**

Methods of bioinformatics and biomolecular modeling from the standpoint of biophysical chemistry. Methods of genome analysis; cluster analysis, phylogenetic trees, microarrays; protein, RNA and DNA structure and dynamics, structural and functional homology; protein-protein interactions and cellular networks; molecular dynamics methods using massively parallel algorithms.

Same as: APPPHYS 315

**BIOPHYS 342A. Mechanobiology and Biofabrication Methods. 3 Units.**

Cell mechanobiology topics including cell structure, mechanical models, and chemo-mechanical signaling. Review and apply methods for controlling and analyzing the biomechanics of cells using traction force microscopy, AFM, micropatterning and cell stimulation. Practice and theory for the design and application of methods for quantitative cell mechanobiology.

Same as: BIOE 342A, ME 342A

**BIOPHYS 371. Computational Biology in Four Dimensions. 3 Units.**

Cutting-edge research on computational techniques for investigating and designing the three-dimensional structure and dynamics of biomolecules, cells, and everything in between. These techniques, which draw on approaches ranging from physics-based simulation to machine learning, play an increasingly important role in drug discovery, medicine, bioengineering, and molecular biology. Course is devoted primarily to reading, presentation, discussion, and critique of papers describing important recent research developments. 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 (BIOPHYS 392). 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 ribozymes, riboswitches, and the formation of ribosomal proteins.

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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