# School of Medicine

*Dean:* Philip Pizzo
*Senior Associate Dean for Research and Training:* Harry B.Greenberg
*Senior Associate Dean for Research and Training:* John C. Boothroyd
*Senior Associate Dean for Education and Student Affairs:* Julie Parsonnet

The School of Medicine offers courses of study leading to the M.S., Ph.D., and M.D. degrees.

## UNDERGRADUATE PROGRAMS

At the undergraduate level, a number of the school's courses are open to any registered Stanford student who has fulfilled the prerequisites, subject to the usual limits of course enrollment and faculty approval. Details on admission into undergraduate programs are described in the "Undergraduate Degrees" section of this bulletin.

## GRADUATE PROGRAMS

### M.S. AND Ph.D. PROGRAMS

Departments offer programs leading to the Ph.D. degree. Applications and information for all graduate programs may be obtained from Graduate Admissions, Registrar's Office, Stanford University, Stanford, CA 94305-3005, or at http://gradadmissions.stanford.edu.

### M.D. PROGRAMS

The School of Medicine provides an educational environment that encourages intellectual diversity and offers stimulation and opportunity for self-motivated students who are interested in developing a scholarly, investigative approach to problems in medicine. Accordingly, Stanford has designed its medical curriculum with a two-fold purpose: to develop in all students the capacity for leadership in the clinical practice of scientific medicine and to provide them opportunities to prepare themselves for careers in research and teaching in the various branches of basic, clinical, and social medicine. The flexible curriculum allows for individual needs in scheduling course work. Students develop study plans that take into consideration their academic background, particular strengths, and career objectives.

All medical students must complete a formal curriculum in the basic medical sciences and have formal clinical experience in medicine, surgery, pediatrics, gynecology-obstetrics, family medicine, and psychiatry. Following completion of 13 quarters of academic work, additional quarters may be taken at a special student rate. Involvement in research and outside course work may extend the time spent in medical school. Completion of the M.D. degree must be achieved within six years, unless a petition is granted to extend this time frame.

There are a variety of opportunities for in-depth study of subject areas in the basic sciences. Students with strong interests in medical research as a career are urged to investigate opportunities available under the auspices of the Medical Scientist Training Program (MSTP). This program provides a limited number of students the opportunity to pursue an individualized program of research and course work leading to both the M.D. and Ph.D. degrees. The estimated time for completion of the program is seven years. Students interested in participating in the MSTP are asked to provide supplemental information relevant to their research background and are considered for entry into the MSTP at the time of their application to the School of Medicine.

The admissions process recognizes that some minorities and women are underrepresented in the medical profession, and especially in academic medicine; the school has a strong commitment to identify, recruit, and educate such students.

Provided an applicant to the school has completed the basic courses in physics, chemistry, and biology, the choice of an undergraduate major may reflect other interests, including the arts and humanities. Course work in mathematics and the behavioral sciences is highly recommended because of its importance in understanding medicine. Extracurricular activities and breadth of interests and experiences play an important role in the selection of students from among those applicants having superior records.

Further details on the M.D. degree, including admission requirements, are in the Stanford University *School of Medicine Catalog*, available on the web at http://www-med.stanford.edu/school/catalog. For application materials write: Committee on Admissions, Stanford University, School of Medicine, 251 Campus Drive, Suite 341, Stanford, CA 94305-5404.

# BIOCHEMISTRY

*Emeriti: (Professors)* Robert L. Baldwin, Paul Berg, David S. Hogness, Arthur Kornberg
*Chair:* Suzanne R. Pfeffer
*Professors:* Patrick O. Brown, Douglas L. Brutlag, Gilbert Chu, Ronald W. Davis, James E. Ferrell, Jr., Daniel Herschlag, A. Dale Kaiser, Mark A. Krasnow, I. Robert Lehman, Suzanne R. Pfeffer, James A. Spudich
*Assistant Professors:* Pehr A. B. Harbury, Julie A. Theriot
*Acting Assistant Professor:* Aaron F. Straight
*Courtesy Professors:* Chaitan S. Khosla, Sharon Long

*Department Offices:* Beckman Center, B400
*Mail Code:* 94305-5307
*Phone:* (650) 723-6161
*Web Site:* http://biochem.stanford.edu/

Courses given in Biochemistry have the subject code BIOC. For a complete list of subject codes, see Appendix B.

Biochemistry is a department within the School of Medicine, with offices and labs located in the Beckman Center for Molecular and Genetic Medicine at the Stanford Medical Center. Courses offered by the department may be taken by undergraduate, graduate, and medical school students.

Advanced courses are offered in more specialized areas and they emphasize the most recent developments in biochemistry, cell biology, and molecular biology. These courses include the physical and chemical principles of biochemistry, enzyme reaction mechanisms, membrane trafficking and biochemistry, molecular motors and the cytoskeleton, mechanisms and regulation of nucleic acid replication and recombination, the biochemistry of bacterial and animal viruses, the molecular basis of morphogenesis, the molecular and cell biology of yeast, and the structure and function of both eukaryotic and prokaryotic chromosomes.

Opportunities exist for directed reading and research in biochemistry and molecular biology, utilizing the most advanced research facilities, including those for light and electron microscopy, chromatography and electrophoresis, protein and nucleic acid purification, rapid kinetic analysis, synthesis and analysis, single molecule analyses using laser light traps, microarray generation and analysis and computer graphic workstation facilities for protein and nucleic acid structural analysis. On-going research utilizes a variety of organisms, from bacteria to animal cells.

## GRADUATE PROGRAM

### DOCTOR OF PHILOSOPHY

Requirements for the M.S. and Ph.D. degrees are described in the "Graduate Degrees" section of this bulletin. The department does not offer undergraduate degrees.

The Department of Biochemistry offers a Ph.D. program which begins in the Autumn Quarter of each year. The program of study is designed to prepare students for productive careers in biochemistry; its emphasis is training in research, and each student works closely with members of the faculty. In addition to the requirement for a Ph.D. dissertation based on original research, students are required to complete six advanced courses in biochemistry and related areas. Selection of these courses is tailored to fit the background and interests of each student. A second

requirement involves the submission of three research proposals, which are presented by the student to a small sy committee of departmental faculty members who are also responsible for monitoring the progress of student curricular and research programs. All Ph.D. students are expected to participate actively in the department's seminar program, and students are encouraged to attend and to present papers at regional and national meetings in cellular biochemistry and molecular biology. Teaching experience is an integral part of the Ph.D. curriculum and is required for the degree.

The Department of Biochemistry offers an M.S. degree only to students already enrolled in the Ph.D. program. Students should contact the Graduate Studies adviser for more details.

Those applying for graduate study should have at least a baccalaureate degree and should have completed work in cell and developmental biology, basic biochemistry and molecular biology, and genetics. Also required are: at least one year of university physics; differential and integral calculus; and analytical, organic, inorganic, and physical chemistry. The department is especially interested in those applicants who have research experience in biology or chemistry. Students must submit an application, including transcripts and letters of recommendation, by December 15.

Beginning September 1, applications are available and can be requested by mail from Graduate Admissions, Registrar's Office, Old Union, 520 Lasuen Mall, Stanford University, Stanford CA 94304-3005, by phone (650) 723-4291, or email at gradadmissions@stanford.edu. Applications may also be submitted electronically at http://gradadmissions.stanford.edu/ and http://www.med.stanford.edu/school/biosciences/. Applicants are notified by April 1 of decisions on their applications. Stanford University requires scores from the Graduate Record Examination (GRE) (verbal, quantitative, and analytical), and applicants must submit scores from the GRE Subject Test in either biochemistry, biology, or chemistry. Applicants should take the October GRE exam.

All applicants are urged to compete for non-Stanford fellowships or scholarships, and U.S. citizens should complete an application for a National Science Foundation Predoctoral Traineeship. Students are provided with financial support to cover normal living expenses; Stanford tuition costs are paid.

All applicants for admission to the department are considered without regard to race, color, creed, religion, sex, age, national origin, or marital status.

Postdoctoral research training is available to graduates who hold a Ph.D. or an M.D. degree. Qualified individuals may write to individual faculty members for further information.

At present, the primary research interests of the department are the structure and function of proteins and nucleic acids, the biochemistry and control of development processes, molecular motors and the cytoskeleton, the trafficking of proteins between membrane-bound organelles, the control and regulation of gene expression, bioinformatics/protein structure design, and the application of microarrays to problems in human health and disease.

## COURSES

**BIOC 118Q. Genomics, Bioinformatics, and Medicine**—Stanford Introductory Seminar. Preference to sophomores. The kind of knowledge gained from sequencing the human genome and the implications of such knowledge for medicine and biomedical research. Novel diagnostic methods and treatment of diseases, including gene therapy and drug design. The ethical implications of genetic information. The use of genome and disease databases to determine the function of genes involved in disease. See http://biochem118.stanford.edu/. Recommended: Biological Sciences 42 or Human Biology 2A. GER:2b

*3 units, Spr (Brutlag)*

**BIOC 199. Undergraduate Research**—Prerequisite: consent of instructor.

*1-18 units (Staff)*

**BIOC 202. Metabolic Biochemistry: Structure, Metabolism, and Energetics**

*4 units (Staff)*

**BIOC 205. Molecular Foundations of Medicine**—Topics include: DNA structure, replication, repair, and recombination; chromosome structure and function; gene expression including mechanisms for regulating transcription and translation; and methods for manipulating DNA, RNA, and proteins. Patient presentations illustrate how molecular biology affects the practice of medicine.

*4 units, Aut (Chu, Brown, Krasnow)*

**BIOC 210. Advanced Topics in Membrane Biochemistry**—The structure, function, and biosynthesis of cellular membranes and organelles. Based on current literature, with extensive student participation. Prerequisites: 200, 203, or equivalents, and consent of instructor.

*4 units, Spr (Pfeffer)*

**BIOC 214. Physical and Chemical Principles of Enzyme Function**—Enzymatic mechanisms, with emphasis on the fundamental behavior of biochemical systems and the properties that emerge due to the complex nature of these systems. Course format is student presentations on specific enzymes based on classic and current literature, developed in consultation with the instructor. Prerequisites: BIOC/SBIO 241 and a course in organic chemistry.

*3-5 units (Herschlag) not given 2003-04*

**BIOC 215. Frontiers in Biological Research**—(Same as DBIO 215, GENE 215.) Literature discussion on how to critically evaluate biological research. Held in conjunction with a seminar series, hosted in alternate weeks by Biochemistry, Developmental Biology, and Genetics. Each Wednesday, distinguished investigators present their current work at the Frontiers in Biological Research seminar. Beforehand, students and faculty meet to discuss one or more papers from the speaker's primary research literature on a related topic. After the seminar, students meet with the speaker to discuss their research and future direction, the techniques most commonly used to study problems in biology, and a comparison between the genetic and biochemical approaches in biological research.

*1 unit, Aut, Win, Spr (Harbury, Kingsley, Baker)*

**BIOC 217. Advanced Tutorial in Special Topics**—Readings and tutorial in membrane biochemistry, enzyme mechanisms, chromosome structure, biochemical genetics, bacterial and animal viruses, and nucleic acid enzymology. Conducted under the guidance of advanced graduate students and postdoctoral fellows.

*1-3 units, Aut, Win, Spr, Sum (Staff) by arrangement*

**BIOC 218. Computational Molecular Biology**—Course online only; see http://biochem218.stanford.edu. For molecular biologists and computer scientists. Hands-on approach to the major issues concerning representation and analysis of biological sequences and structure. Existing methods and future directions. Topics: accessing molecular databases, pattern search, classification of sequence and structure, alignment of sequences, rapid similarity searching, phylogenies, automated pattern learning, representing protein structure, gene expression profiling, clustering expressed genes, and discovering transcription factor binding sites. Lecture/lab. Final project. Enrollment limited to 40. Prerequisite: BIOSCI 52 or equivalent, or consent of instructor.

*3 units, Aut, Win, Spr (Brutlag)*

**BIOC 221. The Teaching of Biochemistry**—To be taken by all teaching assistants in 203, 204, 217, or 218. Emphasizes practical experience in teaching on a one-to-one basis, and problem set design and analysis. Familiarization with current lecture and text materials is expected, along with evaluations of class papers and examinations. Prerequisite: enrollment in the Biochemistry Ph.D. program or consent of instructor.

*3 units, Aut, Win, Spr, Sum (Staff) by arrangement*

**BIOC 225. Molecular Motor Proteins and the Cytoskeleton**—(Same as DBIO 225.) The molecular basis of energy transduction leading to movements generated by microfilament-based and microtubule-based motors. Forms of myosin, dynein, and kinesin and their roles in the cell

as a model for understanding the structural, biochemical, and functional properties of biological machines. Topics: structure of the molecular motors and their accessory proteins; regulation of the function of motile assemblies; functions of molecular motors in cells; spatial and temporal controls on the formation of motile assemblies in cells. Experimental approaches: genetic analysis, DNA cloning and expression, reconstitution of functional assemblies from purified proteins, x-ray diffraction, three-dimensional reconstruction of electron microscope images, spectroscopic methods, and high-resolution light microscopy. Prerequisites: basic biochemistry and cell biology.

*3 units, Spr (Spudich) not given 2004-05*

**BIOC 230. Molecular Interventions in Human Disease**—For M.D. students who intend to declare a concentration in molecular basis of medicine, M.S.T.P. students, and Ph.D. students with a strong interest in medicine. Advanced medical biochemistry focusing on cases where molecular-level research has led to new medical treatments or changes in the understanding of important diseases. The underlying molecular basis of specific diseases and the reasons for success and failure in molecular approaches to treatment. Students lead discussions examining papers from the primary medical and scientific literature. Prerequisite: understanding of molecular biology, cell biology, and biochemistry.

*2-3 units, Aut (Theriot, Harbury)*

**BIOC 241. Biological Macromolecules**—(Enroll in SBIO 241.)

*3-5 units, Aut (Puglisi, Block, Herschlag, Kirkegaard, McKay)*

**BIOC 242. Methods in Molecular Biophysics**—(Same as SBIO 242.) The potential utility of physical approaches to research, and how to evaluate literature that incorporates these methods. Experimental methods in molecular biophysics from theoretical and practical standpoints. Emphasis is on x-ray diffraction and nuclear magnetic resonance spectroscopy. Additional topics include fluorescence spectroscopy, circular dichroism, calorimetry, and separation methods.

*3 units (McKay, Puglis) alternate years, given 2004-05*

**BIOC 257. Currents in Biochemistry**—Limited to graduate students and postdoctoral fellows in the Department of Biochemistry. Seminars by Biochemistry faculty on their ongoing research. Presentations include background, current advances and retreats, general significance, and tactical and strategic research directions. Written reviews required.

*1-2 units, Aut (Kornberg, Lehman)*

**BIOC 299. Directed Reading**—Prerequisite: consent of instructor. See faculty list for section numbers.

*1-18 units, Aut, Win, Spr, Sum, by arrangement*

**BIOC 399. Research and Special Advanced Work**—Prerequisite: consent of instructor. See faculty list for section numbers.

*1-18 units, Aut, Win, Spr, Sum, by arrangement*

**BIOC 450. Introduction to Biotechnology**—(Same as CHEMENG 450). Stanford faculty from the schools of Medicine, Humanities and Sciences, and Engineering, and invited industrial speakers review the interrelated elements of modern biotechnology. Topics: development of recombinant protein pharmaceuticals, bacterial fermentation and scale-up, mammalian cell culture and scale-up, transgenic animals, transgenic protein production in plants, isolation and purification of protein pharmaceuticals, formulation and delivery of pharmaceutical proteins, environmental biotechnology, metabolic engineering, industrial enzymes, diagnostic devices, transciptomics and proteomics, drug delivery systems. Prerequisite: graduate student or upper-division undergraduate in the sciences or engineering.

*3 units, Spr (Kao)*

**BIOC 459. Frontiers in Interdisciplinary Biosciences**—(Crosslisted in multiple departments in the schools of Humanities and Sciences, Engineering, and Medicine. Students should enroll through their affiliated department; otherwise enroll in CHEMENG 459.) See CHEMENG 459 or http://biox.stanford.edu/chemeng_index.html for description.

*1 unit, Aut, Win, Spr (Robertson)*

**GES 53Q. In the Beginning: Theories of the Origin of the Earth,**