SCHOOL OF MEDICINE

Dean: Philip Pizzo
Senior Associate Dean for Graduate Education and Postdoctoral Affairs: John Pringle
Senior Associate Dean for Medical Student Education: Charles Prober

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. In the classroom, the school offers courses targeted to undergraduates as well as graduate-level courses where advanced undergraduates with a strong background in the life sciences are welcome. Among these offerings are many Stanford Introductory Seminars for freshmen and sophomores; interested students are encouraged to peruse the complete list of these offerings in the "Stanford Introductory Seminars" section of this bulletin or at http://www.stanford.edu/group/introsems/.

GRADUATE PROGRAMS

M.S. AND PH.D. PROGRAMS

The School of Medicine is home to graduate programs covering a broad range of disciplines within biomedicine leading to Ph.D. or M.S. degrees. These programs focus on interdisciplinary training with in-depth investigation of an original problem of fundamental importance to bioscience. Each degree program sets its own curriculum, but many courses are taught by groups of faculty from multiple programs and departments. Flexibility is a priority to ensure that all students obtain the best possible training for pursuing careers in their areas of interest. Admission is through one of about 15 home programs. These home programs enable students to carry out dissertation research and training with School of Medicine faculty, as well as investigators in the departments of Biological Sciences and Biophysics in the School of Humanities and Sciences. Detailed information on School of Medicine M.S. and Ph.D. programs, curricula, and research can be found at http://med.stanford.edu/ms/ and http://med.stanford.edu/phd/. Application information may be obtained from Graduate Admissions, Office of the University Registrar, Stanford University, 630 Serra Street, Suite 120, Stanford, CA 94305-6032, or at http://gradadmissions.stanford.edu/.

M.D. PROGRAM

The School of Medicine seeks to attract students who are passionate about scholarship and wish to improve the health of the world's people through research, innovation, and leadership. The Stanford M.D. curriculum provides education in biomedical and clinical sciences along with study and independent research through scholarly concentrations. Emphasis is placed on interdisciplinary learning, with streamlined content and melding of basic science and clinical instruction across the curriculum. Blocks of unscheduled time allow for individual or group study, participation in elective courses, research, and reflection. Alternative pathways through the curriculum include an option of a fifth or sixth year of study as well as opportunities for pursuing a second degree, such as an M.P.H. or Ph.D.

Broad clinical science education occurs throughout the curriculum with exposure to patient care and the practice of medicine beginning on the first day of medical school. Students may begin clinical clerkships as early as May of the second year. A population health course combines classroom and experiential learning to provide understanding of the socioeconomic determinants of the health of patients and communities.

Scholarly concentrations offer opportunities for developing skills that enhance basic science and clinical training, fostering opportunities for research and innovation in areas such as bioengineering, biomedical ethics and medical humanities, biomedical informatics, clinical research, community health, health services and policy research, and the molecular basis of medicine. Study in a scholarly concentration typically includes course work and research activities. There are structured opportunities to link scholarly concentration study with programs in clinical areas housed within centers at Stanford such as the Comprehensive Cancer Center, the Cardiovascular Institute, the Neuroscience Institute, the Institute of Immunity, Transplantation, and Infection, and Women's Health at Stanford. Traveling scholars projects may also be conducted overseas.

Students with interests in medical research as a career are encouraged to investigate opportunities available through the Medical Scientist Training Program (MSTP). Stanford also collaborates with the University of California, Berkeley, to offer students opportunities for M.D./M.P.H. training. Details about these programs may be found at http://med.stanford.edu/combined_degree/.

Stanford is committed to representing the diversity of the U.S. and California populations by seeking a diverse body of students who are interested in the intellectual substance of medicine and committed to advancing the field of health care, broadly defined. Provided an applicant to the school has completed 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 advanced biology such as biochemistry, molecular biology, or genetics and the behavioral sciences is recommended because of their importance in understanding health care. Breadth of interests and depth of experiences play an important role in the selection of students from among those applicants having superior academic records.

The M.D. degree requires 13 quarters of full tuition; the joint M.D./Ph.D. degree requires 16 quarters. All additional quarters are charged at the reduced Terminal Medical Registration (TMR) tuition rate, which is $2,081 per quarter in 2007-08. Completion of the M.D. degree must be achieved within six years, unless a petition is granted to extend this time frame. For further details on the M.D. degree, including admission requirements, see http://med.stanford.edu/md/.

MULTIPLE-DEGREE PROGRAMS

MEDICAL SCIENTIST TRAINING PROGRAM

The Medical Science Training Program (MSTP) provides medical students with an opportunity to pursue an individualized program of research and course work leading to both the M.D. and Ph.D. degrees. It is designed to equip students for careers in academic investigative medicine, and emphasizes individualization of curricular and research programs for each trainee. Training for a combined M.D./Ph.D. should include the same content encountered by students who pursue each degree separately, but the total training time should be less than the sum of the time normally required for each degree. The flexible curriculum at Stanford University School of Medicine allows each student, in consultation with a preceptor and other advisers, to pursue a plan of study that satisfies the requirements for the M.D. degree and allows performance of doctoral-level research leading to the Ph.D. Students interested in joining the MSTP are considered for admission at the time of their application to the School of Medicine M.D. program and are asked to provide supplemental information relevant to their research background. Current Stanford M.D. students may also apply for admission to the MSTP. Further information regarding admission may be obtained from the MSTP administrator; details about the MSTP may be found at http://mstp.stanford.edu.

MASTER OF SCIENCE IN MEDICINE PROGRAM

The Master of Science in Medicine program admits Ph.D. students who have a commitment to translational research, but are not interested in becoming clinicians. The goal of the program is to train researchers in human biology and disease so they are more able to translate new scientific discoveries into useful medical advances. Students offered admission into any Ph.D. program at Stanford may apply for admission to the master's program. During their first five quarters, students take basic biomedical science courses with Stanford M.D. students. The School of Medicine M.D. curriculum is presented in a succinct format that allows time for students to concurrently complete their Ph.D. course requirements and lab

rotations. By early in their second year, students choose a lab for their Ph.D. thesis research and complete their medical course work. They also elect a clinical mentor to discuss translational research needs and help to arrange a short clinical experience. Upon completion of the Ph.D., participating students receive an M.S. in Medicine. Details about the program can be found at http://msm.stanford.edu.

COURSES

The following courses are open to undergraduates or graduate students. Additional courses may also be available; see http://www.med.stanford.edu/education/ for more information.

STANFORD INTRODUCTORY SEMINARS

MED 70Q. Cancer and the Immune System—Stanford Introductory Seminar. Preference to sophomores. Myths and facts surrounding the idea that the immune system is capable of recognizing malignant cells. The biological basis and function of effector arms of the immune system; how these mechanisms may be used to investigate the biological basis and potential therapy of cancer. How the immune system functions. Write-2

3 units, Spr (Negrin, R)

MED 86Q. Seeing the Heart—Stanford Introductory Seminar. Preference to sophomores. Introduction to biomedical technology, science, clinical medicine, and public policy through cardiovascular imaging. Invasive and noninvasive techniques to detect early stage heart disease and to see inside the heart and blood vessels. Topics include: common forms of heart disease, how they develop, and why they affect so many people; imaging technologies such as ultrasound, CT, MRI, PET, and optical; a cost-effective public screening program. Field trips to Stanford Medical Center imaging centers.

1-2 units, Win (McConnell, M)

MED 87Q. Women and Aging—(Same as HUMBIO 87Q.) Stanford Introductory Seminar. Preference to sophomores. Biology, clinical issues, social and health policies of aging; relationships, lifestyles, and sexuality; wise women and grandmothers. Sources include scientific articles, essays, poetry, art, and film. Service-learning experience with older women. GER:EC-Gender

5 units, Win (Winograd, C)

MED 88Q. Dilemmas in Current Medical Practice—Stanford Introductory Seminar. Preference to sophomores. Social, political, scientific, and economic forces influencing medical practice. Spiraling costs, impaired access to health care, and disillusionment toward the health care system. Attempts by government and medical insurers to control costs through managed care and health maintenance organizations. Medical education and how it has affected the practice of medicine. Alternative health care, preventive medicine, and the doctor-patient relationship. The paradox of health in America: why do so many people who are healthy feel unhealthy? Optional observation of instructors in their medical practices.

3 units, Aut (Croke, J; Jones, H)

MED 108Q. Human Rights and Health—Stanford Introductory Seminar. Preference to sophomores. History of human-rights law. Topics such as: the health status of refugees and internally displaced persons; child labor; trafficking in women and children; torture; poverty, the environment, and health; access to clean water; domestic violence and sexual assault; and international availability of drugs. International conventions on human rights as background for social and political changes that could improve the health of groups and individuals. Optional opportunities to observe at sites where human rights and health are issues.

3 units, Win (Laws, A)

MED 120Q. Pathophysiology of Diseases of the Heart and Blood Vessels—Stanford Introductory Seminar. Preference to sophomores. Anatomic, physiologic, and pathologic states that comprise cardiovascular medicine. Anatomy and physiology of the heart and blood vessels as an introduction to pathologic states such as heart attack, stroke, congestive heart failure, rhythm disturbances of the heart, and sudden cardiac death. Underlying principles of diagnosis and treatment of the disease.

3 units, Spr (Stertzer, S)

UNDERGRADUATE AND GRADUATE

INDE 183I/283I. Early Clinical Experience in International Family and Community Medicine—(Graduate students register for 283I.) For preclinical medical students; undergraduates by special arrangement. Interactive early clinical experience with physicians, community leaders, health care workers, and patients in Mexico, India, China, or Tibet. Emphasis is on community health from local and global perspectives. Social, political, historical, and economic backgrounds of the country and local region. Non-western attitudes, beliefs and practices regarding health care, including herbal and other complementary medicine; local institutions and infrastructure including schools, social services, and the public health care system; and policies that impact health and the provision of care. Prerequisites: conversational Spanish for Mexico; for medical students, completion of first year; for undergraduates, junior standing or higher. Undergraduates apply through International Alliance in Service and Education (IASE) for Mexico; Volunteers in Asia (VIA) for Asian sites. Medical students apply through the Center for Education in Family and Community Medicine.

6-12 units, Aut, Win, Spr, Sum (LeBaron, S)

INDE 199. Undergraduate Directed Reading and Research in Family and Community Medicine—Interested students should contact the Center for Education in Family and Community Medicine administration. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

INDE 244. Ethnicity and Medicine—Weekly lecture series introduces basic information about ethnic and cultural factors that impact patient care. Presents information about culturally sensitive health care services and addresses contemporary research issues involving minority and underserved populations. Topics include health care issues and indigenous medical practices of African Americans, Asians, Latinos, Native Americans, immigrants and refugees in both urban and rural settings. One unit for weekly lectures only; two units require additional discussions facilitated by course director; three units (non-medical graduate students and undergraduates) require weekly response papers and a research paper.

1-3 units, Spr (Garcia, R)

INDE 245. Women and Health Care—Lecture and seminar series. Topics of interest to women as health care consumers and providers. The historical role of women in health care; current and future changes.

1-2 units, Aut (Grudzen, M; LeBaron, S; Massion, C)

INDE 247. The Theater of Illness—The immediacy of disease and illness through descriptions of the human condition by playwright and actor. Mental illness, infectious disease, high technology, and end-of-life issues through plays and films from *King Lear* to *Angels in America*.

2 units, Spr (Zaroff, L)

INDE 253. Rural Health with a Global Perspective—Health status of the population, availability of health services and institutions, personal and environmental factors affecting health and medical care, and present and future models for change. Three-day field trip to San Joaquin Valley and mountain sites.

3-5 units, Spr (LeBaron, S; Jones, E)

INDE 256. Current Controversies in Women's Health—(Same as HUMBIO 125.) Interdisciplinary. Focus is on the U.S. Topics include: health research; bioethical, legal, and policy issues; sex and gender differences; scientific and cultural perspectives; social influences; environmental and lifestyle effects on health; and issues related to special populations. Prerequisite: Human Biology core or equivalent, or consent of instructor.

3 units, Spr (Jacobson, M; Stefanick, M)

MED 147/247. Methods in Community Assessment, Evaluation, and Research—(Graduate students register for 247.) Development of pragmatic skills for design, implementation, and analysis of structured interviews, focus groups, survey questionnaires, and field observations. Topics include: principles of community-based participatory research, including importance of dissemination; strengths and limitations of different

study designs; validity and reliability; construction of interview and focus group questions; techniques for moderating focus groups; content analysis of qualitative data; survey questionnaire design; and interpretation of commonly-used statistical analyses.

3 units, Win (Fortmann, S; Kiernan, M)

MED 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MED 207. History of Medicine—The development of Western medical tradition from Babylonian, Egyptian, and Greek cultures to the present.

1 unit, Win (Camargo, C)

MED 217. Technological Frontiers in Digestive Diseases—For engineering, bioengineering, and physical sciences students. Topics include: endoscopes to detect and remove cancer; minimally invasive surgery to treat obesity; measurements of propulsion through the intestine; and technologies to detect and stop internal bleeding. Observations in the clinical setting; visits to laboratories engaged in the development of new technologies. Technologies used in the clinical setting. 1 unit for lecture and observation only; 2-3 units for design and production of a medical device using Stanford's Product Realization Laboratory.

1-3 units, Spr (Lowe, A; Milroy, C)

MED 228. Physicians and Social Responsibility—Social and political context of the roles of physicians and health professionals' role in social change; policy, advocacy, and shaping public attitudes. How physicians have influenced governmental policy on nuclear arms proliferation; environmental health concerns; domestic violence; health and human rights; physicians in government; activism through research; the effects of poverty on health; and gun violence.

1 unit, Aut (Laws, A)

MED 230. Rethinking International Health—Issues and players that shape international health today. A road map for thoughtful, responsible action. Topics include: the role of the physician and health care worker; health as a human right; successful interventions; children's and women's health; issues in immunization; economic development; and NGOs. Online interviews with influential leaders in international health.

2-3 units, Win (Wise, P)

MED 236. Psychosocial and Behavioral Health Interventions—For medical students, graduate students and undergraduates with senior standing in Human Biology or Psychology. Contemporary theory and conceptual frameworks for psychosocial and behavioral change interventions as applied in the context of contemporary models of community medicine. The trans-theoretical model of behavioral change, contemporary behavioral, cognitive behavioral, social cognitive and acceptance-based models of behavioral change. Current models of emotion regulation, goal setting and attainment, and the impact of personality and characterological features on behavior and behavioral change. Application of theory in practicum based community clinic settings. Prerequisite: Stanford HIPAA training.

1 unit, not given this year

MED 242. Physicians and Human Rights—How human rights violations affect health. Topics include torture, domestic violence, regional conflict and health, sweat shops, rape, and war. Guest speakers.

1 unit, Win (Laws, A)

MED 249. Medical Interpreting in Community Clinics—Open to medical students, graduate and undergraduate students. Practical training to serve as a medical interpreter in the Arbor or Pacific Free Clinics, or in other area community health centers. Students must be bilingual. This is not language instruction, but instruction and discussion about the unique role of the medical interpreter in a community-based health care setting, required training in patient privacy, and skill-building. Unit credit also given for service hours in area clinics.

1-2 units, Aut, Win, Spr, Sum (Osterberg, L)

MED 254. Applied Skill-Building in Clinical and Community-Based Research—Skill-building via detailed individualized feedback from instructor on all aspects of research projects. Topics include: grant proposal preparation; study design; field implementation; data entry, analysis and interpretation; and conference abstract/manuscript preparation.

1-6 units, Aut, Win, Spr, Sum (Kiernan, M; Fortmann, S)

MED 255. The Responsible Conduct of Research—Forum. How to identify and approach ethical dilemmas that commonly arise in biomedical research. Issues in the practice of research such as in publication and interpretation of data, and issues raised by academic/industry ties. Debates at the interface of biomedical science and society regarding research on stem cells, bioweapons, genetic testing, human subjects, and vertebrate animals. Completion fulfills NIH/ADAMHA requirement for instruction in the ethical conduct of research. Recommended: research experience.

1 unit, Aut, Win, Spr (Karkazis, K)

MED 256. Global HIV/AIDS—(Same as HUMBIO 156.) Public health, policy, and research issues. Resources at Stanford and institutions such as government, NGOs, and pharmaceutical, advocacy, and international organizations. Sources include biomedical, social, and behavioral sciences. Student projects. Guest lectures.

3 units, Aut (Katzenstein, D)

MED 257A,B,C. Patient Advocacy in Community Clinics—Early clinical experience for pre-medical and medical students. Structured training and shadowing in preparation for a clinical role working with patients in community health clinics; the context of the work, populations served, and social role of physicians. Regular shifts at one of the course-affiliated clinic sites throughout the academic year. 1-2 units for students attending class meetings and performing clinic shifts. 3-4 units for a year-long, clinic-based project. Prerequisite: application.

1-4 units, **A:** *Aut,* **B:** *Win,* **C:** *Spr (Garcia, G; Banchoff, A)*

MED 258. Advanced Patient Advocacy in Community Clinics—Continuation of 257A,B,C for second-year students in Patient Advocacy Program; open to students who have worked in a clinical capacity in a community clinic setting. Skills training in areas such as health education counseling and group facilitation. Regular shifts at partner clinics. Students partner with clinic staff in developing and carrying out a service-learning or research project designed to meet the clinic's needs. May be repeated for credit. Prerequisites: 257A,B,C or consent of instructor.

1-3 units, Aut, Win, Spr, Sum (Garcia, G; Banchoff, A)

MED 262. Economics of Health Improvement in Developing Countries—(Same as ECON 127, HUMBIO 121.) Application of economic paradigms and empirical methods to health improvement in developing countries. Emphasis is on unifying analytic frameworks and evaluation of empirical evidence. How economic views differ from public health, medicine, and epidemiology; analytic paradigms for health and population change; the demand for health; the role of health in international development. Prerequisites: background in economics and statistics, and consent of instructor.

5 units, Win (Miller, N)

MED 272A. Biodesign Innovation: Needs Finding and Concept Creation—(Same as BIOE 374A, OIT 384, ME 374A.) Two quarter sequence. Strategies for interpreting clinical needs, researching literature, and searching patents. Clinical and scientific literature review, techniques of intellectual property analysis and feasibility, basic prototyping, and market assessment. Student entrepreneurial teams create, analyze, and screen medical technology ideas, and select projects for development.

3-4 units, Win (Yock, P; Zenios, S; Milroy, J; Brinton, T)

MED 272B. Biodesign Innovation: Concept Development and Implementation—(Same as BIOE 374B, OIT 385, ME 374B.) Two quarter sequence. Concept development and implementation. Early factors for success; how to prototype inventions and refine intellectual property. Lectures, guest medical pioneers, and entrepreneurs about strategic planning, ethical considerations, new venture management, and financing and licensing strategies. Cash requirements; regulatory (FDA), reimbursement, clinical, and legal strategies, and business or research plans.

3-4 units, Spr (Yock, P; Zenios, S; Milroy, J; Brinton, T)

MED 275. Introduction to Biopharmaceutical Innovation—Open to all students. Biotechnology and the pharmaceutical industry. Topics include the biopharmaceutical industry, historical trends, and experiences; research and development; intellectual property; drug approval: regulatory issues and agencies; business development; marketing; manufacturing; capital structure and financing; careers in biopharmaceutical industry. 3 units requires team project and final presentation. May be repeated for credit.

2-3 units, Win (Gardner, P)

MED 276. Careers in Medical Technology—Career tracks in biomedical technology for medical, life science, engineering, business, and law students. Guest industry professionals.

1 unit, Spr (Yock, P; Popp, R)

MED 279Y. Interdisciplinary Design for Agile Aging—(Same as CS 379Y, HUMBIO 131.) First of two quarter sequence; students may take 279Y without 279Z; offered by the d.school. Perspectives from computer science, design, social and behavioral sciences, physiology, geriatrics, and biodesign to develop projects that address the potential of people to maintain vitality and mobility as they age. New ways to integrate computer and device technologies with behavioral and social interventions. Focus is on small projects. Prerequisite: background in one of design, computing, medicine, behavioral sciences, communications, or business.

3-4 units, Win (Winograd, C; Winograd, T; Friedlander, A; Yock, P)

MED 279Z. Design Project for Agile Aging—(Same as CS 379Z.) Second of two quarter sequence; students may take 279Y without 279Z; offered by the d.school. Small teams develop projects that can have an impact in the world through products, programs, and practices that affect people's health on a broad scale. Technical interventions, social and contextual design, organizational contexts, and business and distribution issues. Limited enrollment. Prerequisites: 279Y, and master's level skills in one of design, computing, medicine, behavioral sciences, communications, or business.

3-4 units, Spr (Winograd, T; Winograd, C; Friedlander, A; Yock, P)

MED 289. Introduction to Bioengineering Research—(Same as BIOE 390.) Preference to medical and bioengineering graduate students. Bioengineering is an interdisciplinary field that leverages the disciplines of biology, medicine, and engineering to understand living systems, and engineer biological systems and improve engineering designs and human and environmental health. Topics include: imaging; molecular, cell, and tissue engineering; biomechanics; biomedical computation; biochemical engineering; biosensors; and medical devices. Limited enrollment.

1-2 units, Aut, Win (Taylor, C)

MED 299. Directed Reading in Medicine—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MED 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

NSUR 278A. From Science to Business: Innovation in Neurologic Disease Beyond Neurosurgery—For medical, business, and engineering students. The process of innovation and company building in the medical field, emphasizing the neurosciences. Overview of neurological diseases; business and regulatory aspects of device and biotech product development. Guest speakers on healthcare entrepreneurship. Venture capital and entrepreneurial mentors guide interdisciplinary student teams in evaluating a solution to an unmet clinical need or a project within a biotech company. May be taken for 2 units without the team project.

2-4 units, Win (Kallmeyer, V)

NSUR 279. Concepts in Drug Delivery and Drug Device Combinations—Open to all graduate students. Issues relating to drug-device combination products, including review of recently approved products such as cardiac stent), and development, regulatory, and reimbursement issues. Emphasis is on market evaluation, product development, and regulatory strategies. Lecture only for 2 units; project for 4 units.

2-4 units, (Kallmeyer, V) alternate years, not given this year

ORTHO 222. Anatomy of Movement—Perspectives include orthopedic surgery, neurology, mechanical engineering, computer science, anthropology, and art. Anatomy and pathology affecting the human locomotor system. Normal function and functional deficit from disease or injury. Engineering dilemmas that assist or emulate human movement, such as design of an artificial joint or simulation of tendon transfers for nerve palsy. The expression of human movement in art masterpieces and photography. The evolution of the hand as it became an instrument of purpose. Student team projects. Lecture only for 2 units; project for 4 units.

2-4 units, Win (Ladd, A; Rose, J)

ORTHO 260. Tissue Engineering—Biological principles underlying the use of engineering strategies and biocompatible materials for tissue repair and regeneration. Structure, physiology, and mechanics of articular cartilage, bone, and dense soft connective tissues. Current ideas, approaches, and applications being implemented as therapeutic regimens for arthritis, spinal deformities, and limb salvage. Multidisciplinary constraints on the design and creation of tissue constructs. Prerequisite: familiarity with basic cell and molecular mechanisms underlying tissue differentiation.

3 units, Win (Smith,R)

PEDS 105/215. Health Promotion and the Campus Culture—Multidisciplinary perspectives of public health and health psychology. The prevalence of health risk behaviors on the contemporary college campus and the challenges of risk reduction. Students apply theoretical frameworks to peer health promotion campus projects. Limited enrollment. Prerequisite: consent of instructor following first meeting.

4 units, Win, Spr (Friedman, I; Pertofsky, C)

PEDS 216. Alcohol Issues and the Campus Culture—Multidisciplinary perspectives of public health, health psychology, and sociology. The prevalence and scope of alcohol-related problems; challenges of risk reduction and intervention strategies. Students apply theoretical frameworks to alcohol-related research topics and projects. Limited enrollment. Prerequisite: consent of instructor following first meeting.

4 units, Win (Castro, R)

PSYC 135/235. Sleep and Dreams—Current research on how sleep affects our daily lives. Physiology of non-REM and REM sleep, dreams and dreaming, content, psychophysiological cause, lucid dreaming, sleep need, sleep debt, daytime alertness, and performance; biological clock and circadian rhythms; sleep disorders, insomnia, narcolepsy, sleep apnea, sleepwalking, jet lag, sleeping pills, sleep and mental illness, sleep and memory, and the impact of sleep deprivation and sleep disorders on academic and social life. Multimedia presentations, guest lectures, and projects.

3 units, Win (Dement, W)

PSYC 230. Freud, Human Behavior, and Medical Care—Seminar; applicable to all human behavior disciplines. The role of the unconscious in mental and physical functioning. Freudian psychology on mental functioning and its effect on the body and group behaviors. Topics include Freud's model of the mind, dreams, neurosis and psychosis, psychosomatic illness, eating disorders and addiction, and treatment options.

2 units, Win (Fisk, S)

BIOCHEMISTRY

Emeriti: (Professors) Robert L. Baldwin, Paul Berg, David S. Hogness, Arthur Kornberg, A. Dale Kaiser, I. Robert Lehman
Chair: Mark A. Krasnow
Professors: Patrick O. Brown, Douglas L. Brutlag, Gilbert Chu, Ronald W. Davis, James E. Ferrell, Jr., Daniel Herschlag, Mark A. Krasnow, Suzanne R. Pfeffer, James A. Spudich
Associate Professors: Pehr A. B. Harbury, Julie A. Theriot
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://biochemistry.stanford.edu/

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

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 offered in more specialized areas emphasize 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. Ongoing 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 among the 135 total units required for the Ph.D. Selection of these courses is tailored to fit the background and interests of each student. A second requirement involves the submission of two research proposals which are presented by the student to a small committee of departmental faculty members who are also responsible for monitoring the progress of student curricular and research programs, and a journal club presentation. 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 12.

Applications should be submitted at http://gradadmissions.stanford.edu/. Applicants are notified by March 24 of decisions on their applications. Stanford University requires scores from the Graduate Record Examination (GRE) (verbal, quantitative, and analytical), and applicants are encouraged to 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. 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 and Medicine—Stanford Introductory Seminar. Preference to sophomores. Knowledge gained from sequencing human, bacterial, and viral genomes and implications for medicine and biomedical research. Novel diagnoses (chips, SNPs and gene expression) and treatment of diseases including gene therapy, stem cell therapy, and rational drug design. Ethical implications of stem cell therapy and uses of genetic information. Use of genome and disease databases to determine gene function in disease, diagnosis, and potential treatments. See http://biochem118.stanford.edu/. GER:DB-EngrAppSci
3 units, Spr (Brutlag, D)

BIOC 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

BIOC 201. Advanced Molecular Biology—Literature-based lectures and discussion on rapidly developing frontiers in chromosome structure and function and modern insights into the control of gene expression. Emphasis is on experimental approaches and insights. Topics include chromosome organization, novel modes of transcriptional control, RNA-based mechanisms for controlling gene expression and emerging translational regulatory mechanisms. Prerequisite: undergraduate molecular biology.
5 units, not given this year

BIOC 202. Metabolic Biochemistry: Structure, Metabolism, and Energetics—(Review course for medical students only). Structure and function of biological molecules, enzyme kinetics and mechanisms, bioenergetics, pathways of intermediary metabolism and their control, and membrane structure and function. Course offered via online lectures and problem sets, with weekly small-group review sessions.
1-3 units, Aut (Brutlag, D)

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.
3 units, Aut (Brown, P; Chu, G; Krasnow, M)

BIOC 210. Advanced Topics in Membrane Trafficking—The structure, function, and biosynthesis of cellular membranes and organelles. Current literature. Prerequisite: consent of instructor.

3 units, Spr (Pfeffer, S)

BIOC 215. Frontiers in Biological Research—(Same as DBIO 215, GENE 215.) Literature discussion in conjunction with the Frontiers in Biological Research seminar series hosted by Biochemistry, Developmental Biology, and Genetics in which distinguished investigators present current work. Students and faculty meet beforehand to discuss papers from the speaker's primary research literature. Students meet with the speaker after the seminar to discuss their research and future direction, commonly used techniques to study problems in biology, and comparison between the genetic and biochemical approaches in biological research.

1 unit, Aut, Win (Harbury, P; Brunet, A; Villeneuve, A)

BIOC 218. Computational Molecular Biology—(Same as BIOMEDIN 231.) Via Internet. For molecular biologists and computer scientists. Representation and analysis of genomes, sequences, and proteins. Strengths and limitations of existing methods. Course work performed on web or using downloadable applications. See http://biochem218.stanford.edu/. Prerequisites: introductory molecular biology course at level of BIOSCI 41 or consent of instructor.

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

BIOC 220. Chemistry of Biological Processes—(Same as CSB 220.) The principles of organic and physical chemistry as applied to biomolecules. Goal is a working knowledge of chemical principles that underlie biological processes, and chemical tools used to study and manipulate biological systems. Prerequisites: organic chemistry and biochemistry, or consent of instructor.

4 units, Aut (Herschlag, D; Chen, J; Bogyo, M; Wandless, T)

BIOC 221. The Teaching of Biochemistry—Required for teaching assistants in Biochemistry. Practical experience in teaching on a one-to-one basis, and problem set design and analysis. Familiarization with current lecture and text materials; 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)

BIOC 224. Cell Biology of Physiological Processes—(Same as BIOSCI 214.) For Ph.D. students. Current research on cell structure, function, and dynamics. Topics include complex cell phenomena such as cell division, apoptosis, compartmentalization, transport and trafficking, motility and adhesion, differentiation, and multicellularity. Current papers from the primary literature. Prerequisite for advanced undergraduates: BIOSCI 129A,B, and consent of instructor.

2-5 units, Win (Theriot, J; Nelson, W; Straight, A; Bogyo, M; Pfeffer, S)

BIOC 225. Interdisciplinary Approaches to Cell Biology: the Role of the Cytoskeleton—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, high-resolution light microscopy, and computational approaches. Prerequisites: basic biochemistry and cell biology.

3 units, Spr (Spudich, J)

BIOC 228. Computational Genomic Biology—Application of computational genomics methods to biological problems. Topics include: assembly of genomic sequences; genome databases; comparative genomics; gene discovery; gene expression analyses including gene clustering by expression, transcription factor binding site discovery, metabolic pathway discovery, functional genomics, and gene and genome ontologies; and medical diagnostics using SNPs and gene expression. Recent papers from the literature and hands-on use of the methods. Prerequisites: introductory course in computational molecular biology or genomics such as BIOC 218 or GENE 211. Via Internet in Winter and Spring.

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

BIOC 230. Molecular Interventions in Human Disease—For M.D. students who intend to declare a concentration in molecular basis of medicine, MSTP students, and Ph.D. students. Advanced medical biochemistry focusing on cases where molecular-level research has led to new medical treatments or changes in the understanding of important diseases. Different topics each week explore the underlying molecular basis of a variety of diseases and the reasons for success and failure in molecular approaches to treatment. Student-led discussions dissect papers from the primary medical and scientific research literature.

2-3 units, Aut (Theriot, J; Harbury, P)

BIOC 238. Computational Proteomic Biology—Application of computational protein analysis to biological problems. Topics include: protein sequence analysis and comparison including protein sequence databases, amino acid composition, protein alignment, protein motifs, protein families, and probabilistic models of families; protein structure including structure comparison and superposition methods, structural motifs, and structure and domain databases; protein structure prediction including secondary structure, homology modeling, threading, and ab initio structure prediction; protein-protein interaction databases and protein-protein interaction prediction; and protein-DNA interaction motifs and protein-ligand docking. Prerequisite: BIOC 218 or SBIO/BIOPHYS 228. Via Internet in Spring.

3 units, Win, Spr (Brutlag, D)

BIOC 241. Biological Macromolecules—(Same as BIOPHYS 241, SBIO 241.) The physical and chemical basis of macromolecular function. Forces that stabilize biopolymers with three-dimensional structures and their functional implications. Thermodynamics, molecular forces, and kinetics of enzymatic and diffusional processes, and relationship to their practical application in experimental design and interpretation. Biological function and the level of individual molecular interactions and at the level of complex processes. Case studies. Prerequisites: introductory biochemistry and physical chemistry or consent of instructor.

3-5 units, Aut (Herschlag, D; Puglisi, J; Garcia, K; Ferrell, J; Block, S; Pande, V; Weis, W; Harbury, P)

BIOC 257. Currents in Biochemistry—Seminars by Biochemistry faculty on their ongoing research. Background, current advances and retreats, general significance, and tactical and strategic research directions.

1 unit, Aut (Spudich, J)

BIOC 299. Directed Reading in Biochemistry—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

BIOC 399. Graduate Research and Special Advanced Work—Investigations sponsored by individual faculty members.

1-18 units, Aut, Win, Spr, Sum (Staff)

BIOC 459. Frontiers in Interdisciplinary Biosciences—(Same as BIOE 459, BIOSCI 459, CHEMENG 459, CHEM 459, PSYCH 459. Students register through their affiliated department; otherwise register for CHEMENG 459.) For specialists and non-specialists. Sponsored by the Stanford BioX Program. Three seminars per quarter address scientific and technical themes related to interdisciplinary approaches in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and the world present breakthroughs and endeavors that cut across core disciplines. Pre-seminars introduce basic concepts and background for non-experts. Registered students attend all pre-seminars; others welcome. See http://www.stanford.edu/group/biox/courses/459.html. Recommended: basic mathematics, biology, chemistry, and physics.

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

COGNATE COURSES

See respective department listings for course description. See degree requirements above or the program's student services office for applicability of these courses to a major or minor program.

CHEMENG 450. Advances in Biotechnology
3 units, Spr (Hwang, L; Swartz, J)

SBIO 242. Methods in Molecular Biophysics—(Same as BIOPHYS 242.)
3 units, alternate years, not given this year

CENTER FOR BIOMEDICAL ETHICS

Director: David C. Magnus
Director Emeritus: Thomas A. Raffin
Associate Director: Mildred K. Cho
Participating Faculty and Staff: Clarence H. Braddock, Julie A. Collier, LaVera M. Crawley, Maren Grainger-Monsen, Henry Greely, Agnieszka Jaworska, Katrina A. Karkazis, Sandra S. Lee, Jose R. Maldonado, Christopher T. Scott, Audrey Shafer, Sara L. Tobin, Lawrence I. Zaroff
Center Offices: 701 Welch Road, Building A, Suite 1105
Mail Code: 94304-5748
Phone: (650) 723-5760
Web Site: http://bioethics.stanford.edu/

The Stanford University Center for Biomedical Ethics (SCBE) is dedicated to interdisciplinary research and education, and provides clinical and research ethics consultation. SCBE serves as a scholarly resource on emerging ethical issues raised by medicine and biomedical research.

SCBE offers a scholarly concentration in Biomedical Ethics and Medical Humanities to medical students. This program allows medical students to study in depth the ethical and humanistic dimensions of research and practice. Additional information on requirements for the scholarly concentration, and a comprehensive list of other related courses is available at http://bioethics.stanford.edu/education/bemh/.

COURSES

MEDICINE

INDE 212. The Human Condition: Medicine, Arts, and Humanities—The interdisciplinary field of medical humanities: the use of the arts and humanities to examine medicine in personal, social, and cultural contexts. Topics include the doctor/patient relationship, the patient perspective, the meaning of doctoring, and the meaning of illness. Sources include visual and performing arts, film, and literary genres such as poetry, fiction, and scholarly writing. For medical students in the Biomedical Ethics and Medical Humanities Scholarly Concentration; all students welcome.
2 units, Aut (Zaroff, L; Shafer, A)

INDE 226. History of Medicine Online—Topics include: ancient medicine, Egypt and Babylonia, ancient Greece and Rome, Europe in the Middle Ages and the Renaissance, 18th-century schools of thought, and technological medicine. Sources include Kleinman's core clinical functions, and text, pictures, hypertext links, and sound clips.
1 unit, Aut, Win, Spr, Sum (Shafer, A)

INDE 238. Current Concepts and Dilemmas in Genetic Testing—(Same as GENE 238.) Issues arising from the translational process from research to commercialization. Diagnostic inventions and applications, community implications, newborn screening, cancer genetics, and pharmacogenomics. Guest experts. For M.D., biomedical graduate, and genetic counseling students.
2 units, Spr (Tobin, S; Schrijver, I; Cowan, T; Magnus, D)

INDE 247. The Theater of Illness—The immediacy of disease and illness through descriptions of the human condition by playwright and actor. Mental illness, infectious disease, high technology, and end-of-life issues through plays and films from *King Lear* to *Angels in America*.
2 units, Spr (Zaroff, L)

MED 250A. Medical Ethics I—Required for Scholarly Concentration in Biomedical Ethics and Medical Humanities. The field of bioethics, including theoretical approaches to bioethical problems. Contemporary controversies and clinical cases. Values that arise in different situations and clinical encounters. Issues include: genetics and stem cell research, rationing, ethical issues in care at the end of life, organ transplantation issues.
2 units, Win (Magnus, D)

MED 250B. Medical Ethics II—The integration of ethical theory with applications of theory or conceptual issues in medicine, health care, and the life and social sciences. Topic varies by year. Possible topics include: ethical issues in stem cell research; death and dying; genetics and ethics; concepts of health and disease; the ethics of international research; and ethical implications of new reproductive technology.
2 units, Spr (Magnus, D)

MED 255. The Responsible Conduct of Research—Forum. How to identify and approach ethical dilemmas that commonly arise in biomedical research. Issues in the practice of research such as in publication and interpretation of data, and issues raised by academic/industry ties. Contemporary debates at the interface of biomedical science and society regarding research on stem cells, bioweapons, genetic testing, human subjects, and vertebrate animals. Completion fulfills NIH/ADAMHA requirement for instruction in the ethical conduct of research. Recommended: research experience.
1 unit, Aut, Win, Spr, Sum (Karkazis, K)

COGNATE COURSES

See respective department listings for course descriptions and General Education Requirements (GER) information. See degree requirements above or the program's student services office for applicability of these courses to a major or minor program.

CASA 160/260. Race, Genetics, and Interpreting Difference
5 units, Aut (Lee, S)

HRP 209. FDA's Regulation of Health Care—(Same as LAW 458.)
3-4 units, Win (Greely, H)

HRP 210. Health Law and Policy I—(Same as LAW 313.)
3-4 units, Aut (Greely, H)

HRP 211. Law and the Biosciences—(Same as LAW 368.)
3 units, Win (Greely, H)

HUMBIO 99Q. Becoming a Doctor: Readings from Medical School, Medical Training, Medical Practice
4 units, Aut (Zaroff, L)

HUMBIO 174. Foundations of Bioethics
3 units, Win (Magnus, D)

HUMBIO 175. Health Care as Seen Through Medical History, Literature, and the Arts
3 units, Aut (Zaroff, L)

HUMBIO 175S. Novels and Theater of Illness
4 units, Spr (Zaroff, L)

PHIL 78. Medical Ethics—(Same as ETHICSOC 78.)
4 units, Win (Jaworska, A)

PHIL 170/270. Ethical Theory—(Same as ETHICSOC 170.)
4 units, Aut (Jaworska, A)

BIOMEDICAL INFORMATICS PROGRAM

Committee: Russ B. Altman *(Chair and Program Director)*; Mark A. Musen *(Co-Director)*; Betty Cheng, Lawrence M. Fagan *(Associate Directors)*; Atul Butte, Amar K. Das, Parvati Dev, Teri E. Klein, David Paik

Participating Faculty and Staff by Department:
Reserach opportunities are not limited to faculty and departments listed.

Anesthesia: David M. Gaba (Professor)
Biochemistry: Douglas L. Brutlag (Professor), Ron Davis (Professor), Julie Theriot (Associate Professor)
Biological Sciences: Dmitri Petrov (Associate Professor)
Bioengineering: Russ B. Altman (Professor), Markus Covent (Assistant Professor)
Chemistry: Vijay Pande (Associate Professor)
Chemical and Systems Biology: James Ferrell (Professor)
Civil and Environmental Engineering: Raymond E. Levitt (Professor)
Computer Science: Serafim Batzoglou (Assistant Professor), Gill Bejerano (Assistant Professor), Leo Guibas (Professor), Daphne Koller (Associate Professor), Jean-Claude Latombe (Professor), Gio Wiederhold (Professor, Research, emeritus)
Developmental Biology: Gill Bejerano (Assistant Professor), Stuart Kim (Professor)
Genetics: Russ B. Altman (Professor), Mike Cherry (Associate Professor, Research), Stanley N. Cohen (Professor), Teri E. Klein (Senior Research Scientist), Richard M. Myers (Professor), Gavin Sherlock (Assistant Professor)
Health Research and Policy: Mark A. Hlatky (Professor), Richard A. Olshen (Professor), Robert Tibshirani (Professor)
Management Science and Engineering: Margaret Brandeau (Professor), Ross D. Shachter (Associate Professor)
Mathematics: Samuel Karlin (Professor, emeritus)
Medicine: Russ B. Altman (Professor), Terrance Blaschke (Professor, emeritus), Atul Butte (Assistant Professor), Robert W. Carlson (Professor), Amar K. Das (Assistant Professor), Parvati Dev (Senior Research Scientist), Lawrence M. Fagan (Associate Director), Alan M. Garber (Professor), Mary Goldstein (Professor), Michael Higgins (Consulting Associate Professor), Peter D. Karp (Consulting Assistant Professor), David Katzenstein (Professor, Research), John Koza (Consulting Professor), Henry Lowe (Associate Professor, Research; Senior Associate Dean for Information Resources and Technology), Mark A. Musen (Professor), Douglas K. Owens (Associate Professor), Robert W. Shafer (Assistant Professor, Research), P.J. Utz (Associate Professor)
Microbiology and Immunology: Karla Kirkegaard (Professor), Garry Nolan (Associate Professor)
Obstetrics and Gynecology: W. LeRoy Heinrichs (Professor, emeritus)
Pathology: Arend Sidow (Assistant Professor)
Pediatrics: Atul Butte (Assistant Professor)
Psychiatry and Behavioral Sciences: Amar K. Das (Assistant Professor)
Radiation Oncology: Lei Xing (Assistant Professor, Research)
Radiology: Sam Gambhir (Professor), Gary H. Glover (Professor), Sandy A. Napel (Professor), David Paik (Assistant Professor), Norbert J. Pelc (Professor), Sylvia Plevritis (Associate Professor), Geoffrey Rubin (Associate Professor)
Statistics: Trevor J. Hastie (Professor), Susan Holmes (Professor), Art Owen (Professor), Balaji Srinivasan (Lecturer)
Structural Biology: Michael Levitt (Professor)
Surgery: Thomas Krummel (Professor), Charles Taylor (Assistant Professor, Research)

Program Offices: MSOB 215
Mail Code: 94305-5479
Phone: (650) 723-6979
Web Site: http://bmi.stanford.edu

Courses given in Biomedical Informatics Program have the subject code BIOMEDIN. For a complete list of subject codes, see Appendix.

The program in Biomedical Informatics emphasizes research to develop novel computational methods that can advance biomedicine. Students receive training in the investigation of new approaches to conceptual modeling and to development of new algorithms that address challenging problems in the biological sciences and clinical medicine. Students with a primary interest in developing new informatics methods and knowledge are best suited for this program. Students with a primary interest in the biological or medical application of existing informatics techniques may be better suited for training in the application areas themselves.

GRADUATE PROGRAMS

The Biomedical Informatics Program is interdepartmental and offers instruction and research opportunities leading to M.S. and Ph.D. degrees in Biomedical Informatics. All students are required to complete the core curriculum requirements outlined below, and also to elect additional courses to complement both their technical interests and their goals in applying informatics methods to clinical settings, biology, or imaging. Candidates must maintain a 3.0 GPA in each of the five core areas, and an overall GPA of 3.0. If the candidate's GPA does not meet the minimum requirement, the executive committee may require corrective courses of action. In addition, prior to being formally admitted to candidacy for the Ph.D. degree, the student must demonstrate knowledge of biomedical informatics fundamentals and a potential for research by passing a qualifying exam.

The core curriculum is common to all degrees offered by the program but is adapted or augmented depending on the interests and experience of the student. Deviations from the core curriculum outlined below must be justified in writing and approved by the student's Biomedical Informatics academic adviser and the chair of the Biomedical Informatics Committee. It should be noted, however, that the program is intended to provide flexibility and to complement other opportunities in applied medical research that exist at Stanford. Although most students are expected to comply with the basic program of study outlined here, special arrangements can be made for those with unusual needs or those simultaneously enrolled in other degree programs within the University. Similarly, students with prior relevant training may have the curriculum adjusted to eliminate requirements met as part of prior training.

CORE CURRICULUM

Students are expected to participate regularly in the Biomedical Informatics Student Seminar (201) and Colloquia (200), regardless of whether they register for credit in those courses. In addition, all students are expected to fulfill requirements in the following five categories:

1. *Core Biomedical Informatics* (17 units): students are expected to understand current applications of computers in biology and medicine and to develop a broad appreciation for research in the management of biomedical information. Required courses are: BIOMEDIN 200, 201, 210, 211, 212, 214, and 217, all of which should be taken during the first and second year in the program. BIOMEDIN 200 and 201 are required courses but are not counted toward the core or elective units. Students must also take an additional 3 units of Biomedical Informatics course work (which may include crosslisted courses from other departments, but not including BIOMEDIN 200, 201, 299, 302, 303, or 305), selected in consultation with the academic adviser.
2. *Computer Science* (9 units): the student is expected to acquire a knowledge of the use of computers, computer organization, programming, and symbolic systems. It is assumed that students have had by matriculation computing experience at least equivalent to a course introducing the fundamentals of data structures and algorithms such as CS 103A,B, 103X, 106A,B, 106X, or other courses approved by academic adviser or executive committee. Students are required to take a minimum of 9 units of courses in the Department of Computer Science. If similar courses have not been taken previously, these units must include CS 121 or 221, 161, and a course that requires significant programming and knowledge of machine architectures (for example,

CS 108, or the CS 193 series). For those who have taken such courses previously, replacement units may be taken from any other course in CS selected by the student and approved by the academic adviser. A course in databases is especially recommended. With the exception of CS 108, all other courses applied to the degree requirements must be numbered 137 or higher.

3. *Probability, Statistics, and Decision Science* (9 units): students are required to take at least three courses that span the following five topics: basic probability theory, Bayesian statistics, decision analysis, machine learning, and experimental-design techniques. Prior courses in statistics at least equivalent to STATS 60 and calculus equivalent to MATH 42 are prerequisites. A prior course in linear algebra equivalent to MATH 103 or 113 is recommended. For the probability requirements, students may, for example, take MS&E 120, STATS 116, or MS&E 221. For the statistics requirements, students should take STATS 141, if they have not had an equivalent class prior to entry to the program. Otherwise, sequences (taken after STATS 116) may include STATS 200 followed by a course in stochastic modeling, machine learning or data mining, such as STATS 202 or 315A,B, or CS 228 or 229. Options for decision analysis include MS&E 152 or 252, or cost effectiveness analysis (BIOMEDIN 432). Specific courses should be chosen in consultation with the student's academic adviser. Also recommended is a course in the psychology of human problem solving.
4. *Biomedical Domain Knowledge* (6 units): students are expected to acquire an understanding of pertinent life sciences and how to analyze a domain of application interest. Prior courses in biology at least equivalent to BIOSCI 41 and 42 are prerequisites. All students must have completed a course in basic biochemistry, molecular biology, or genetics. Other areas of basic biology may be an acceptable alternative. Exposure to laboratory methods in biology is encouraged. All students without formal health care training are encouraged to take IMMUNOL 230 (formerly BIOMEDIN 207).
5. *Social and Ethical Issues* (4 units): candidates are expected to be familiar with issues regarding ethics, public policy, financing, organizational behavior, management, and pertinent legal topics. Students may choose at least 3 units from suitable courses, including BIOMEDIN 432; CS 201; MS&E 284, 197; HRP 391, 392; or any other advanced course in policy and social issues proposed by the student and approved by the Biomedical Informatics academic adviser.

The core curriculum generally entails a minimum of 45 units of course work for master's students and 54 units of course work for Ph.D. students, but can require substantially more or less depending upon the courses selected and the previous training of the student. All courses must be taken for a letter grade. Students may request an elective course be taken for a grade of credit/no credit by submitting a petition to the BMI executive committee. BIOMEDIN 299 and BIOMEDIN 802 may be taken for satisfactory/no credit (S/NC). The varying backgrounds of students are well recognized and no one is required to take courses in an area in which he or she has already been adequately trained; under such circumstances, students are permitted to skip courses or substitute more advanced work. Students design appropriate programs for their interests with the assistance and approval of their Biomedical Informatics academic adviser. At least 27 units of formal course work are expected.

PROGRAM REQUIREMENTS FOR THE ACADEMIC M.S., PROFESSIONAL M.S., AND COTERMINAL DEGREES

Students enrolled in any of the M.S degrees must complete the program requirements in order to graduate. Programs of at least 45 units that meet the following guidelines are normally approved:

1. Completion of the core curriculum.
2. A minimum of 6 additional units of courses in Computer Science numbered 135 or higher, courses in Management Science and Engineering or Statistics numbered 200 or higher, PSYCH 256 or 225, or relevant courses in other departments approved by the student's academic adviser.
3. Electives: additional courses to bring the total to 45 or more units.

The University requirements for the M.S. degree are described in the "Graduate Degrees" section of this bulletin.

MASTER OF SCIENCE (ACADEMIC)

This degree is designed for individuals who wish to undertake in-depth study of biomedical informatics with research, typically supported with fellowship funding. Normally, a student spends two years in the program and implements and documents a substantial project during the second year. The first year involves acquiring the fundamental concepts and tools through course work and research project involvement. All first- and second-year students are expected to devote 50 percent or more of their time participating in research projects. Research rotations are not required, but can be done with approval of the academic adviser or training program director. Graduates of this program are prepared to contribute creatively to basic or applied projects in biomedical informatics. This degree requires a written research paper to be approved by two faculty members.

MASTER OF SCIENCE (HONORS COOPERATIVE PROGRAM)

This degree is primarily designed for the working professional who already has advanced training in one discipline and wishes to acquire interdisciplinary skills. All classes necessary for the degree are available online. The professional M.S. is offered in conjunction with Stanford Center of Professional Development (SCPD), which establishes the rates of tuition and fees. The program uses the honors cooperative model (HCP), which assumes that the student is working in a corporate setting and is enrolled in the M.S. on a part-time basis. The student has up to five years to complete the program. Research projects are optional and the student must make arrangements with program faculty. Graduates of this program are prepared to contribute creatively to basic or applied projects in biomedical informatics.

MASTER OF SCIENCE (COTERMINAL)

The coterminal degree program allows undergraduates to study for a master's degree while completing their bachelor's degree(s) in the same or a different department. Please refer to the "Coterminal Bachelor's and Master's Degrees" section under "Undergraduate Degrees and Programs" in this bulletin for additional information.

The coterminal Master of Science program follows the same program requirements as the Master of Science (Professional), except for the requirement to be employed in a corporate setting. The coterminal degree is only available to current Stanford undergraduates. Coterminal students are enrolled full-time and courses are taken on campus. Research projects are optional and the student must make arrangements with program faculty. Graduates of this program are prepared to contribute creatively to basic or applied projects in biomedical informatics.

For University coterminal degree program rules and University application forms, see http://registrar.stanford.edu/shared/publications.htm#Coterm.

DOCTOR OF PHILOSOPHY

The University's basic requirements for the doctorate (residence, dissertation, examination, and so on) are discussed in the "Graduate Degrees" section of this bulletin.

Individuals wishing to prepare themselves for careers as independent researchers in biomedical informatics, with applications experience in bioinformatics, clinical informatics, or imaging informatics, should apply for admission to the doctoral program. The following are additional requirements imposed by the Biomedical Informatics Interdisciplinary Committee:

1. A student plans and completes a coherent program of study including the core curriculum and additional requirements for the master's program. In addition, doctoral candidates are expected to take at least three more advanced courses (see categories under item '2' of the master's program requirements) and must complete a total of 54 units. In the first year, two or three research rotations are encouraged. The master's requirements should be completed by the end of the second year in the program (six quarters of study, excluding summers). Doctoral students are generally advanced to Ph.D. candidacy after passing the qualifying exam, which takes place during the end of the second year of training or early in the third year. A student's

academic adviser has primary responsibility for the adequacy of the program, which is regularly reviewed by the Biomedical Informatics executive committee.

2. To remain in the Ph.D. program, each student must attain a grade point average (GPA) of 3.0 (B) in each of the five core areas. The student must fulfill these requirements and apply for admission to candidacy for the Ph.D. by the end of six quarters of study (excluding summers). In addition, reasonable progress in the student's research activities is expected of all doctoral candidates.
3. During the third year of training, generally in the Winter Quarter, each doctoral student is required to give a preproposal seminar that describes evolving research plans and allows program faculty to assure that the student is making good progress toward the definition of a doctoral dissertation topic.
4. By the end of nine quarters (excluding summers), each student must orally present a written thesis proposal and an oral university defense of this proposal to a dissertation committee that generally includes at least one member of the Biomedical Informatics executive committee. The committee determines whether the student's general knowledge of the field and the details of the planned thesis are sufficient to justify proceeding with the dissertation.
5. As part of the training for the Ph.D., each student is required to be a teaching assistant for two courses approved by the Biomedical Informatics executive committee; one should be completed in the first two years of study.
6. The most important requirement for the Ph.D. degree is the dissertation. Prior to the oral dissertation proposal and defense, each student must secure the agreement of a member of the program faculty to act as dissertation adviser. The principal adviser need not be an active member of the Biomedical Informatics program faculty, but all committees should include at least one participating BMI faculty member.
7. No official additional oral examination is required upon completion of the dissertation. The oral defense of the dissertation proposal satisfies the University oral examination requirement. At the completion of training, the student should give a final talk describing their results.
8. The student is expected to demonstrate an ability to present scholarly material and research in a lecture at a formal seminar.
9. The student is expected to demonstrate an ability to present scholarly material in concise written form. Each student is required to write a paper suitable for publication, usually discussing his or her doctoral research project. This paper must be approved by the student's academic adviser as suitable for submission to a refereed journal before the doctoral degree is conferred.
10. The dissertation must be accepted by a reading committee composed of the principal dissertation adviser, a member of the program faculty, and a third faculty member chosen from anywhere within the University.

COURSES

BIOMEDIN 109Q. Genomics: A Technical and Cultural Revolution—(Same as GENE 109Q.) Stanford Introductory Seminar. Preference to sophomores. For non-science majors. Concepts of genomics, high-throughput methods of data collection, and computational approaches to analysis of data. The social, ethical, and economic implications of genomic science. Students may focus on computational or social aspects of genomics.

3 units, Win (Altman, R)

BIOMEDIN 156/256. Economics of Health and Medical Care—(Graduate students register for 256; same as ECON 126, HRP 256.) Graduate students with research interests should take ECON 248. Institutional, theoretical, and empirical analysis of the problems of health and medical care. Topics: institutions in the health sector; measurement and valuation of health; nonmedical determinants of health; medical technology and technology assessment; demand for medical care and medical insurance; physicians, hospitals, and managed care; international comparisons. Prerequisites: ECON 50 and ECON 102A or equivalent statistics, or consent of instructor. Recommended: ECON 51.

5 units, Aut (Bhattacharya, J)

BIOMEDIN 200. Biomedical Informatics Colloquium—Series of colloquia offered by program faculty, students, and occasional guest lecturers. Credit available only to students in a Biomedical Informatics degree program. May be repeated three times for credit.

1 unit, Aut, Win, Spr (Musen, M)

BIOMEDIN 201. Biomedical Informatics Student Seminar—Participants report on recent articles from the Biomedical Informatics literature or their research projects. Goal is to teach presentation skills. Credit available only to students in a Biomedical Informatics degree program. May be repeated three times for credit.

1 unit, Aut, Win, Spr (Musen, M)

BIOMEDIN 202. Introductory Biomedical Informatics—Via Internet. Current research problems and computational approaches to them. Topics include medical security and privacy, electronic medical records, controlled terminologies and biomedical ontologies, electronic retrieval, technology-assisted learning environments, medical decision making and support, sequence analysis, phylogenetics, biological networks and pathways, microarray analysis, natural language processing, and protein structural analysis and prediction. Graduate students in the Biomedical Informatics training program may not take this class for credit.

1 unit, Aut, Win, Spr, Sum (Altman, R)

BIOMEDIN 204. Pharmacogenomics—Via Internet. Genetically determined responses to drugs; applications focusing on the PharmGKB database, a publicly available Internet tool to aid researchers in understanding how genetic variation among individuals contributes to differences in reactions to drugs. Topics include: introduction to pharmacogenomics and pharmacology; the genome and genetics; human polymorphisms, frequencies, significance, and populations; informatics in pharmacogenomics; genotype to phenotype and phenotype to genotype approaches; drug discovery and validation; genomic variation discovery and genotyping; adverse drug reactions and interactions; pathways of drug metabolism; and cancer pharmacogenomics. Prerequisites: two of BIOSCI 41, 42, 43, and 44X,Y or consent of instructor.

1 unit, Aut, Win, Spr, Sum (Altman, R)

BIOMEDIN 205. Biomedical Informatics for Medicine—Primarily for M.D. students; open to others. Emphasis is on practical applications of bioinformatics and medical informatics for medicine, health care, clinicians, and medical research. Topics may include: methods to analyze genetic conditions; integrative methods for microarray, proteomic, and genomic data to understand the etiology of disease; clinical information systems in local healthcare facilities, and pharmacogenomics. Applications such as BLAST (sequence alignment), PharmGKB (matches allelic variation to drug response), and statistical packages such as R. Background in programming or medicine not required. May be repeated for credit.

2 units, Aut, Spr (Butte, A)

BIOMEDIN 210. Introduction to Biomedical Informatics: Fundamental Methods—(Same as CS 270.) Methods for modeling biomedical systems and for making those models explicit in the context of building software systems. Emphasis is on intelligent systems for decision support. Topics: knowledge representation, controlled terminologies, ontologies, reusable problem solvers, and knowledge acquisition. Recommended: exposure to object-oriented systems, basic knowledge of biology.

3 units, Aut (Musen, M)

BIOMEDIN 211. Biomedical Informatics: Biomedical Systems Engineering.—(Same as CS 271.) Focus is on undertaking design and implementation of computational and information systems for life scientists and healthcare providers. Case studies illustrate what design factors lead to success or failure in building systems in complex biomedical environments. Topics: requirements analysis, workflow and organizational factors, functional specification, knowledge modeling, data heterogeneity, component-based architectures, human-computer interaction, and system evaluation. Prerequisite: 210, or consent of instructor.

3 units, Win (Das, A)

BIOMEDIN 212. Introduction to Biomedical Informatics Research Methodology—(Same as BIOE 212, CS 272, GENE 212.) Hands-on software building. Student teams conceive, design, specify, implement, evaluate, and report on a software project in the domain of biomedicine. Creating written proposals, peer review, providing status reports, and preparing final reports. Guest lectures from professional biomedical informatics systems builders on issues related to the process of project management. Software engineering basics. Prerequisites: 210, 211 or 214, or consent of instructor.

3 units, Aut (Altman, R; Cheng, B; Klein, T)

BIOMEDIN 214. Representations and Algorithms for Computational Molecular Biology—(Same as BIOE 214, CS 274, GENE 214.) Topics: algorithms for alignment of biological sequences and structures, computing with strings, phylogenetic tree construction, hidden Markov models, computing with networks of genes, basic structural computations on proteins, protein structure prediction, protein threading techniques, homology modeling, molecular dynamics and energy minimization, statistical analysis of 3D biological data, integration of data sources, knowledge representation and controlled terminologies for molecular biology, graphical display of biological data, machine learning (clustering and classification), and natural language text processing. Prerequisites: programming skills; consent of instructor for 3 units.

3-4 units, Spr (Altman, R)

BIOMEDIN 216. Lectures on Representations and Algorithms for Molecular Biology—Lecture series for BIOMEDIN 214. Recommended: familiarity with biology.

1 unit, Spr (Altman, R)

BIOMEDIN 217. Translational Bioinformatics—(Same as CS 275.) Analytic, storage, and interpretive methods to optimize the transformation of genetic, genomic, and biological data into diagnostics and therapeutics for medicine. Topics: access and utility of publicly available data sources; types of genome-scale measurements in molecular biology and genomic medicine; analysis of microarray data; analysis of polymorphisms, proteomics, and protein interactions; linking genome-scale data to clinical data and phenotypes; and new questions in biomedicine using bioinformatics. Case studies. Prerequisites: programming ability at the level of CS 106A and familiarity with statistics and biology.

4 units, Win (Butte, A)

BIOMEDIN 218. Translational Bioinformatics—Same content as 217; for medical and graduate students who attend lectures and participate in limited assignments and final project.

2 units, Win (Butte, A)

BIOMEDIN 231. Computational Molecular Biology—(Same as BIOC 218.) Via Internet. For molecular biologists and computer scientists. Representation and analysis of genomes, sequences, and proteins. Strengths and limitations of existing methods. Course work performed on web or using downloadable applications. See http://biochem218.stanford.edu/. Prerequisites: introductory molecular biology course at level of BIOSCI 41 or consent of instructor.

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

BIOMEDIN 233. Intermediate Biostatistics: Analysis of Discrete Data—(Same as HRP 261, STATS 261.) The 2x2 table. Chi-square test. Fisher's exact test. Odds ratios. Sampling plans; case control and cohort studies. Series of 2x2 tables. Mantel Hantzel. Other tests. k x m tables. Matched data logistic models. Conditional logistic analysis, application to case-control data. Log-linear models. Generalized estimating equations for longitudinal data. Cell phones and car crashes: the crossover design. Special topics: generalized additive models, classification trees, bootstrap inference.

3 units, Win (Sainani, K)

BIOMEDIN 234. Biomedical Genomics—Genomic technologies, bioinformatics methods, and clinical and epidemiological applications for the study of human pathogens. DNA sequencing and gene expression and proteomics as applied to the genomes of humans and human pathogens. Core concepts in bioinformatics, molecular phylogenetics, and population genetics; how to retrieve, manipulate, and analyze sequence data; and use of web databases and online programs. Recommended for those with limited biology course work: consent of instructor.

3 units, Spr (Shafer, R)

BIOMEDIN 251. Outcomes Analysis—(Same as HRP 252.) Methods of conducting empirical studies which use large existing medical, survey, and other databases to ask both clinical and policy questions. Econometric and statistical models used to conduct medical outcomes research. How research is conducted on medical and health economics questions when a randomized trial is impossible. Problem sets emphasize hands-on data analysis and application of methods, including re-analyses of well-known studies. Prerequisites: one or more courses in probability, and statistics or biostatistics.

3 units, Spr (Bhattacharya, J)

BIOMEDIN 262. Computational Genomics—(Same as CS 262.) Applications of computer science to genomics, and concepts in genomics from a computer science point of view. Topics: dynamic programming, sequence alignments, hidden Markov models, Gibbs sampling, and probabilistic context-free grammars. Applications of these tools to sequence analysis: comparative genomics, DNA sequencing and assembly, genomic annotation of repeats, genes, and regulatory sequences, microarrays and gene expression, phylogeny and molecular evolution, and RNA structure. Prerequisites: 161 or familiarity with basic algorithmic concepts. Recommended: basic knowledge of genetics.

3 units, Win (Batzoglou, S)

BIOMEDIN 273A. A Computational Tour of the Human Genome—(Same as CS 273A, DBIO 273A.) Genomes as the ultimate biological information medium, carrying instructions for every organism's development, life cycle, and reproduction. Bioinformatics perspective. Advances in biology resulting from sequencing of human and related organisms. Genome sequencing: technologies, assembly, personalized sequencing. Functional landscape: genes, regulatory modules, repeats, RNA genes. Genome evolution: processes, comparative genomics, ultraconservation, exaptation. Topics may include population genetics and personalized genomics, ancient DNA, and metagenomics. Prerequisities: computational biology at the level of 262, 274, or BIOC 218.

3 units, Aut (Batzoglou, S; Bejerano, G)

BIOMEDIN 299. Directed Reading and Research—For students wishing to receive credit for directed reading or research time. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

BIOMEDIN 301. Special Topics in Biomedical Informatics

1-6 units, Sum (Staff)

BIOMEDIN 303. Statistics for Research—Statistical methods commonly used in research. Emphasis is on when and how to use the methods rather than on proofs. How to describe data and detect unusual values, compare treatment effects, interpret p-values, detect and quantify trends, detect and measure association and correlation, determine the sample size and power for an experiment, and choose statistical tests and software. Topics include descriptive statistics (mean, median, standard deviation, standard error), probability, paired and unpaired t-tests, analysis of variance, correlation, regression, chi-square, discriminant analysis, and power and sample size. Statistical analysis software including Excel and Statistica.

1 unit, Spr (Walker, M; Musen, M), alternate years, not given next year

BIOMEDIN 366. Computational Biology—(Same as STATS 166, STATS 366.) Methods to understand sequence alignments and phylogenetic trees built from molecular data, and general genetic data. Phylogenetic trees, median networks, microarray analysis, Bayesian statistics. Binary labeled trees as combinatorial objects, graphs, and networks. Distances between trees. Multivariate methods (PCA, CA, multidimensional scaling). Combining data, nonparametric inference. Algorithms used: branch and bound, dynamic programming, Markov chain approach

to combinatorial optimization (simulated annealing, Markov chain Monte Carlo, approximate counting, exact tests). Software such as Matlab, Phylip, Seq-gen, Arlequin, Puzzle, Splitstree, XGobi.

2-3 units, Aut (Holmes, S)

BIOMEDIN 374. Algorithms in Biology—(Same as CS 374.) Algorithms and computational models applied to molecular biology and genetics. Topics vary annually. Possible topics include biological sequence comparison, annotation of genes and other functional elements, molecular evolution, genome rearrangements, microarrays and gene regulation, protein folding and classification, molecular docking, RNA secondary structure, DNA computing, and self-assembly. May be repeated for credit. Prerequisites: 161, 262 or 274, or BIOCHEM 218, or equivalents.

2-3 units, Spr (Batzoglou, S)

BIOMEDIN 390A,B,C. Curricular Practical Training—Provides educational opportunities in biomedical informatics research. Qualified biomedical informatics students engage in internship work and integrate that work into their academic program. Students register during the quarter they are employed and must complete a research report outlining their work activity, problems investigated, key results, and any follow-up on projects they expect to perform. BIOMEDIN 390A, B, and C may each be taken only once.

1 unit, Aut, Win (Staff), Spr, Sum (Musen, M)

BIOMEDIN 432. Analysis of Costs, Risks, and Benefits of Health Care—(Same as MGTECON 332, HRP 392.) For graduate students. The principal evaluative techniques for health care, including utility assessment, cost-effectiveness analysis, cost-benefit analysis, and decision analysis. Emphasis is on the practical application of these techniques. Group project presented at end of quarter. Guest lectures by experts from the medical school, pharmaceutical industry, health care plans, and government.

4 units, Aut (Garber, A; Owens, D)

COGNATE COURSES

See respective department listings for course descriptions and General Education Requirements (GER) information. See degree requirements above or the program's student services office for applicability of these courses to a major or minor program.

CS 228. Probabilistic Models in Artificial Intelligence

3 units, Win (Koller, D)

CS 329. Topics in Artificial Intelligence

3 units, offered occasionally

CS 348B. Computer Graphics: Image Synthesis Techniques

3-4 units, Spr (Hanrahan, P)

CS 379. Interdisciplinary Topics

3 units, Aut (Staff)

MS&E 355. Influence Diagrams and Probabilistics Networks

3 units, Win (Shachter, R), alternate years, not given next year

CANCER BIOLOGY PROGRAM

Program Director: Amato Giaccia (Radiation Oncology)
Committee on Cancer Biology: Nicholas Denko (Radiation Oncology), Howard Chang (Dermatology), Jeffrey Axelrod (Pathology), Katrin Chua (Medicine, Endocrinology), Julien Sage (Pediatrics), Alexandro Sweet-Cordero (Pediatrics), Timothy Stearns (Biological Sciences, Genetics)

Program Office: Alway Building, 300 Pasteur Drive, Room M105I
Mail Code: 94305-5121
Phone: (650) 723-6198
Email: dalima@stanford.edu
Web Site: http://www.stanford.edu/group/cancerbio/

Courses given in Cancer Biology have the subject code CBIO. For a complete list of subject codes, see Appendix.

The Cancer Biology Program at Stanford University is an interdisciplinary program leading to the Ph.D. degree. During the past three decades, understanding of cancer has increased with the discovery of oncogenes, tumor suppressor genes, pathways of DNA damage and repair, chromatin remodeling, cell cycle regulation, angiogenesis and responses to hypoxia, and recent glimpses into the molecular basis of metastasis and cancer stem cell biology. In addition, methods of parallel analysis including gene expression arrays, protein arrays, and tissue arrays have begun to refine and redefine the taxonomy of cancer diagnosis. This explosion of basic and clinical science has resulted in the first successful cancer chemotherapies and immunotherapies based on the knowledge of specific molecular targets. Stanford presents a unique environment to pursue interdisciplinary cancer research because the schools of Medicine, Humanities and Sciences, and Engineering are located on a single campus

The goal of the Cancer Biology Ph.D. program is to provide students with education and training that enables them to make significant contributions to this field. Course work during the first year is designed to provide a broad understanding of the molecular, genetic, cell biological, and pathobiological aspects of cancer. Students also learn about the current state of the epidemiology, clinical diagnosis, treatment, and prevention of human cancers. Equally important during the first year is a series of three rotations in research laboratories chosen by each student. By the beginning of the second year, each student chooses a research adviser and begins work on the dissertation project. A qualifying examination must be completed by the end of the second year. An annual Cancer Biology conference at Asilomar on the Pacific Ocean provides students with an opportunity to present their research to one another and to faculty. The expected time to degree is four to five years.

Students are not limited to a single department in choosing their research adviser. The Cancer Biology Ph.D. program currently has approximately 60 graduate students located in basic science and clinical departments throughout the School of Medicine and the School of Humanities and Sciences.

GRADUATE PROGRAM

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described under the "Graduate Degrees" section of this bulletin.

A small number of applicants are admitted to the program each year. Applicants should have completed an undergraduate major in the biological sciences; applicants with undergraduate majors in physics, chemistry, or mathematics may be admitted if they complete background training in biology during the first two years of study. During the first year, each student is required to complete a minimum of three, one quarter laboratory rotations. Students must choose a dissertation adviser prior to the end of Summer Quarter, first year, but not before the end of Spring Quarter, first year.

The requirements for the Ph.D. degree are as follows:

1. Training in biology equivalent to that of an undergraduate biology major at Stanford.

2. Completion of the following courses:
   a) CBIO 241. Molecular, Cellular, and Genetic Basis of Cancer
   b) GENE 203. Advanced Genetics
   c) BIOSCI 214. Cell Biology of Physiological Processes
   d) CSB 210. Signal Transduction Pathways and Networks. Students can take GENE 211, Genomics, or SBIO 214, Biological Macromolecules in lieu of CSB 210.
   e) CBIO 280. Cancer Biology Journal Club; required for first- and second-year graduate students in Autumn, Winter, and Spring quarters.
   f) MED 255. Responsible Conduct in Research; with consent, may be audited.
3. At least 6 units of additional cancer biology-related, graduate-level courses. Course work taken is determined in consultation with the student's adviser and/or the Program Director.
4. Presentation of research results at the annual Cancer Biology Conference on at least three occasions, at least one being an oral presentation.
5. Completion of a qualifying examination in Cancer Biology is required for admission to Ph.D. candidacy. The exam consists of an NIH-style written grant proposal not to exceed ten pages (excluding references), and an oral examination. The examining committee consists of three faculty members from the Cancer Biology Program and does not include the student's dissertation adviser. The composition of this committee is chosen by the student and dissertation adviser and must be submitted to and approved by the program director prior to the end of Autumn Quarter, second year. The qualifying examination must be taken prior to the end of Spring Quarter, second year. If necessary, one retake is permitted prior to the end of Summer Quarter, second year. After the qualifying examination has been completed, the student is required to form a dissertation reading committee that includes the student's adviser and three other members of the Academic Council with appropriate expertise. Each student is required to arrange annual meetings (more frequently, if necessary) of the dissertation reading committee, at which time oral presentations of progress during the past year and a plan of study for the coming year are presented and discussed. Completion of each annual committee meeting must be communicated in writing to the program director by the adviser by the end of Spring Quarter each year.
6. The major accomplishment of each successful Ph.D. student is the presentation of a written dissertation resulting from independent investigation that contributes to knowledge in the area of cancer biology. An oral examination is also required for the Ph.D. degree. In the Cancer Biology Program, a public seminar (one hour) is presented by the Ph.D. candidate, followed by a closed-door oral examination. The oral examination committee consists of at least four examiners (the members of the doctoral dissertation reading committee) and a chair. The oral examination chair may not have a full or joint appointment in the adviser's or student's home department. However, a courtesy appointment does not affect eligibility. The oral examination chair may be from the same department as any other member(s) of the examination committee. All members of the oral examination committee are normally members of the Academic Council, as the oral examination chair must be. With the prior approval of the program director or school dean, one of the examiners may be a person who is not a member of the Academic Council if that individual contributes expertise not otherwise available. Official responsibility for selecting the oral examination chair rests with the program. Cancer Biology delegates this to the student and dissertation adviser.

COURSES

Course and lab instruction in the Cancer Biology Program conform to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

CBIO 101. Cancer Biology—(Same as PATH 101.) Experimental approaches to understanding the origins, diagnosis, and treatment of cancer. Focus on key experiments and discoveries with emphasis on genetics, molecular biology, and cell biology. Topics include carcinogens, tumor virology, oncogenes, tumor suppressor genes, cell cycle regulation, angiogenesis, invasion and metastasis, cancer genomics, cancer epidemiology, and cancer therapies. Discussion sections based on primary research articles that describe key experiments in the field. Prerequisite: Biological Sciences or Human Biology core or equivalent, or consent of instructor.
4 units, Spr (Lipsick, J)

CBIO 241. Molecular, Cellular, and Genetic Basis of Cancer—Core course required of first-year Cancer Biology graduate students. Focus is on key experiments and classic primary research papers in cancer biology. Letter grade required. Undergraduates require consent of course director.
5 units, Aut (Giaccia, A)

CBIO 260. Teaching in Cancer Biology—Practical experience in teaching by serving as a teaching assistant in a cancer biology course. Unit values are allotted individually to reflect the level of teaching responsibility assigned to the student.
1-10 units, Aut (Giaccia, A), Win (Staff), Spr (Lipsick, J)

CBIO 280. Cancer Biology Journal Club—Required of and limited to first- and second-year graduate students in Cancer Biology. Recent papers in the literature presented by graduate students. When possible, discussion relates to and precedes cancer-related seminars at Stanford. Attendance at the relevant seminar required.
1 unit, Aut, Win, Spr (Giaccia, A)

CBIO 299. Directed Reading in Cancer Biology—Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

CBIO 399. Graduate Research—Investigations sponsored by individual faculty members. Cancer Biology Ph.D. students must register as soon as they begin dissertation-related research work.
1-18 units, Aut, Win, Spr, Sum (Staff)

COGNATE COURSES

See respective department listings for course descriptions. See degree requirements above or the program's student services office for applicability of these courses to a major or minor program.

BIOSCI 203. Advanced Genetics—(Same as DBIO 203, GENE 203.)
4 units, Aut (Stearns, T; Barsh, G; Sidow, A; Kim, S)

BIOSCI 214. Cell Biology of Physiological Processes—(Same as BIOC 224.)
2-5 units, Win (Theriot, J; Nelson, W; Straight, A; Bogyo, M; Pfeffer, S)

CHEMICAL AND SYSTEMS BIOLOGY

Emeriti: (Professors) Robert H. Dreisbach, Avram Goldstein, Dora B. Goldstein, Tag E. Mansour, Oleg Jardetzky, James P. Whitlock
Chair: James E. Ferrell, Jr.
Professors: James E. Ferrell, Jr., Tobias Meyer, Daria Mochly-Rosen, Richard A. Roth
Associate Professor: Karlene A. Cimprich
Assistant Professors: James K. Chen, Thomas J. Wandless, Joanna K. Wysocka
Courtesy Professors: Beverly S. Mitchell, Paul A. Wender
Courtesy Assistant Professors: Matthew Bogyo, Jennifer J. Kohler, Calvin J. Kuo
Consulting Professor: Juan Jaen
Web Site: http://casb.stanford.edu

Courses given in Chemical and Systems Biology have the subject code CSB. For a complete list of subject codes, see Appendix.

In Autumn of 2006, the Department of Molecular Pharmacology changed its name to become the Department of Chemical and Systems Biology. The department has established a new Ph.D. program in Chemical and Systems Biology. Molecular Pharmacology Ph.D. students who enrolled prior to Autumn 2007 have the option of receiving their Ph.D. in either Molecular Pharmacology or Chemical and Systems Biology. Ph.D. students matriculating in Autumn 2007 and thereafter are admitted to Chemical and Systems Biology. Further details about degree requirements are available from the department.

GRADUATE PROGRAMS

MASTER OF SCIENCE

Students in the Ph.D. program may apply for an M.S. degree after having satisfactorily completed the course and laboratory requirements of the first two years. The degree also requires a written thesis based on literature or laboratory research. Postdoctoral research training is available to graduates having the Ph.D. or M.D. degree.

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described in the "Graduate Degrees" section of this bulletin.

The Department of Chemical and Systems Biology offers interdisciplinary training to prepare students for independent careers in biomedical science. The main focus of the program is cell signaling, chemical biology, and systems biology.

The program leading to the Ph.D. degree includes formal and informal study in chemical biology, systems biology, drug discovery, biochemistry, and other areas of relevance to the interests of particular students. First-year students spend one quarter in each of three different laboratories, working closely with other graduate students, a professor, and postdoctoral fellows on various research projects. During the fourth quarter, the student chooses a faculty mentor with whom to undertake thesis research, based on available positions and the student's interest. During or before the eighth quarter of study, students must pass a qualifying exam which consists of an oral exam on general knowledge and a defense of a research proposal. Course requirements are fulfilled during the first two years of study; the later years of the four- to six-year program are devoted to full-time dissertation research. Close tutorial contact between students and faculty is stressed throughout the program.

Research opportunities also exist for medical students and undergraduates. The limited size of the labs in the department allows for close tutorial contact between students, postdoctoral fellows, and faculty.

The department participates in the four quarter Health and Human Disease sequence which provides medical students with a comprehensive, systems-based education in physiology, pathology, microbiology, and pharmacology.

COURSES

Course and lab instruction in the Department of Chemical and Systems Biology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

Open to all University students; consent of instructor required prior to registration. Students should consult with the instructor about the adequacy of their preparation.

CSB 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

CSB 210. Signal Transduction Pathways and Networks—The molecular mechanisms through which cells receive and respond to external signals. Emphasis is on principles of cell signaling, the systems-level properties of signal transduction modules, and experimental strategies through which cell signaling pathways are being studied. Prerequisite: working knowledge of biochemistry and genetics.
4 units, Win (Ferrell, J; Meyer, T)

CSB 220. Chemistry of Biological Processes—(Same as BIOC 220.) The principles of organic and physical chemistry as applied to biomolecules. Goal is a working knowledge of chemical principles that underlie biological processes, and chemical tools used to study and manipulate biological systems. Prerequisites: organic chemistry and biochemistry, or consent of instructor.
4 units, Aut (Herschlag, D; Chen, J; Bogyo, M; Wandless, T) alternate years, not given next year

CSB 240. Drug Discovery—The scientific principles and technologies involved in making the transition from a basic biological observation to the creation of a new drug emphasizing molecular and genetic issues. Prerequisite: biochemistry, chemistry, or bioengineering.
4 units, alternate years, not given this year

CSB 260. Quantitative Chemical Biology—Current topics including protein and small molecule engineering, cell signaling sensors and modulators, molecular imaging, chemical genetics, combinatorial chemistry, in vitro evolution, and signaling network modeling. Prerequisites: undergraduate organic chemistry, and biochemistry or cell biology.
4 units, Spr (Chen, J), alternate years, not given next year

CSB 270. Research Seminar—Guest speakers and discussion on current research in pharmacology.
1-2 units, not given this year (Staff)

CSB 278. Introduction to Systems Biology—(Same as CS 278.) For biologists, engineers, and computer scientists. Experimental and computational approaches to modeling and analysis of complex biological systems. Topics: biological noise; simple signaling circuits (cascades, feedback, and feed-forward circuits); bistability and oscillations; large scale models; synthetic biology; and analysis of omics-scale data sets. Computational approached include ODE modeling, stochastic simulation, boolean networks, Bayesian approaches, and hybrid modeling.
4 units, Spr (Dill, D; Brutlag, D; Koller, D; Covert, M; Ferrell, J)

CSB 299. Directed Reading in Chemical and Systems Biology—Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

CSB 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

COMPARATIVE MEDICINE

Chair: Linda C. Cork
Professor: Linda C. Cork
Associate Professors: Donna Bouley, Paul Buckmaster, Sherril Green, Shaul Hestrin
Assistant Professor: Corinna Darian-Smith
Department Offices: Edwards Building, Room R321
Mail Code: 94305-5342
Phone: (650) 498-5080
Web Site: http://med.stanford.edu/compmed/

Courses given in Comparative Medicine have the subject code COMPMED. For a complete list of subject codes, see Appendix.

The Department of Comparative Medicine is a clinical department that offers residency training in laboratory animal medicine for veterinarians, although it does not offer degrees. Its faculty offer courses at the undergraduate and graduate levels and participate in teaching in other departments. Both clinical faculty members, who are specialists in a veterinary medical specialty, and basic science faculty also accept students to participate in ongoing research projects within the department and assist students with special research projects.

The discipline of Comparative Medicine use the differences and similarities among species to understand biologic and disease mechanisms. It incorporates spontaneous or induced disease models as one of several approaches to research. The research interests of faculty are in neuroscience, infectious diseases, neuropathology, cancer, and molecular genetics.

COURSES

Course and lab instruction in the Department of Comparative Medicine conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

COMPMED 81N. Comparative Anatomy and Physiology of Mammals—Stanford Introductory Seminar. Preference to freshmen. Comparative approach to common mammals, laboratory, and domestic species. The unique adaptations of each species in terms of its morphological, anatomical, and behavioral characteristics. How these species interact with human beings and other animals. GER: DB-NatSci
3 units, Win (Bouley, D)

COMPMED 83Q. Horse Medicine—Stanford Introductory Seminar. Preference to sophomores. The most common equine diseases, ranging from colic to lameness. Equine anatomy and physiology relevant to topics in equine medicine. Equine infectious diseases, care of the newborn foal, medical emergencies, and neurological disorders.
1-2 units, Aut (Green, S)

COMPMED 106. A Primate Perspective on Brain Evolution—How to distinguish primate subgroups; how to place primates among mammals, and humans among primates, with respect to body structure, brain organization, and function. The unique characteristics of primates; what factors contributed to the evolution of primate groups, hominids, and modern human beings. The role of the hand in primate evolution. What extant primates reveal about language acquisition. How these changes are reflected in the sensorimotor organization of the primate brain. Prerequisite: freshman biology.
3 units, not given this year

COMPMED 107/207. Comparative Neuroanatomy—(Graduate students register for 207.) Functional organization and evolution of the vertebrate nervous system. Topics include paleoneurology, cladistic analysis, allometry, mosaic versus concerted evolution, and evolution of brain region structure, connectivity, and neurons. Comparisons between structure and function of vertebrate forebrains including hippocampi. Evolution of the primate visual and sensorimotor central nervous system as related to vocalization, socialization, and intelligence.
4 units, not given this year

COMPMED 110. Pre-Vet Advisory—For students interested in a career in veterinary medicine. Guest speakers present career options in veterinary medicine. Networking with other pre-vet students. How to meet the academic and practical experience prerequisites for admission to veterinary school. Prerequisite: consent of instructor.
1 unit, Aut, Win, Spr (Bouley, D)

COMPMED 198. Undergraduate Directed Reading in Comparative Medicine—May be taken as a prelude to research and may also involve participation in a lab or research group seminar and/or library research.
1-3 units, Aut, Win, Spr, Sum (Staff)

COMPMED 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-3 units, Aut, Win, Spr, Sum (Staff)

FOR GRADUATE STUDENTS

COMPMED 299. Directed Reading in Comparative Medicine—Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

COMPMED 399. Graduate Research—Investigations sponsored by individual faculty members.Opportunities are available in comparative medicine and pathology, immuno-histochemistry, electron microscopy, molecular genetics, quantitative morphometry, neuroanatomy and neurophysiology of the hippocampus, pathogenesis of intestinal infections, immunopathology, biology of laboratory rodents, anesthesiology of laboratory animals, gene therapy of animal models of neurodegenerative diseases, and development and characterization of transgenic animal models. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

DEVELOPMENTAL BIOLOGY

Emeriti: (Professors) David S. Hogness, A. Dale Kaiser
Chair: Roeland Nusse
Associate Chair: Lucy Shapiro
Professors: Ben Barres, Philip Beachy, Gerald Crabtree, Margaret Fuller, Stuart Kim, David Kingsley, Roeland Nusse, Matthew Scott, Lucy Shapiro, James Spudich, William Talbot, Irving Weissman
Associate Professors: Seung Kim, Anne Villeneuve
Assistant Professors: Gill Bejerano, Joanna Wysocka
Associate Professor (Teaching): Ellen Porzig
Professor (Research): Harley McAdams

Courses given in Development Biology have the subject code DBIO. For a complete list of subject codes, see Appendix.

A fundamental problem in biology is how the complex set of multicellular structures that characterize an adult animal is generated from the fertilized egg. Recent advances at the molecular level, particularly with respect to the genetic control of development, have been explosive. These advances represent the beginning of a major movement in the biological sciences toward the understanding of the molecular mechanisms underlying developmental decisions and the resulting morphogenetic processes. This new thrust in developmental biology derives from the extraordinary methodological advances of the past decade in molecular genetics, immunology, and biochemistry. However, it also derives from groundwork laid by the classical developmental studies, the rapid advances in cell biology and animal virology, and from models borrowed from prokaryotic systems. Increasingly, the work is directly related to human diseases, including oncogene function and inherited genetic disease.

The Department of Developmental Biology includes a critical mass of scientists who are leading the thrust in developmental biology and who can train new leaders in the attack on the fundamental problems of development. Department labs work on a wide variety of organisms from microbes to worms, flies, and mice. The dramatic evolutionary conservation of genes that regulate development makes the comparative

approach of the research particularly effective. Scientists in the department labs have a very high level of interaction and collaboration. The discipline of developmental biology draws on biochemistry, cell biology, genetics, molecular biology, and genomics. People in the department have a major interest in regenerative medicine and stem cell biology.

The department is located in the Beckman Center for Molecular and Genetic Medicine within the Stanford University Medical Center.

GRADUATE PROGRAM

MASTER OF SCIENCE

University requirements for the M.S. are described in the "Graduate Degrees" section of this bulletin.

Students in the Ph.D. program in Developmental Biology may apply for an M.S. degree, assuming completion of their course requirements and preparation of a written proposal. The master's degree awarded by the Department of Developmental Biology does not include the possibility of minors for graduate students enrolled in other departments or programs.

Students are required to take, and satisfactorily complete, at least three lecture courses offered by the department, including 210, Developmental Biology. In addition, students are required to take three courses outside the department. Students are also expected to attend Developmental Biology seminars and journal clubs. In addition, the candidate must complete a research paper proposing a specific experimental approach and background in an area of science relative to developmental biology.

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described in the "Graduate Degrees" section of this bulletin.

The graduate program in Developmental Biology leads to the Ph.D. degree. The department also participates in the Medical Scientists Training Program (MSTP) in which individuals are candidates for both the M.D. and Ph.D. degrees.

Students are required to complete at least six courses, including Developmental Biology (210); Advanced Genetics (203); Frontiers in Biological Sciences (215); and an advanced molecular biology, biochemistry, or biophysics course. Students are expected to attend Developmental Biology seminars and journal clubs.

Completion of a qualifying examination is required for admission to Ph.D. candidacy. The examination consists of two parts. One proposal is on a subject different from the dissertation research and the other proposal is on the planned subject of the thesis. The final requirements of the program include presentation of a Ph.D. dissertation as the result of independent investigation and constituting a contribution to knowledge in the area of developmental biology. The student must pass the University oral examination, taken only after the student has substantially completed research. The examination is preceded by a public seminar in which the research is presented by the candidate. The oral examination is conducted by a dissertation reading committee.

COURSES

Course and lab instruction in the Department of Developmental Biology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

DBIO 12Q. The Evolution and Development of the Human Hand—Stanford Introductory Seminar. Preference to sophomores. Evolution of the human hand in the context of primate evolution; roles of the human hand in tool use, manufacture, art, music, and communication. Development of the hand: embryonic axes, appearance of the digit program, roles of cell death, molecular bases of normal and abnormal hand patterns. Prerequisite: advanced placement biology.

3-4 units, Win (Porzig, E)

DBIO 156. Human Developmental Biology and Medicine—(Same as HUMBIO 141.) The biological, medical, and social aspects of normal and abnormal human development. Topics: in vitro fertilization and embryo transfer; gene and cell therapy; gametogenesis; pattern formation in the nervous system and limb development; gene and grand multiple pregnancies; prematurity, in utero effects of teratogens; sex determination and differentiation; growth control; gigantism and dwarfism; neural tube defects; cardiac morphogenesis; progress in the developmental biology of humans. Limited enrollment. Prerequisites: Human Biology or Biological Sciences core, or consent of instructor.

4 units, not given this year

DBIO 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

DBIO 201. Development and Disease Mechanisms—Mechanisms that direct human development from conception to birth. Conserved molecular and cellular pathways regulate tissue and organ development; errors in these pathways result in congenital anomalies and human diseases. Topics: molecules regulating development, cell induction, developmental gene regulation, cell migration, programmed cell death, pattern formation, stem cells, cell lineage, and development of major organ systems. Emphasis on links between development and clinically significant topics including infertility, assisted reproductive technologies, contraception, prenatal diagnosis, multiparity, teratogenesis, inherited birth defects, fetal therapy, adolescence, cancer, and aging.

4 units, Aut (Porzig, E; Kim, S; Kingsley, D; Scott, M)

DBIO 202. Assisted Reproductive Technologies—(Same as OBGYN 202.) Primary literature in basic and clinical science, and demonstrations of assisted reproductive technologies (ART). Techniques include in vitro fertilization covering micromanipulation procedures such as intracytoplasmic sperm injection and the culture of blastocysts, using mouse gametes, and pre-embryos. Class only may be taken for 1 unit. 2 units includes papers and attendance at clinical demonstrations. 3 units includes a term paper. Prerequisite: DBIO 201 recommended, or consent of instructors.

1-3 units, Win (Porzig, E; Behr, B)

DBIO 203. Advanced Genetics—(Same as BIOSCI 203, GENE 203.) For graduate students in Bioscience programs; may be appropriate for graduate students in other programs. The genetic toolbox. Examples of analytic methods, genetic manipulation, genome analysis, and human genetics. The use of genetic tools in dissecting complex biological pathways, developmental processes, and regulatory systems. Faculty-led discussion sections with evaluation of papers. Students with minimal experience in genetics should prepare by working out problems in college level textbooks.

4 units, Aut (Stearns, T; Barsh, G; Sidow, A; Kim, S)

DBIO 210. Developmental Biology—Current areas of research in developmental biology. How organismic complexity is generated during embryonic and post-embryonic development. The roles of genetic networks, induction events, cell lineage, maternal inheritance, cell-cell communication, and hormonal control in developmental processes in well-studied organisms such as vertebrates, insects, and nematodes. Team-taught. Students meet with faculty to discuss current papers from the literature. Prerequisite: graduate standing, consent of instructor. Recommended: familiarity with basic techniques and experimental rationales of molecular biology, biochemistry, and genetics.

5 units, Spr (Villeneuve, A; Fuller, M; Beachy, P)

DBIO 215. Frontiers in Biological Research—(Same as BIOC 215, GENE 215.) Literature discussion in conjunction with the Frontiers in Biological Research seminar series hosted by Biochemistry, Developmental Biology, and Genetics in which distinguished investigators present current work. Students and faculty meet beforehand to discuss papers from the speaker's primary research literature. Students meet with the speaker after the seminar to discuss their research and future direction, commonly used techniques to study problems in biology, and comparison between the genetic and biochemical approaches in biological research.

1 unit, Aut, Win (Harbury, P; Brunet, A; Villeneuve, A)

DBIO 221. Current Issues in Aging—(Same as GENE 221, NENS 221.) Current research literature on genetic mechanisms of aging in animals and human beings. Topics include: mitochondria mutations, insulin-like signaling, sirtuins, aging in flies and worms, stem cells, human progeria, and centenarian studies. Prerequisite: GENE 203.

1-2 units, Win (Kim, S; Brunet, A; Rando, T), Spr (Kim, S)

DBIO 232. Topics in Regenerative Medicine—(Same as MI 232.) Forum. Students and researchers discuss current developments in regenerative medicine at Stanford to spark collaboration. Topics include novel applications in biological and chemical engineering, stem cell biology, biotechnology, and human disease. May be repeated for credit.

2 units, Aut, Win, Spr (Blau, H; Fuller, M)

DBIO 257. The Stem Cell: Science, Ethics, and Politics—(Same as HUMBIO 157.) The biology of stem cells. Their role in human development and potential for treating disease. Guest lectures by biologists, ethicists, and legal scholars. Prerequisites: HUMBIO 2A,B, or consent of instructor.

3 units, Spr (Nusse, R; Fuller, M; Porzig, E)

DBIO 273A. A Computational Tour of the Human Genome—(Same as BIOMEDIN 273A, CS 273A.) Genomes as the ultimate biological information medium, carrying instructions for every organism's development, life cycle, and reproduction. Bioinformatics perspective. Advances in biology resulting from sequencing of human and related organisms. Genome sequencing: technologies, assembly, personalized sequencing. Functional landscape: genes, regulatory modules, repeats, RNA genes. Genome evolution: processes, comparative genomics, ultraconservation, exaptation. Topics may include population genetics and personalized genomics, ancient DNA, and metagenomics. Prerequisities: computational biology at the level of 262, 274, or BIOC 218.

3 units, Aut (Batzoglou, S; Bejerano, G)

DBIO 296. Stem Cell Biology and Regenerative Medicine—(Same as PATH 296.) For graduate and medical students. Embryonic and adult stem cells, including origin, regulation, self-renewal, differentiation, fate, and relationship to cancer; biological mechanisms and methods to translate findings to therapeutic applications. Medical students must enroll for 5 units; graduate students may choose to take only the basic science part for 3 units. Prerequisites: DBIO 201 and 210, or consent of instructor.

3-5 units, Win (Weissman, I; Fuller, M; Nusse, R)

DBIO 299. Directed Reading in Developmental Biology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

DBIO 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

EPIDEMIOLOGY PROGRAM

Director: Victor W. Henderson (Professor, Health Research and Policy, and Neurology and Neurological Sciences)

Advisory Committee: Stephen P. Fortmann (Professor, Medicine), John R. Huguenard (Professor, Neurology and Neurological Sciences), Charles C. Prober (Professor, Pediatrics, and Microbiology and Immunology), Robert Tibshirani (Professor, Health Research and Policy)

Core Faculty and Academic Teaching Staff: Raymond R. Balise (Lecturer, Health Research and Policy), Gary D. Friedman* (Consulting Professor, Health Research and Policy), Victor W. Henderson* (Professor, Health Research and Policy, and Neurology and Neurological Sciences), Abby C. King* (Professor, Health Research and Policy, and Medicine), Philip Lavori (Professor, Health Research and Policy), Yvonne A. Maldonado* (Associate Professor, Pediatrics), Lorene M. Nelson* (Associate Professor, Health Research and Policy), Julie Parsonnet* (Professor, Medicine, and Health Research and Policy), Rita A. Popat (Clinical Assistant Professor, Health Research and Policy), Kristin L. Sainani (Clinical Assistant Professor, Health Research and Policy), Dee W. West* (Professor, Health Research and Policy), Alice S. Whittemore* (Professor, Health Research and Policy)

* Member of the program steering committee

Program Offices: HRP Redwood Building, Room T138C
Mail Code: 94305-5405
Phone: (650) 723-5456
Email: epiprogram@med.stanford.edu
Web Site: http://www.stanford.edu/dept/HRP/epidemiology/

MASTER OF SCIENCE

The Graduate Interdisciplinary Program in Epidemiology offers instruction and interdisciplinary research opportunities leading to the M.S. degree in Epidemiology. Most core faculty and academic teaching staff are administratively housed within the Department of Health Research and Policy. Affiliated faculty come from a large number of Stanford University departments and centers, and from notable Bay Area research facilities. The program seeks students with the potential to be future leaders in clinical and translational research, epidemiology, and allied disciplines. The program provides researchers from diverse clinical backgrounds the knowledge and skills to become clinical investigators; it also offers an introduction to epidemiology for individuals with research experience in the behavioral and social sciences and for others without a clinical background. Research strengths include cancer epidemiology, cardiovascular disease epidemiology, infectious disease epidemiology, musculoskeletal disease epidemiology, neuroepidemiology, and aspects of epidemiologic methods, genetic epidemiology, reproductive epidemiology and women's health, and environmental and occupational epidemiology.

Two academic tracks lead to the M.S. degree; these tracks are not declared on Axess and they do not appear on the transcript or the diploma. The Clinical Research track is for physicians and others with specific interests in clinical and translational research. Students in this track receive training in epidemiologic methods, statistical analysis, and other areas essential to patient-oriented clinical research. These students are usually clinical investigators with an M.D. or comparable clinical degree, often in the fellowship stage of their postgraduate training, or in an early stage of faculty development. Typically, they are anticipating careers in academic medicine. The Traditional track serves students without prior clinical training. One category of such students consists of behavioral and social scientists who wish to bring an epidemiologic orientation to their research. Students pursuing a Ph.D. in these disciplines may wish to consider a concurrent master's degree in Epidemiology. The Traditional track also serves as an introduction to epidemiology for students with baccalaureate degrees who are considering careers in epidemiology or a related discipline.

University requirements for the M.S. degree are described in the "Graduate Degrees" section of this bulletin.

To receive the M.S. degree, students in both instructional tracks are expected to obtain a grounding in epidemiologic methods and applied biostatistics and to demonstrate research skills through the completion of a master's thesis. Required courses are HRP 225, Design and Conduct of Clinical and Epidemiologic Studies; HRP 226, Advanced Epidemiologic and Clinical Research Methods; HRP 236, Epidemiology Research Seminar, 3 units required); HRP 259, Introduction to Probability and Statistics for Epidemiology; HRP 261, Intermediate Biostatistics; HRP 262, Regression, Prediction, Survival Analysis; and a master's thesis with 12 or more units. Students in the Clinical Epidemiology track must also complete HRP 251, Design and Conduct of Clinical Trials; and MED 255, Responsible Conduct of Research. Students are required to select at least two other courses in Epidemiology. Students are assigned a methodology mentor, who is usually from the Department of Health Research and Policy, and a research mentor, who may be from another department. For the students in the Clinical Research Epidemiology track, the research mentor is often an affiliated faculty member from the department of the student's clinical specialty. Other programmatic requirements are described in *Graduate Program in Epidemiology, Information and Guidelines*, available from the educational coordinator in the Department of Health Research and Policy.

COURSES

The course listings of individual departments participating in the Graduate Interdisciplinary Program in Epidemiology should be consulted for complete descriptions.

GENETICS

Emeritus: (Professor) Luca Cavalli-Sforza, Leonard Herzenberg
Chair: Richard M. Myers
Professors: Russ Altman, Gregory Barsh, Stanley Cohen, Ronald Davis, Andrew Fire, Uta Francke, Margaret Fuller, Mark Kay, Stuart Kim, Joseph Lipsick, Richard Myers, John Pringle, Matthew Scott
Associate Professors: Michele Calos, Arend Sidow, Tim Stearns, Anne Villenueve, Douglas Vollrath
Assistant Professors: Laura Attardi, Julie Baker, Anne Brunet, James Ford, Julien Sage, Man-Wah Tan
Professor (Research): Leonore Herzenberg
Associate Professors (Research): J. Michael Cherry, Zijie Sun
Assistant Professor (Research): Gavin Sherlock
Courtesy Professor: Hank Greely
Consulting Professor: David Cox
Mail Code: 94305-5120
Phone: (650) 723-3335
Email: genetics-info@genome.stanford.edu
Web Site: http://genetics.stanford.edu/

Courses given in Genetics have the subject code GENE. For a complete list of subject codes, see Appendix.

GRADUATE PROGRAMS

University requirements for the Ph.D. degree are described in the "Graduate Degrees" section of this bulletin.

The Ph.D. program in the Department of Genetics offers graduate students the opportunity to pursue a discipline that encompasses both a set of tools and a coherent way of thinking about biology and medicine. All major areas of genetics are represented in the department, including human genetics (molecular identification of Mendelian traits and the pathophysiology of genetic disease, gene therapy, genetic epidemiology, analysis of complex traits, genetic anthropology, and human evolution), and application of model organisms such as bacteria, yeast, flies, worms, or mice to basic questions in biomedical research. The department is especially strong in genomic and bioinformatic approaches to genome biology and evolution, and includes several genome-scale databases such as the Saccharomyces Genome Database (SGD), the Stanford Microarray Database (SMD), and the Pharmacogenetics and Pharmacogenomics Knowledge Base (PharmGKB), the Stanford Human Genome Center (SHGC), and, administered through the Department of Biochemistry, the Stanford Genome Technology Center (SGTC).

Exposure to the intellectual scope of the department is provided by laboratory rotations, dissertation research, advanced courses in genetics and other areas of biomedical science, seminar series, journal clubs, and an annual three-day retreat of faculty, students, postdoctoral fellows, and staff scientists. Emphasis is placed on interactions and collaborations among students, postdoctoral students, and faculty within the department and throughout the campus.

During their first year, graduate students in the department take graduate courses and sample areas of research by doing rotations in three or four laboratories. At the end of the first three quarters, students may select a laboratory in which to do their dissertation research. While the dissertation research is generally performed in one laboratory, collaborative projects with more than one faculty member are encouraged. In addition to interacting with their faculty preceptor, graduate students receive advice regularly from other faculty members who serve as members of their dissertation committee. Study for the Ph.D. generally requires between four and five years of graduate work, most of which is focused on dissertation research.

Students are generally enrolled in the program to receive the Ph.D. degree, although a limited number of M.D. candidates can combine research training in genetics with their medical studies. Ph.D. candidates who have passed the qualifying exam in the second year can opt to receive the M.S. degree.

There are opportunities for graduate students to teach in graduate-level and professional-school courses. In addition, students are encouraged to participate in educational outreach activities coordinated by the department, which include opportunities to interact with secondary school students and teachers, lay groups, and local science museums.

Students who have recently received a bachelor's, master's, M.D., or Ph.D. degree in related fields may apply for graduate study. Prospective students must have a background in general biology, mathematics, physics, and chemistry. Decisions for admission are based on comparison of the relative merits of all the candidates' academic abilities and potential for research and the department's interest in promoting a diverse learning environment. Interviews take place in late February or early March and successful applicants are offered admission by early spring. Students who wish to pursue a combined M.D./Ph.D. degree are considered for admission into the graduate program in the Department of Genetics after they have been admitted to the M.D. program in the School of Medicine.

Students begin graduate studies in Autumn Quarter. Prospective students are encouraged to start the application process early to ensure that they are able to submit a complete application by the December deadline. All students accepted into the Ph.D. program in the Department of Genetics are provided with full tuition and a stipend. Two training grants from the National Institutes of Health provide major support for the graduate training program in the department. Other student support is provided by departmental funds and from research grants, both federal and private, of the faculty. In addition, a number of graduate students are funded by fellowships, including those from the National Science Foundation and the Stanford Graduate Fellows program.

COURSES

For further information on the availability of courses, consult the quarterly *Time Schedule*, or inquire at the departmental office. Additional courses in or related to genetics are included in the listings of the departments of Biological Sciences, Biochemistry, Developmental Biology, Microbiology and Immunology, Neuroscience, Biomedical Informatics, and Structural Biology.

GENE 106Q. The Heart of the Matter—(Same as BIOSCI 106Q.) Stanford Introductory Seminar. Preference to sophomores. The molecular and biochemical basis of life. Emphasis is on the methods and scientific logic that lead to advances in knowledge. The human heart and circulatory system is the unifying theme for topics such as the constituents and activities of cells, tissues, and organs; the chemicals and proteins that carry on life processes; the biotechnology revolution; the role of genes in

human disease and normal functions; and the Human Genome Project. How scientific knowledge is built up through research; how biology initiates advances in medicine; and how science, engineering, and economics interact in biotechnology. Student presentations, demonstrations, and field trips. GER: DB-NatSci

3 units, Win (Myers, R; Simoni, R)

GENE 109Q. Genomics: A Technical and Cultural Revolution—(Same as BIOMEDIN 109Q.) Stanford Introductory Seminar. Preference to sophomores. For non-science majors. Concepts of genomics, high-throughput methods of data collection, and computational approaches to analysis of data. The social, ethical, and economic implications of genomic science. Students may focus on computational or social aspects of genomics. Write-2

3 units, Win (Altman, R)

GENE 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

GENE 202. Human Genetics—Theoretical and experimental basis for the genetics of human health and disease. Molecular, chromosomal, biochemical, developmental, cancer, and medical genetics, emphasizing the last. Clinical case discussions. Prerequisites: biochemistry; basic genetics.

4 units, Aut (Ford, J; Myers, R)

GENE 203. Advanced Genetics—(Same as BIOSCI 203, DBIO 203.) For graduate students in Bioscience programs; may be appropriate for graduate students in other programs. The genetic toolbox. Examples of analytic methods, genetic manipulation, genome analysis, and human genetics. Emphasis is on use of genetic tools in dissecting complex biological pathways, developmental processes, and regulatory systems. Faculty-led discussion sections with evaluation of papers. Students with minimal experience in genetics should prepare by working out problems in college level textbooks.

4 units, Aut (Stearns, T; Barsh, G; Sidow, A; Kim, S)

GENE 206. Epigenetics—(Same as PATH 206.) For graduate students; undergraduates by consent of instructor. Mechanisms by which phenotypes not determined by the DNA sequence are stably inherited in successive cell divisions. From the discovery of position-effect variegation in Drosophila in the 20s to present-day studies of covalent modifications of histones and DNA methylation. Topics include: position effect, gene silencing, heterochromatin, centromere identity, genomic imprinting, histone code, variant histones, and the role of epigenetics in cancer. Prerequisite: background in genetics and molecular biology.

2 units, Win (Lipsick, J)

GENE 211. Genomics—Genome evolution, organization, and function; technical, computational, and experimental approaches; hands-on experience with representative computational tools used in genome science; and a beginning working knowledge of PERL.

3 units, Win (Cherry, J; Myers, R; Sidow, A; Sherlock, G)

GENE 212. Introduction to Biomedical Informatics Research Methodology—(Same as BIOE 212, BIOMEDIN 212, CS 272.) Hands-on software building. Student teams conceive, design, specify, implement, evaluate, and report on a software project in the domain of biomedicine. Creating written proposals, peer review, providing status reports, and preparing final reports. Guest lectures from professional biomedical informatics systems builders on issues related to the process of project management. Software engineering basics. Prerequisites: 210, 211 or 214, or consent of instructor.

3 units, Aut (Altman, R; Cheng, B; Klein, T; Garten, Y)

GENE 214. Representations and Algorithms for Computational Molecular Biology—(Same as BIOE 214, BIOMEDIN 214, CS 274.) Topics: algorithms for alignment of biological sequences and structures, computing with strings, phylogenetic tree construction, hidden Markov models, computing with networks of genes, basic structural computations on proteins, protein structure prediction, protein threading techniques, homology modeling, molecular dynamics and energy minimization, statistical analysis of 3D biological data, integration of data sources, knowledge representation and controlled terminologies for molecular biology, graphical display of biological data, machine learning (clustering and classification), and natural language text processing. Prerequisites: programming skills; consent of instructor for 3 units.

3-4 units, Spr (Altman, R)

GENE 215. Frontiers in Biological Research—(Same as BIOC 215, DBIO 215.) Literature discussion in conjunction with the Frontiers in Biological Research seminar series hosted by Biochemistry, Developmental Biology, and Genetics in which distinguished investigators present current work. Students and faculty meet beforehand to discuss papers from the speaker's primary research literature. Students meet with the speaker after the seminar to discuss their research and future direction, commonly used techniques to study problems in biology, and comparison between the genetic and biochemical approaches in biological research.

1 unit, Aut, Win (Harbury, P; Brunet, A; Villeneuve, A)

GENE 221. Current Issues in Aging—(Same as DBIO 221, NENS 221.) Current research literature on genetic mechanisms of aging in animals and human beings. Topics include: mitochondria mutations, insulin-like signaling, sirtuins, aging in flies and worms, stem cells, human progeria, and centenarian studies. Prerequisite: GENE 203.

1-2 units, Win (Kim, S; Brunet, A; Rando, T), Spr (Kim, S)

GENE 222. Method and Logic in Experimental Genetics—For graduate students only. How experimental strategies are applied to biological questions irrespective of discipline boundaries. Examples include purifying activities from complex mixtures, localizing molecules in space and time, discovering macromolecular interactions, inferences from sequence similarity, using structure to elucidate function, and applying genomics to biological problems. Weekly discussion of two representative papers selected by faculty and a student presentation of a third paper which illustrate principles of biochemistry and cell and molecular biology, and the historical context of important scientific advances.

3 units, Win (Baker, J; Brunet, A)

GENE 233. The Biology of Small Modulatory RNAs—(Same as MI 233, PATH 233.) Open to graduate and medical students. How recent discoveries of miRNA, RNA interference, and short interfering RNAs reveal potentially widespread gene regulatory mechanisms mediated by small modulatory RNAs during animal and plant development. Required paper proposing novel research.

2 units, Aut (Fire, A; Chen, C), alternate years, not given next year

GENE 235. *C. Elegans* Genetics—Genetic approaches to *C. elegans*, practice in designing experiments and demonstrations of its growth and anatomy. Probable topics include: growth and genetics, genome map and sequence, mutant screens that start with a desired phenotype, reverse genetics and RNAi screens, genetic duplications, uses of null phenotype non-null alleles, genetic interactions and pathway analysis, and embryogenesis and cell lineage. Focus of action, mosaic analysis, and interface with embryological and evolutionary approaches.

2 units, Win (Fire, A), not given next year

GENE 238. Current Concepts and Dilemmas in Genetic Testing—(Same as INDE 238.) Issues arising from the translational process from research to commercialization. Diagnostic inventions and applications, community implications, newborn screening, cancer genetics, and pharmacogenomics. Guest experts. For M.D., biomedical graduate, and genetic counseling students.

2 units, Spr (Tobin, S; Schrijver, I; Cowan, T; Magnus, D)

GENE 244. Introduction to Statistical Genetics—Statistical methods for analyzing human genetics studies of Mendelian disorders and common complex traits. Probable topics include: principles of population genetics; epidemiologic designs; familial aggregation; segregation analysis; linkage analysis; linkage-disequilibrium-based association mapping approaches; and genome-wide analysis based on high-throughput genotyping platforms. Prerequisite: STATS 116 or equivalent or consent of instructor.

3 units, Aut (Tang, H)

GENE 260. Supervised Study—Genetics graduate student lab research from first quarter to filing of candidacy. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

GENE 299. Directed Reading in Genetics—Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

GENE 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

COGNATE COURSE

See respective department listings for course descriptions. See degree requirements above or the program's student services office for applicability of this course to a major or minor program.

MED 255. The Responsible Conduct of Research
1 unit, Aut, Win, Spr, Sum (Karkazis, K)

HEALTH RESEARCH AND POLICY

Emeriti: (Professors) Dan Bloch, John Farquhar, Victor R. Fuchs
Chair: Phil Lavori
Co-Chair: Robert Tibshirani
Professors: Bradley Efron, Trevor Hastie, Victor W. Henderson, Mark Hlatky, Iain M. Johnstone, Abby C. King, Philip W. Lavori, Richard A. Olshen, Julie Parsonnet, Robert Tibshirani, Alice S. Whittemore, Dee W. West, Wing Wong
Associate Professors: Laurence Baker, Lorene M. Nelson, David Rogosa
Assistant Professors: M. Kate Bundorf, Marc Coram, Mei-Chiung Shih
Assistant Professors (Clinical): Rita Popat, Kristin Sainani
Courtesy Professors: Stephen P. Fortmann, Alan M. Garber, Mary Goldstein, Daniel Kessler, Alex Macario, Douglas Owens, Paul Wise
Courtesy Associate Professors: Michael K. Gould, Paul Heidenreich, Yvonne Maldonado, Mark McClellan (on leave), David R. Rogosa, Marilyn Winkleby
Courtesy Assistant Professors: Jay Bhattacharya, Grant Miller
Senior Lecturer: Irene Corso
Lecturers: Raymond Balise, Ellen Chang, Christina Clarke-Dur, Scarlett Gomez, Laurel Habel, Lisa Herrington, Theresa Keegan, De Kun Li, David Lilienfeld, Cynthia O'Malley, Caroline Tanner, Stephen Van Den Eeden
Consulting Professors: Gary Friedman, Elizabeth Holly, Marion Lee, George Lundberg, Peggy Reynolds, Joseph Selby
Consulting Associate Professors: Paul Barnett, Sally Glaser, Pamela Horn-Ross, Esther John, Ciaran Phibbs
Consulting Assistant Professors: Ellen Chang, Christina Clarke-Dur, Theresa Keegan, Bang Nguyen, Ingrid Oakley-Girvan, Rudy Rull, Todd Wagner
Mail Code: 94305-5405
Phone: (650) 723-5456
Web Site: http://hrp.stanford.edu/

Courses given in Health Research and Policy have the subject code HRP. For a complete list of subject codes, see Appendix.

The Department of Health Research and Policy has three principal areas of scholarly interest:

1. Biostatistics deals with scientific methodology in the medical sciences, emphasizing the use of statistical techniques.
2. Epidemiology is the study of the distribution and determinants of illness and impairment in human populations. Epidemiology training provides analytic tools for clinical and translational research, including studies of disease etiology, prevention, and therapy.
3. Health Services Research is concerned with many aspects of health policy analysis in the public and private sectors.

GRADUATE PROGRAMS

The Program in Epidemiology and the Program in Health Services Research are housed in the Department of Health Research and Policy. These programs, which offer M.S. degrees in Epidemiology and in Health Services Research, are described separately in the relevant sections of this bulletin. Students with an interest in pursuing advanced degrees with an emphasis on biostatistics can do so through programs offered by the Department of Statistics. Division of Biostatistics faculty participate in these programs.

For additional information, address inquiries to the Educational Coordinator, Department of Health Research and Policy, Stanford University School of Medicine, HRP Redwood Building, Room T138C, Stanford, California 94305-5405.

COURSES

Course and lab instruction in the Department of Health Research and Policy conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www. stanford.edu/dept/DoR/rph/8-2.html.

HRP 89Q. Introduction to Crosscultural Issues in Medicine—Stanford Introductory Seminar. Preference to sophomores. Crosscultural issues that impact health care delivery such as ethnicity, immigration, language barriers, and service expectations. Focus is on culturally unique and non-English speaking populations and developing interpersonal and communication skills with diverse ethnic groups. GER:EC-AmerCul
3 units, Win (Corso, I)

HRP 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

HRP 207,208. Issues and Methods of Health Services and Policy Research—Primarily for students in the Health Services and Policy Research scholarly track. Health care systems and institutions, health insurance, regulation, cost effectiveness analysis, and medical decision making.
2 units, **207:** *Aut (Baker, L; McDonald, K; Haberland, C),*
208: *offered occasionally*

HRP 209. FDA's Regulation of Health Care—(Same as LAW 458.) Open to law or medical students; graduate students by consent of instructor. The FDA's regulatory authority over drugs, biologics, medical devices, and dietary supplements. The nature of the pharmaceutical, biotech, medical device, and nutritional supplement industries.
3-4 units, Win (Greely, H)

HRP 210. Health Law and Policy I—(Same as LAW 313.) Open to law or medical students and to qualified undergraduates by consent of instructor. Introduction to the American health care system and its legal and policy problems. Topics: the special characteristics of medical care compared to other goods and services, the difficulties of assuring quality care, the complex patchwork of the financing system, and the ethical problems the system raises.
3-4 units, Aut (Greely, H)

HRP 211. Law and the Biosciences—(Same as LAW 368.) For medical students; graduate students by consent of instructor. Legal, social, and ethical issues arising from advances in the biosciences. Focus is on human genetics; also advances in assisted reproduction and neuroscience. Topics include forensic use of DNA, genetic testing, genetic discrimination, eugenics, cloning, pre-implantation genetic diagnosis, neuroscientific methods of lie detection, and genetic or neuroscience enhancement.
3 units, Win (Greely, H)

HRP 212. Crosscultural Medicine—Interviewing and behavioral skills needed to facilitate culturally relevant health care across all population groups. Explicit and implicit cultural influences operating in formal and informal medical contexts.
3 units, Spr (Corso, I)

HRP 213. Research Protocol Development for Clinical and Translational Research—Primarily for medical students in the Clinical Research Scholarly concentration; open to graduate students except in Epidemiology. Development of research questions and plans for statistical analysis. Study design, sample size and power calculations, and statistical analysis of study data. Analytic methods to carry out statistical power and sample size calculations. Prerequisites: 225, and 258 or 259, or consent of instructor.

2-3 units, not given this year

HRP 214. Scientific Writing—Step-by-step through the process of writing and publishing a scientific manuscript. How to write effectively, concisely, and clearly. Preparation of an actual scientific manuscript. Students are encouraged to bring a manuscript on which they are currently working to develop and polish throughout the course.

2-3 units, Win (Sainani, K)

HRP 215. Scientific Writing for Basic and Translational Scientists—Teaches students in the basic sciences how to write clearly, concisely, and effectively. Focuses on the process of writing and publishing a scientific manuscript. Not intended for epidemiology graduate students.

2-3 units, not given this year

HRP 216. Analytical and Practical Issues in the Conduct of Clinical and Epidemiologic Research—Topics include: advanced aspects of study design and data analyses; development of health measurement instruments; methods of summarizing literature and quantifying effect sizes; and multivariable nature of health events in human populations. 3 units requires a term paper. Prerequisites: 225, and 258 or 259, or consent of instructor.

2-3 units, Spr (Popat, R)

HRP 223. Epidemiologic Analysis: Data Management and Statistical Programming—The skills required for management and analysis of biomedical data. Topics include importing and exporting data from multiple database systems, visualizing and cleaning data, data management for multicenter projects, and data security. Introduction to applied statistical programming relevant to epidemiologic and clinical research. No previous programming experience required.

2-3 units, Aut (Balise, R)

HRP 225. Design and Conduct of Clinical and Epidemiologic Studies—Intermediate-level. The skills to design, carry out, and interpret epidemiologic studies, particularly of chronic diseases. Topics: epidemiologic concepts, sources of data, cohort studies, case-control studies, cross-sectional studies, sampling, estimating sample size, questionnaire design, and the effects of measurement error. Prerequisite: 159/259 or equivalent, or consent of instructor.

3-4 units, Aut (Popat, R)

HRP 226. Advanced Epidemiologic and Clinical Research Methods—The principles of measurement, measures of effect, confounding, effect modification, and strategies for minimizing bias in epidemiologic studies. Prerequisite: 225 or consent of instructor.

3-4 units, Win (Nelson, L)

HRP 229. Chronic Disease Epidemiology—Descriptive epidemiology and sources of incidence and mortality data; biological bases of neurological, musculoskeletal, cardiovascular, and other chronic diseases except cancer; methodological issues relevant to chronic epidemiologic research; causal inference; major environmental risk factors; genetic susceptibility; and examples of current research and critiques of literature. Prerequisite: 225 or consent of instructor.

2-3 units, alternate years, not given this year

HRP 230. Cancer Epidemiology—Descriptive epidemiology and sources of incidence/mortality data; the biological basis of carcinogenesis and its implications for epidemiologic research; methodological issues relevant to cancer research; causal inference; major environmental risk factors; genetic susceptibility; cancer control; examples of current research; and critique of the literature. 3 units requires paper or project. Prerequisite: 225, or consent of instructor.

2-3 units, Win (West, D)

HRP 231. Epidemiology of Infectious Diseases—Principles of the transmission of the infectious agents (viruses, bacteria, rickettsiae, mycoplasma, fungi, and protozoan and helminth parasites). The role of vectors, reservoirs, and environmental factors. Pathogen and host characteristics that determine the spectrum of infection and disease. Endemicity, outbreaks, and epidemics of selected infectious diseases. Principles of control and surveillance.

3 units, alternate years, not given this year

HRP 234. Foundations of Pharmacoepidemiology—Historical development of the field, the drug development process and pharmacoepidemiology's role in it, pharmacovigilance/drug safety systems, epidemiology in outcomes research, the role of pharmacoepidemiology in risk management, and classic examples of pharmacoepidemiologic investigations.

2-3 units, alternate years, not given this year

HRP 236. Epidemiology Research Seminar—Weekly forum for ongoing epidemiologic research by faculty, staff, guests, and students, emphasizing research issues relevant to disease causation, prevention, and treatment. May be repeated for credit.

1 unit, Aut, Win, Spr (Friedman, G; Henderson, V; Whittemore, A)

HRP 239. Understanding Statistical Models and their Social Science Applications—(Same as EDUC 260X, STATS 209.) Information that statistical modeling can provide in experimental and non-experimental settings emphasizing misconceptions in social science applications such as causal modeling. Text is *Statistical Models: Theory and Practice*, by David Freedman. See http://www-stat.stanford.edu/~rag/stat209. Prerequisite: intermediate-level statistical methods including multiple regression, logistic regression, and log-linear models.

3 units, Win (Rogosa, D)

HRP 251. Design and Conduct of Clinical Trials—The rationale for phases 1-3 clinical trials, the recruitment of subjects, techniques for randomization, data collection and endpoints, interim monitoring, and reporting of results. Emphasis is on the theoretical underpinnings of clinical research and the practical aspects of conducting clinical trials.

3 units, Spr (Henderson, V; Lavori, P)

HRP 252. Outcomes Analysis—(Same as BIOMEDIN 251.) Methods of conducting empirical studies which use large existing medical, survey, and other databases to ask clinical and policy questions. Econometric and statistical models used to conduct medical outcomes research. How research is conducted on medical and health economics questions when a randomized trial is impossible. Problem sets emphasize hands-on data analysis and application of methods, including re-analyses of well-known studies. Prerequisites: one or more courses in probability, and statistics or biostatistics.

3 units, Spr (Bhattacharya, J)

HRP 256. Economics of Health and Medical Care—(Same as BIOMEDIN 156/256, ECON 126.) Graduate students with research interests should take ECON 248. Institutional, theoretical, and empirical analysis of the problems of health and medical care. Topics: institutions in the health sector; measurement and valuation of health; nonmedical determinants of health; medical technology and technology assessment; demand for medical care and medical insurance; physicians, hospitals, and managed care; international comparisons. Prerequisite: ECON 50 and 102A or equivalent statistics, or consent of instructor. Recommended: ECON 51.

5 units, Aut (Bhattacharya, J)

HRP 258. Introduction to Probability and Statistics for Clinical Research—Open to medical and graduate students; required of medical students in the Clinical Research Scholarly Concentration. Tools to evaluate medical literature. Topics include random variables, expectation, variance, probability distributions, the central limit theorem, sampling theory, hypothesis testing, confidence intervals, correlation, regression, analysis of variance, and survival analysis.

3 units, Spr (Sainani, K)

HRP 259. Introduction to Probability and Statistics for Epidemiology—Topics: random variables, expectation, variance, probability distributions, the central limit theorem, sampling theory, hypothesis testing,

confidence intervals. Correlation, regression, analysis of variance, and nonparametric tests. Introduction to least squares and maximum likelihood estimation. Emphasis is on medical applications.

4-5 units, Aut (Balise, R)

HRP 260A,B,C. Workshop in Biostatistics—(Same as STATS 260A,B,C) Applications of statistical techniques to current problems in medical science. Enrollment for more than 2 units of credit involves extra reading or consulting and requires consent of instructor.

1-2 units, **A:** *Aut,* **B:** *Win,* **C:** *Spr (Olshen, R)*

HRP 261. Intermediate Biostatistics: Analysis of Discrete Data—(Same as BIOMEDIN 233, STATS 261.) The 2x2 table. Chi-square test. Fisher's exact test. Odds ratios. Sampling plans; case control and cohort studies. Series of 2x2 tables. Mantel Hantzel. Other tests. k x m tables. Matched data logistic models. Conditional logistic analysis, application to case-control data. Log-linear models. Generalized estimating equations for longitudinal data. Cell phones and car crashes: the crossover design. Special topics: generalized additive models, classification trees, bootstrap inference.

3 units, Win (Sainani, K)

HRP 262. Intermediate Biostatistics: Regression, Prediction, Survival Analysis—(Same as STATS 262.) Methods for analyzing longitudinal data. Topics include Kaplan-Meier methods, Cox regression, hazard ratios, time-dependent variables, longitudinal data structures, profile plots, missing data, modeling change, MANOVA, repeated-measures ANOVA, GEE, and mixed models. Emphasis is on practical applications. Prerequisites: basic ANOVA and linear regression.

3 units, Spr (Sainani, K)

HRP 280,281,282. Spanish for Medical Students—(Same as SPANLANG 121M,122M,123M.) Goal is a practical and rapid command of spoken Spanish. Topics: the human body, hospital procedures, diagnostics, food, and essential phrases for on-the-spot reference when dealing with Spanish-speaking patients. Series can be taken independently, depending on the level of prior knowledge.

3 units, **280:** *Aut,* **281:** *Win (Corso, I),* **282:** *Spr (Corso, I)*

HRP 283. Health Services Research Core Seminar—Presentation of research in progress and tutorials in the field of health services research.

1 unit, Aut (Bundorf, M; Baker, L), Win (McDonald, K), Spr (Baker, L; Hlatky, M), Sum (McDonald, K)

HRP 290. Advanced Spanish Conversation—Oral language skills covering pediatric, gynecological, and other specialty exams; patient health education and counseling; and diseases such as diabetes, asthma, and TB. Prerequisite: Spanish proficiency or consent of instructor.

3 units, Aut, Win, Spr (Corso, I)

HRP 299. Directed Reading in Health Research and Policy—Epidemiology, health services research, preventive medicine, medical genetics, public health, economics of medical care, occupational or environmental medicine, international health, or related fields. May be repeated for credit. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

HRP 351. Innovation and Management in Health Care—(Same as GSBGEN 351.) The workings of the major institutions such as hospitals, health insurance companies, HMOs, Medicare and Medicaid, federal regulators, and the medical establishment. National health expenditures and alternative models for healthcare financing and delivery. Trends in treatment innovations provided by biopharmaceuticals, medical devices, and surgical procedures; delivery innovations facilitated by information systems and new processes. Policy and business challenges raised by these innovations and the health care ecosystems they promote.

4 units, Win (Zenios, S; Chess, R)

HRP 391. Political Economy of Health Care in the United States—(Same as MGTECON 331, PUBLPOL 231.) The economic tools and institutional and legal background to understand how markets for health care products and services work. Moral hazard and adverse selection. Institutional organization of the health care sector. Hospital and physician services markets, integrated delivery systems, managed care, pharmaceutical and medical device industries. Public policy issues in health care, medical ethics, regulation of managed care, patients' bill of rights, regulation of pharmaceuticals, Medicare reform, universal health insurance, and coverage of the uninsured. International perspectives, how other countries' health care systems evolved, and what the U.S. can learn from their experiences.

4 units, Spr (Kessler, D; Bundorf, K)

HRP 392. Analysis of Costs, Risks, and Benefits of Health Care—(Same as BIOMEDIN 432, MGTECON 332) For graduate students. The principal evaluative techniques for health care, including utility assessment, cost-effectiveness analysis, cost-benefit analysis, and decision analysis. Emphasis is on the practical application of these techniques. Group project presented at end of quarter. Guest lectures by experts from the medical school, pharmaceutical industry, health care plans, and government.

4 units, Aut (Garber, A; Owens, D)

HRP 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

HEALTH SERVICES RESEARCH PROGRAM

Director: Mark Hlatky (Professor, Health Research and Policy, and Medicine)

Executive Committee: Laurence Baker (Associate Professor, Health Research and Policy), M. Kate Bundorf (Assistant Professor, Health Research and Policy), Alan Garber (Professor, Medicine), Mary Goldstein (Professor, Medicine), Mark Hlatky (Professor, Health Research and Policy, and Medicine), Douglas Owens (Professor, Medicine)

Participating Faculty and Staff by Department:

Anesthesia: Alex Macario (Professor)

Economics: Mark McClellan (Associate Professor, on leave)

Business: Alain Enthoven (Professor, emeritus), Daniel Kessler (Professor)

Health Research and Policy: Laurence Baker (Associate Professor), Paul Barnett (Consulting Associate Professor), M. Kate Bundorf (Assistant Professor), Victor Fuchs (Professor, emeritus), Trevor Hastie (Professor), Mark Hlatky (Professor), Philip Lavori (Professor), Richard Olshen (Professor), Ciaran Phibbs (Consulting Associate Professor), Joseph Selby (Consulting Professor), Robert Tibshirani (Professor)

Law: Henry Greely (Professor)

Management Science and Engineering: Margaret Brandeau (Professor)

Medicine: Jay Bhattacharya (Assistant Professor), Alan Garber (Professor), Mary Goldstein (Professor), Michael Gould (Associate Professor), Paul Heidenreich (Associate Professor), Mark Hlatky (Professor), Mark McClellan (Associate Professor, on leave), Grant Miller (Assistant Professor) Douglas Owens (Professor)

Pediatrics: Paul Wise (Professor)

Psychiatry: Rudolph Moos (Professor)

Sociology: Richard Scott (Professor, emeritus)

Program Offices: HRP Redwood Building, Room T138C
Mail Code: 94305-5405
Phone: (650) 723-5456
Email: hsr-program@med.stanford.edu
Web Site: http://med.stanford.edu/hsr/

GRADUATE PROGRAM

MASTER OF SCIENCE

The Master's Degree Program in Health Services Research seeks to train students in the quantitative analysis of issues in health and medical care. The program emphasizes an individually designed program of course work and completion of a master's project under the mentorship of a faculty

member. The typical student in the program is either a physician who has completed residency training and is preparing for a research career, or a student with a strong background in policy analysis who wishes to focus on problems in health or medical care. Faculty interests include outcomes research, health economics, health care organization, health care access, quality of care, decision analysis, clinical guidelines, and assessment of patient preferences and quality of life.

To receive the degree, students are expected to demonstrate knowledge of issues in health services research and the quantitative skills necessary for research in this area. Students must take at least 45 units of course work (9 of the units may be double-counted to meet other degree requirements) and write a University thesis. The course work requirements are:

1. At least 8 units from the following group of Health Research and Policy (HRP) core courses: 256, Economics of Health and Medical Care; 391, Political Economy of Health Care in the United States; 392, Analysis of Costs, Risks, and Benefits in Health Care.
2. At least 6 units of graduate-level statistics courses. The sequence of HRP 261 and 262 is strongly recommended.
3. At least 3 units of HRP 283, Health Services Research Core Seminar.
4. At least 15 units of HRP research credit from 299, Directed Reading, or 399, Research.
5. An additional set of approved elective courses to complete the program total of at least 45 units.

For additional information, address inquiries to the Educational Coordinator, Department of Health Research and Policy, Stanford University School of Medicine, HRP Redwood Building, Room T138C, Stanford, California 94305-5405.

COURSES

The course listings of individual departments participating in the Health Services Research Program should be consulted for complete descriptions.

IMMUNOLOGY PROGRAM

Chair, Executive Committee for the Immunology Program: Lawrence Steinman (Professor, Neurology and Neurological Sciences)

Director for Immunology Program: K. Christopher Garcia (Associate Professor, Microbiology and Immunology)

Director for Clinical Immunology Program: C. Garrison Fathman (Medicine/Immunology and Rheumatology)

Participating Departments and Faculty:

Biological Sciences: Anthony W. De Tomaso (Assistant Professor), Patricia P. Jones (Professor)

Chemistry: Harden M. McConnell (Professor, emeritus)*

Genetics: Leonard A. Herzenberg (Professor, emeritus), Lenore A. Herzenberg (Professor, Research), Man-wah Tan (Assistant Professor)

Medicine/Bone Marrow Transplantation Program: Robert Negrin (Professor), David Miklos (Assistant Professor), Judith Shizuru (Associate Professor)

Medicine/Endocrinology: Ajay Chawla (Assistant Professor)

Medicine/Hematology: Calvin Kuo (Assistant Professor), Peter Lee (Associate Professor)

Medicine/Immunology and Rheumatology: C. Garrison Fathman (Professor), William Robinson (Assistant Professor), Samuel Strober (Professor), Paul J. Utz (Associate Professor)

Medicine/Oncology: Gilbert Chu (Professor, and Biochemistry), Dean Felsher (Associate Professor, and Pathology), Ronald Levy (Professor), Shoshana Levy (Professor, Research)

Microbiology and Immunology: Chang-Zheng Chen (Assistant Professor), Yueh-Hsiu Chien (Professor), Mark M. Davis (Professor), Hugh McDevitt (Professor), Garry P. Nolan (Professor), David Schneider (Assistant Professor)

Molecular and Cellular Physiology: K. Christopher Garcia (Associate Professor, and Structural Biology), Richard S. Lewis (Professor)

Neurology and Neurological Sciences: Lawrence Steinman (Professor, and Pediatrics), Tony Wyss-Coray (Associate Professor)

Pathology: Eugene C. Butcher (Professor), Michael Cleary (Professor), Gerald R. Crabtree (Professor, and Developmental Biology), Edgar G. Engleman (Professor, and Medicine/Immunology and Rheumatology), Magali Fontaine (Assistant Professor), Joseph S. Lipsick (Professor), Sara Michie (Associate Professor), Raymond A. Sobel (Professor), Irving L. Weissman (Professor, and Developmental Biology)

Pediatrics: Ann Arvin (Professor, and Microbiology and Immunology), Christopher Contag (Associate Professor, Research, and Microbiology and Immunology, and Radiology), David B. Lewis (Professor), Elizabeth Mellins (Associate Professor)

Psychiatry and Behavioral Sciences: Firdaus Dhabhar (Associate Professor)

Structural Biology: Peter Parham (Professor, and Microbiology and Immunology)

Surgery: Sheri Krams (Associate Professor, Research), Olivia Martinez (Professor, Research)

* Recalled to active duty

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Web Site: http://immunol.stanford.edu/

Courses given in Immunology have the subject code IMMUNOL. For a complete list of subject codes, see Appendix.

GRADUATE PROGRAMS

MASTER OF SCIENCE

Students in the Ph.D. program in Immunology may apply for an M.S. degree in Immunology, assuming completion of appropriate requirements. Students must complete:

1. Three full-tuition quarters of residency as a graduate student at Stanford.
2. At least 45 units of academic work, all of which must be in courses at or above the 100 level, 36 units of which must be at or above the 200 level.
3. 2-3 quarters of graduate research (IMMUNOL 399), consisting of rotations in the labs of 3 faculty members.
4. Course work in Immunology as follows: basic immunology (BIOSCI 230, IMMUNOL 205 or equivalent), advanced Immunology such as IMMUNOL 201, 200, and 203. In addition, the student may take one elective course. Some possible electives are: MPHA 210, Signal Transduction Pathways and Networks, SBIO 241, Biological Macromolecules, Cancer Biology, CBIO 241, or DBIO 210, Developmental Biology. Other required core courses are: GENE 203, Advanced Genetics, IMMUNOL 215, Principles of Biological Technologies, MCP 221, Cell Biology of Physiological Processes.
5. Graduate-level biochemistry and molecular biology (BIOC 187, 200, 201, or equivalents).
6. Course work in IMMUNOL 311, Seminar in Immunology, and IMMUNOL 311A, Seminar Discussion in Immunology.
7. Participation in the Immunology journal club (IMMUNOL 305), and attendance at the weekly Immunology seminar and at the annual Stanford Immunology Scientific Conference.
8. The qualifying examination process in Immunology before admission to Ph.D. candidacy has two parts: an oral exam on many fields in immunology, part I, in the last week in June, first year; the thesis proposal, part II, before December 17th, second year. In addition, an oral presentation is required on the research of one rotation, mid-July, first year.

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described in the "Graduate Degrees" section of this bulletin.

The Immunology Program offers instruction and research opportunities leading to a Ph.D. in Immunology. The goal of the program is to develop investigators who have a solid foundation in immunology and related

sciences to carry out innovative research. The program features a flexible choice of courses and seminars combined with extensive research training in the laboratories of participating Immunology faculty.

Students applying to the program typically have an undergraduate major in biological sciences, but majors in other areas are acceptable if the applicants have had sufficient course work in biology and chemistry. Formal application should be made by December 4. Applications are evaluated by the Immunology predoctoral committee based upon: GRE scores; grades; evi dence of research experience; letters of recommendation, including letters from research sponsor(s); and commitment to a career in biomedical research. Subject tests are not required. Interested Stanford medical students are welcome to apply to the program and should submit a formal application by December 4.

Students admitted to the program are offered financial support covering tuition, a living stipend, insurance coverage, and an allowance for books/travel. Applicants are urged to apply for independent fellowships such as from the National Science Foundation. Fellowship applications are due in November of the year prior to matriculation in the graduate program, but Immunology graduate students may continue to apply for outside fellowships after matriculation. Because of the small number of department-funded slots, students who have been awarded an outside fellowship have an improved chance of acceptance into the program. On matriculation, each student is assisted by a first-year advising committee in selecting courses and lab rotations in the first year and in choosing a lab for the dissertation research. Once a dissertation adviser has been selected, a dissertation committee including at least two Immunology faculty, and including the dissertation adviser, is constituted to guide the student during the dissertation research. The student must meet with the dissertation committee at least once a year.

Candidates for Ph.D. degrees at Stanford must satisfactorily complete a three-year program of study that includes 72 units of graduate course work and research. At least 3 units must be taken with each of four different Stanford faculty members.

The requirements for the Ph.D. degree in Immunology include:

1. Training in biology and cognate disciplines equivalent to that provided by the undergraduate Biology major at Stanford.
2. Completion of the following courses (or their equivalents from undergraduate work):
   a) Basic Immunology (BIOSCI 230)
   b) Advanced Immunology (IMMUNOL 201, 202, 203)
   c) Biochemistry and Molecular Biology (BIOC 187, 200, or 201)
   d) Advanced Genetics (GENE 203)
   e) Cell Biology of Physiological Processes (MCP 221)
   f) Biostatistics (BIOSCI 141)
   g) Principles of Biological Technologies (IMMUNOL 215)
   h) One elective course; suggested courses include: MPHA 210, Signal Transduction Pathways and Networks; SBIO 241, Biological Macromolecules; CBIO 241, Cancer Biology; DBIO 210, Developmental Biology.
   i) Responsible Conduct in Science (MED 255)
   j) Immunology Journal Club (IMMUNOL 305)
3. First-year students are required to take both the IMMUNOL 311, Seminar in Immunology, and the companion course, IMMUNOL 311A, Seminar Discussion in Immunology, and participate in IMMUNOL 305, Immunology Journal Club. Students in their second year and above must participate in the IMMUNOL 311, Seminar in Immunology and may opt to take the companion course, IMMUNOL 311A. Students who have not yet achieved TGR status must register for 1 unit for IMMUNOL 311. Students attend the weekly Immunology Seminar Series (4-5 p.m., Tuesdays). Students read the papers of and have dinner with visiting seminar speakers two or three times each quarter, and meet to discuss the material.
4. Elective courses as agreed upon by the student, adviser, and advisory committee. Electives may be chosen from graduate courses and seminars in any of the biomedical science departments and programs.
5. Completion in the first year of three one quarter rotations. Two weeks after taking the oral examination (part 1 of the qualifying examination) at the end of June, students, including MSTP and M.D./Ph.D. students, present their lab rotation research projects to the predoctoral committee. Medical students who have declared Immunology as their scholarly concentration major, and who are accepted into the Ph.D. program, must do at least three rotations.
6. Teaching assistantship in two Immunology courses (IMMUNOL 290, Teaching in Immunology). A teaching assistantship requirement may be fulfilled by proposing a graduate student-initiated course IMMUNOL 315, Topics in Immunology. Before fulfilling their teaching assistantships, Immunology graduate students are required to undertake a teaching assistantship workshop offered at the beginning of every quarter by the Center for Teaching and Learning. MSTP students may submit one of their medical school TAships as partial fulfillment of the TA requirement for the Ph.D. in immunology.
7. For admission to candidacy, completion of two requirements by the end of the Autumn Quarter of the second year: a rotation presentation on one of three lab rotations, and a comprehensive oral examination in immunology and related biomedical sciences must be completed satisfactorily by the middle of Summer Quarter of the first year. Finally, students must prepare and defend a research proposal on their dissertation research by December 17, the end of Autumn Quarter of their second year. Administration and evaluation of these requirements is the responsibility of the student's dissertation committee.
8. Participation (through regular attendance and oral presentation) in the student-run immunology journal clubs for at least the first 2 years (IMMUNOL 305). First- through fourth-year students are also expected to attend the graduate students' journal club, the Tuesday evening immunology seminars, and the annual Stanford Immunology Scientific Conference at Asilomar. Students are required to give one poster and one scientific presentation at these annual Stanford Immunology scientific conferences.
9. Passing the University oral examination on the dissertation research, which is to be taken only after the student has substantially completed the research. The examination is preceded by a public seminar in which the candidate presents his/her research.
10. Completion of a Ph.D. dissertation, resulting from independent investigation and constituting a contribution to knowledge in the area of immunology.

COURSES

Course and lab instruction in the Immunology Program conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

IMMUNOL 201. Advanced Immunology I—(Same as MI 211.) For graduate and medical students and advanced undergraduates. Molecules and cells of the innate and adaptive immune systems; genetics, structure, and function of immune molecules; lymphocyte differentiation and activation; regulation of immune responses; autoimmunity and other problems in immune system dysfunction. Prerequisites: undergraduate course in Immunology and familiarity with experimental approaches in biochemistry, molecular biology, and cell biology.

3 units, Win (Chien, Y)

IMMUNOL 202. Advanced Immunology II—(Same as MI 212.) Readings of immunological literature. Classic problems and emerging areas based on primary literature. Student and faculty presentations. Prerequisite: IMMUNOL 201.

3 units, Spr (Garcia, K)

IMMUNOL 203. Advanced Immunology III—Key experiments and papers in immunology. Student presentations and faculty participation; faculty describe their experimental process and scientific papers. Prerequisite: IMMUNOL 201/MI 211 or IMMUNOL 202/MI 212.

3 units, Sum (Staff)

IMMUNOL 205. Immunology in Health and Disease—Concepts and application of adaptive and innate immunology and the role of the immune system in human diseases. Case presentations of diseases including autoimmune diseases, infectious disease, transplantation, genetic and acquired immunodeficiencies, hypersensitivity reactions, and allergic diseases. Problem sets based on lectures and current clinical literature. Laboratory in acute and chronic inflammation.

2-4 units, Win (Lewis, D)

IMMUNOL 215. Principles of Biological Technologies—(Same as MI 215.) Required of first-year graduate students in Microbiology and Immunology, and the Immunology program. The principles underlying commonly utilized technical procedures in biological research. Lectures and primary literature critiques on gel electrophoresis, protein purification and stabilization, immunofluorescence microscopy, FACS. Prerequisites: biochemistry, organic chemistry, and physics.

3 units, Spr (Kirkegaard, K)

IMMUNOL 230. Introduction to Medicine—For graduate students in biological sciences, bioengineering, and biomedical informatics. Information and approaches used by physicians to understand human disease. Focus is on diabetes; attention to other diseases. Guest medical school and outside faculty. Field trip to anatomy lab, clinics, and the clinical laboratory. Quarter-long, team projects addressing current medical issues.

2-4 units, Spr (Mellins, E; Aye, T)

IMMUNOL 230A. Independent Study in Medical Sciences—For doctoral students. Completion of team projects begun in 230.

1-4 units, Aut, Win, Spr, Sum (Mellins, E; Aye, T)

IMMUNOL 290. Teaching in Immunology—Practical experience in teaching by serving as a teaching assistant in an immunology course. Unit values are allotted individually to reflect the level of teaching responsibility assigned to the student. May be repeated for credit.

1-15 units, Aut, Win, Spr, Sum (Staff)

IMMUNOL 299. Directed Reading in Immunology—Prerequisite: consent of instructor.

1-15 units, Aut, Win, Spr, Sum (Staff)

IMMUNOL 305. Immunology Journal Club—Required of first- to fourth-year graduate students. Graduate students present and discuss recent papers in the literature. May be repeated for credit.

1 unit, Aut, Win, Spr (Steinman, L)

IMMUNOL 311. Seminar in Immunology—Enrollment limited to Ph.D., M.D./Ph.D., and medical students whose scholarly concentrations are in Immunology. Current research topics.

1 unit, Aut, Win, Spr (Steinman, L; Fathman, C)

IMMUNOL 311A. Discussions in Immunology—Students discuss papers of speakers in 311, and meet with the speakers. Corequisite: 311.

1 unit, Aut, Win, Spr (Steinman, L; Fathman, C)

IMMUNOL 315. Special Topics in Immunology—Graduate student-initiated seminar in journal club style. Previous topics include evolutionary immunology and the principles of vaccine development, cytokines, tumor immunology, and neuroimmunology. May be repeated for credit.

1-4 units, Aut, Win, Spr, Sum (Staff)

IMMUNOL 399. Graduate Research—For Ph.D., M.D./Ph.D. students, and medical students whose scholarly concentrations are in Immunology.

1-15 units, Aut, Win, Spr, Sum (Staff)

MICROBIOLOGY AND IMMUNOLOGY

Emeriti: (Professors) Edward S. Mocarski, Sidney Raffel, Leon T. Rosenberg
Chair: Karla Kirkegaard
Associate Chair: Hugh O. McDevitt
Professors: Ann Arvin, Helen Blau, John C. Boothroyd, Yueh-Hsiu Chien, Mark M. Davis, Stanley Falkow, Stephen J. Galli, Harry B. Greenberg, Karla Kirkegaard, A. C. Matin, Hugh O. McDevitt, Peter Parham, Phillip Pizzo, Charles Prober, Peter Sarnow, Gary K. Schoolnik, Lucy S. Tompkins
Associate Professors: Christopher Contag, Garry Nolan, David Relman, Julie Theriot
Assistant Professors: Matthew Bogyo, Chang-Zheng Chen, Denise Monack, David Schneider, Upinder Singh
Associate Professor (Teaching): Robert D. Siegel

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Phone: (650) 725-8541
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Web Site: http://cmgm.stanford.edu/micro/

Courses given in Microbiology and Immunology have the subject code MI. For a complete list of subject codes, see Appendix.

The Department of Microbiology and Immunology offers a program of training leading to the Ph.D. degree, as well as research training, courses, and seminars for medical students and postdoctoral fellows. Research interests focus on two broad areas: host/parasite interactions; and the function of the immune system. Laboratories investigate mechanisms of pathogenesis and the physiology of viruses, bacteria, and protozoan parasites, as well as the lymphocyte function in antigen recognition, immune response, and autoimmunity.

GRADUATE PROGRAMS

MASTER OF SCIENCE

A regular M.S. program is not offered, although this degree is awarded under special circumstances. Candidates for master's degrees are expected to have completed the preliminary requirements for the B.S. degree, or the equivalent. In addition, the candidate is expected to complete 45 quarter units of work related to microbiology; at least 25 of these units should concern research devoted to a thesis. The thesis must be approved by at least two members of the department faculty.

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described in the "Graduate Degrees" section of this bulletin.

Application, Admission, and Financial Aid—Prospective Ph.D. candidates should have completed a bachelor's degree in a discipline of biology or chemistry, including course work in biochemistry, chemistry, genetics, immunology, microbiology, and molecular biology. The deadline for receipt of applications with all supporting materials is December 4.

Applicants must file a report of scores on the general subject tests of the Graduate Record Examination (GRE). It is strongly recommended that the GRE be taken before October so that scores are available when applications are evaluated.

In the absence of independent fellowship support, entering predoctoral students are fully supported with a stipend and tuition award. Highly qualified applicants may be honored by a nomination for a Stanford Graduate Fellowship. Successful applicants have been competitive for predoctoral fellowships such as those from the National Science Foundation.

Program for Graduate Study—The Ph.D. degree requires course work and independent research demonstrating an individual's creative, scholastic, and intellectual abilities. On entering the department, students meet an advisory faculty member; together they design a timetable for completion

of the degree requirements. Typically, this consists of first identifying gaps in the student's undergraduate education and determining courses that should be taken. Then, a tentative plan is made for two to four lab rotations (one rotation per quarter). During the first year of graduate study in the department, each student also takes six or seven upper-level (200-series) courses. Three of these courses are requirements of the department: MI 215, Principles of Biological Techniques; MI 209, Advanced Pathogenesis of Bacteria, Viruses, and Eukaryotic Parasites, Part I; and MI 210, Advanced Pathogenesis of Bacteria, Viruses, and Eukaryotic Parasites, Part II. Three courses are part of the core curriculum that is required of many graduate students in Stanford Biosciences: BIOSCI 203 /DBIO 203 /GENE 203, Advanced Genetics; BIOSCI 230, Molecular and Cellular Immunology; and MCP 221/BIOSCI 214, Cell Biology of Physiological Processes.

In Autumn Quarter of the second year, a research proposal based on the student's own thesis topic is defended to the thesis committee. In Spring Quarter of the second year, each student defends orally a formal research proposal on a topic outside the intended thesis project. This qualifying examination proposal is due to the graduate program steering committee by May 1. Based on successful performance on this proposal, the student is admitted to candidacy. Teaching experience and training are also part of the graduate curriculum. Graduate students are required to act as teaching assistants for two courses. In addition, first- and second-year graduate students are required to participate in a bi-weekly journal club.

COURSES

MI 25N. Modern Plagues—Stanford Introductory Seminar. Preference to freshmen. Molecular and medical aspects of new and old microorganisms that infect humans. Goal is to place modern human plagues in scientific and historical perspective. Factors that lead to emergence and control. Write-2

3 units, Spr (Boothroyd, J)

MI 104/204. Innate Immunology—(Undergraduates register for 104.) Innate immune mechanisms as the only defenses used by the majority of multicellular organisms. Topics include Toll signaling, NK cells, complement, antimicrobial peptides, phagocytes, neuroimmunity, community responses to infection, and the role of native flora in immunity. How microbes induce and defeat innate immune reactions, including examples from vertebrates, invertebrates, and plants.

3 units, Spr (Schneider, D)

MI 115B. The Vaccine Revolution—(Same as HUMBIO 155B.) Advanced seminar. Human aspects of viral disease, focusing on recent discoveries in vaccine development and emerging infections. Journal club format: students select articles from primary scientific literature, write formal summaries, and synthesize them into a literature review. Emphasis is on analysis, experimental design, and interpretation of data. Oral presentations. Enrollment limited to 10. Prerequisite: 115A.

6 units, alternate years, not given this year

MI 155H. Humans and Viruses I—(Same as HUMBIO 155H.) Intensive introduction to Human Virology integrating epidemiology, molecular biology, clinical sciences, social sciences, history, and the arts. Emphasis on host pathogen interactions and policy issues. Topics: polio and vaccination, smallpox and eradication, yellow fever and history, influenza and genomic diversity, rubella and childhood infections, adenovirus and viral morphology, ebola and emerging infection, lassa fever and immune response.

6 units, Aut (Siegel, R)

MI 155V. Humans and Viruses II—Intensive introduction to Human Virology integrating epidemiology, molecular biology, clinical sciences, social sciences, history, and the arts. Emphasis on host pathogen interactions and policy issues. Topics: measles and viral epidemiology, rotavirus and world health, rabies and infections of the brain, HPV and cancer -causing viruses, herpes simplex and viral latency, CMV and viral teratogenesis, retrovirology and endogenous viral sequences, HIV and viral treatement, viral hepatitis and chronic infections, prions and diseases of life style. Prerequisite: 155H.

6 units, Win (Siegel, R)

MI 185. Topics in Microbiology—Topics include diversity, molecular regulation, growth, bioenergetics, and unique metabolic processes. Student papers for presentation on current topics such as antibiotic resistance and molecular approaches to bioremediation. Prerequisites: CHEM 31X, Biological Sciences core.

3 units, Win (Matin, A)

MI 198. Directed Reading in Microbiology and Immunology—Fields of study are decided in consultation with sponsoring professor. Prerequisite: consent of instructor.

1-15 units, Aut, Win, Spr, Sum (Staff)

MI 199. Undergraduate Research—Investigations sponsored by individual faculty members. Possible fields: microbial molecular biology and physiology, microbial pathogenicity, immunology, virology, and molecular parasitology. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MI 209. Advanced Pathogenesis of Bacteria, Viruses, and Eukaryotic Parasites: Part I—For graduate students and advanced undergraduates; required of first-year graduate students in Microbiology and Immunology. Emphasis is on mechanisms to establish infection in the host and responses of the host to infection. Current literature. Prerequisite: background in biochemistry and molecular biology.

4 units, Win (Sarnow, P)

MI 210. Advanced Pathogenesis of Bacteria, Viruses, and Eukaryotic Parasites: Part II—For graduate and medical students, and advanced undergraduates; required of first-year graduate students in Microbiology and Immunology. The molecular mechanisms by which microorganisms invade animal and human hosts, express their genomes, interact with macromolecular pathways in the infected host, and induce disease. Current literature.

4 units, Spr (Chen, C)

MI 211. Advanced Immunology I—(Same as IMMUNOL 201.) For graduate and medical students and advanced undergraduates. Molecules and cells of the innate and adaptive immune systems; genetics, structure, and function of immune molecules; lymphocyte differentiation and activation; regulation of immune responses; autoimmunity and other problems in immune system dysfunction. Prerequisites: undergraduate course in Immunology and familiarity with experimental approaches in biochemistry, molecular biology, and cell biology.

3 units, Win (Chien, Y)

MI 212. Advanced Immunology II—(Same as IMMUNOL 202.) Readings of immunological literature. Classic problems and emerging areas based on primary literature. Student and faculty presentations. Prerequisite: IMMUNOL 201.

3 units, Spr (Garcia, K)

MI 214. Biodefense and Biosecurity—Science and policy behind American and international biosecurity and biodefense. Is the international community prepared to defend against a naturally-occurring disease or a bioterror attack? Topics include the scope of the problem, agent pathogenesis, threat of biological weapons, responding to a biological attack, microbial forensics, international health, the threat of naturally emerging infectious disease, and policy against these threats. Guest lecturers.

2 units, offered occasionally

MI 215. Principles of Biological Technologies—(Same as IMMUNOL 215.) Required of first-year graduate students in Microbiology and Immunology, and the Immunology program. The principles underlying commonly utilized technical procedures in biological research. Lectures and primary literature critiques on gel electrophoresis, protein purification and stabilization, immunofluorescence microscopy, FACS. Prerequisites: biochemistry, organic chemistry, and physics.

3 units, Spr (Kirkegaard, K)

MI 232. Topics in Regenerative Medicine—(Same as DBIO 232.) Forum. Students and researchers discuss current developments in regenerative medicine at Stanford to spark collaboration. Topics include novel applications in biological and chemical engineering, stem cell biology, biotechnology, and human disease. May be repeated for credit.

2 units, Aut, Win, Spr (Blau, H; Fuller, M)

MI 233. The Biology of Small Modulatory RNAs—(Same as GENE 233, PATH 233.) Open to graduate and medical students. How recent discoveries of miRNA, RNA interference, and short interfering RNAs reveal potentially widespread gene regulatory mechanisms mediated by small modulatory RNAs during animal and plant development. Required paper proposing novel research.

2 units, Aut (Fire, A; Chen, C), alternate years, not given next year

MI 250. Frontiers in Microbiology and Immunology—Required of first- and second-year students in Microbiology and Immunology. How to evaluate biological research. Held in conjunction with the Microbiology and Immunology Friday noon seminar series. Before the seminar, students and faculty discuss one or more papers from the speaker's primary research literature on a related topic. After the seminar, students meet informally with the speaker to discuss their research.

1 unit, Aut, Win, Spr (Schneider, D)

MI 299. Directed Reading in Microbiology and Immunology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MI 399. Graduate Research—Students who have completed the necessary foundation courses undertake investigations in general bacteriology, bacterial physiology and ecology, bacterial genetics, microbial pathogenicity, immunology, parasitology, or virology sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MOLECULAR AND CELLULAR PHYSIOLOGY

Chair: Richard S. Lewis
Professors: Axel T. Brunger, Brian K. Kobilka, Richard S. Lewis, W. James Nelson, Stephen J. Smith, Richard W. Tsien, William Weis
Associate Professors: Christopher Garcia, V. Daniel Madison
Assistant Professors: Miriam Goodman, Merritt Maduke
Courtesy Associate Professor: Stefan Heller, John Huguenard, Anson W. Lowe, Tony Ricci
Courtesy Assistant Professor: Richard J. Reimer
Department Offices: Beckman Center, B100
Mail Code: 94305-5345
Phone: (650) 725-7554
Email: schantae@stanford.edu
Web Site: http://mcp.stanford.edu

Courses given in Molecular and Cellular Physiology have the subject code MCP. For a complete list of subject codes, see Appendix.

The Department of Molecular and Cellular Physiology is located in the Beckman Center for Molecular and Genetic Medicine.

A central goal of physiology in the post-genomic era is to understand how thousands of encoded proteins serve to bring about the highly coordinated behavior of cells and tissues. Research in the department approaches this goal at many levels of organization, ranging from single molecules and individual cells to multicellular systems and the whole organism. The faculty share common interests in the molecular mechanisms of cell signaling and behavior, with a special focus on structure/function analysis of ion channels and G-protein coupled receptors, and their roles at the cellular, organ, and whole-organism levels; the molecular basis of sensory transduction, synaptic transmission, plasticity and memory; the role of ion channels and calcium in controlling gene expression in neural and immune cells; and the regulation of vesicle trafficking and targeting, cell polarity, and cell-cell interactions in the nervous system and in epithelia. Research programs employ a wide range of approaches, including molecular and cell biology, biochemistry, genetics, biophysics, x-ray crystallography and solution NMR, electrophysiology, and *in vitro* and *in vivo* imaging with confocal and multi-photon microscopy.

GRADUATE PROGRAMS

The department offers required and elective courses for students in the School of Medicine and is also open to other qualified students with the consent of the instructor. Training of medical, graduate, and postdoctoral students is available. The program offers a course of study leading to the Ph.D. degree. No B.S. is offered, and an M.S. is offered only in the unusual circumstance where a student completes the course work, rotation, and the written section of the qualifying exam, but is unable to complete the requirements for the Ph.D.

DOCTOR OF PHILOSOPHY

Students with undergraduate or master's degrees who have completed a year each of college chemistry (including lectures in organic and physical chemistry), physics, calculus, and biology are considered for admission to graduate study. Applicants submit a report of scores from the Graduate Record Examination (verbal, quantitative, analytical, and an advanced subject test in one of the sciences) as part of the application.

Students who do not speak English as their native language must submit scores from TOEFL unless waived by Graduate Admissions, the Registrar's Office.

Study toward the Ph.D. is expected to occupy five years, including summers. A minimum of six quarter-long courses is required. These include four graduate-level courses (200-300 series) and a choice of two out of these three courses: MCP 221, MCP 255, and MCP 256. Students are also required to take the Molecular and Cellular Physiology seminar/Research In Progress series. Each student presents a talk on research in progress to the department at least every other year, starting their second year. Acceptable grades for all course work must be a minimum of 'B-', and at least two grades equal to 'A-' or above are necessary (but not sufficient) for continuation in the program.

Qualifying Examination—At the end of the second year in residence as a graduate student, each Ph.D. candidate presents a written thesis proposal to be defended at an oral comprehensive examination. The examinations may be taken only after all course work has been completed by the required standard. Students undertake individual research studies as early as possible after consultation with their preceptor. Upon passing this exam, the student is advanced to candidacy for the Ph.D.

Dissertation and University Oral Examination—The results of independent, original work by the students are presented in a dissertation. The oral examination is largely a defense of the dissertation.

Advisers and Advisory Committees—A graduate advisory committee, currently Professors Lewis and Madison, advises students during the period before the formation of their qualifying committees.

Financial Aid—Students may be funded by their advisers' research grants, by training grants, by department funds, or by extramural funds. Students are encouraged to obtain funding from outside sources such as NIH and NSF.

COURSES

Course and lab instruction in the Department of Molecular and Cellular Physiology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

MCP 100Q. The Hippocampus as a Window to the Mind—Stanford Introductory Seminar. Preference to sophomores. Electrical physiology of the brain using the hippocampus as a model system. The seminar builds from basic anatomical and electrical principles of brain structure and function, through the electrical properties of individual neurons and simple neuronal circuits, to the nature of behaviors that emerge from these more

basic properties. Also discusses other brain regions where the hippocampal model provides insight into specific neuronal functions. Culminates in a discussion of neuronal disorders such as epilepsy, drug addiction, and obsessive-compulsive disorder that can be better understood on a basis of knowledge of the hippocampal model.

3 units, Spr (Madison, V)

MCP 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MCP 200. Cardiovascular Physiology—Offered jointly with the Department of Medicine. Lectures, small group instruction, clinical presentations, and lab demonstrations of normal and disordered human cardiovascular physiology. Prerequisite: understanding of general biochemistry.

5 units, Spr (Kobilka, B)

MCP 213. Special Topics in Molecular and Cellular Physiology—Introductory and advanced physiological topics agreed on by an instructor and students. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MCP 216. Genetic Analysis of Behavior—(Same as NBIO 216.) Advanced seminar. Findings and implications of behavioral genetics as applied to invertebrate and vertebrate model systems. Topics include biological clocks, and sensation and central pattern generators. Relevant genetic techniques and historical perspective. Student presentation.

4 units, Win (Goodman, M; Clanindin, T)

MCP 222. Imaging: Biological Light Microscopy—(Same as BIOSCI 152, NBIO 222.) Survey of instruments which use light and other radiation for analysis of cells in biological and medical research. Topics: basic light microscopy through confocal fluorescence and video/digital image processing. Lectures on physical principles; involves partial assembly and extensive use of lab instruments. Lab. Prerequisites: some college physics, Biological Sciences core.

3 units, Spr (Smith, S; Dolmetsch, R)

MCP 232. Advanced Imaging Lab in Biophysics—(Same as BIOSCI 132/232, BIOPHYS 232.) 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, and optical trapping. Limited enrollment. Recommended: basic physics, Biological Sciences core or equivalent, and consent of instructor.

4 units, Spr (Block, S; Schnitzer, M; Smith, S; Stearns, T)

MCP 256. How Cells Work: Energetics, Compartments, and Coupling in Cell Biology—Open to graduate and medical students, and advanced undergraduates. Dynamic aspects of cell behavior and function, including cellular energetics, homeostasis, heterogeneity of membranes, structure and function of organelles, solute and water transport, signaling and motility. Emphasis is on the principles of how coupling of molecular processes gives rise to essential functions at the cellular level. Mathematical models of cell function. Student presentations.

4 units, Spr (Goodman, M; Maduke, M)

MCP 258. Information and Signaling Mechanisms in Neurons and Circuits—(Same as NBIO 258.) How synapses, cells, and neural circuits process information relevant to a behaving organism. How phenomena of information processing emerge at several levels of complexity in the nervous system, including sensory transduction in molecular cascades, information transmission through axons and synapses, plasticity and feedback in recurrent circuits, and encoding of sensory stimuli in neural circuits.

5 units, Aut (Tsien, R; Baccus, S)

MCP 299. Directed Reading in Molecular and Cellular Physiology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

MCP 399. Graduate Research—Investigations sponsored by individual faculty members. Research fields include endocrinology, neuroendocrinology, and topics in molecular and cellular physiology. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

NEUROBIOLOGY

Emeritus: Denis Baylor, Eric Shooter, Lubert Stryer
Chair: William T. Newsome
Professors: Ben Barres, Eric I. Knudsen, Uel J. McMahan, William T. Newsome
Assistant Professors: Stephen Baccus, Thomas Clandinin, Ricardo Dolmetsch, Tirin Moore, Jennifer Raymond
Department Offices: Fairchild Building, Second Floor
Mail Code: 94305-5125
Web Site: http://www.stanford.edu/dept/nbio/

Courses given in Neurobiology have the subject code NBIO. For a complete list of subject codes, see Appendix.

GRADUATE PROGRAM

Graduate students in the Department of Neurobiology obtain the Ph.D. degree through the interdepartmental Neurosciences Ph.D. program. Accepted students receive funding for tuition and a living stipend. Applicants should familiarize themselves with the research interests of the faculty and, if possible, indicate their preference on the application form which is submitted directly to the Neurosciences Program.

Medical students also are encouraged to enroll in the Ph.D. program. The requirements of the Ph.D. program are fitted to the interests and time schedules of the student. Postdoctoral training is available to graduates holding Ph.D. or M.D. degrees, and further information is obtained directly from the faculty member concerned.

Research interests of the department include information processing in vertebrate retina; structure, function, and development of auditory and visual systems; development and regeneration in the central and peripheral nervous system; neural mechanisms mediating higher nervous system functions, including perception, learning, attention and decision making.

COURSES

Course and lab instruction in the Department of Neurobiology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

The department offers a one quarter course (NBIO 206) on the structure and function of the nervous system, which is open to medical and graduate students and advanced undergraduates. Advanced courses are open to students who have completed the basic course.

NBIO 101/201. Social and Ethical Issues in the Neurosciences—(Graduate students register for 201.) Influences on public debate and policy of scientific advances in the study of the brain and behavior: theories of brain function; philosophical and scientific approaches; advances in the neurosciences, possible uses in medical therapy, and interventions involving genetic screening, genetic selection, enhancement of neurological functioning, and manipulation of behavior; questions related to medical therapy, social policy, and broader considerations of human nature such as consciousness, free will, personal identity, and moral responsibility. May be taken for 2 units without a research paper. Prerequisite: Neuroscience, Biological Sciences, or Symbolic Systems major; or Human Biology core; or consent of instructor.

2-4 units, Spr (Hurlbut, W; Newsome, W)

NBIO 198. Directed Reading in Neurobiology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

NBIO 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

NBIO 206. The Nervous System—Introduction to the structure and function of the nervous system, including neuroanatomy, neurophysiology, and systems neurobiology. Topics include the properties of neurons and the mechanisms and organization underlying higher functions. Framework for general work in neurology, neuropathology, clinical medicine, and for more advanced work in neurobiology. Lecture and lab components must be taken together.
7-8 units, Win (Clandinin, T)

NBIO 216. Genetic Analysis of Behavior—(Same as MCP 216.) Advanced seminar. Findings and implications of behavioral genetics as applied to invertebrate and vertebrate model systems. Topics include biological clocks, and sensation and central pattern generators. Relevant genetic techniques and historical perspective. Student presentation.
4 units, Win (Goodman, M; Clandinin, T)

NBIO 218. Neural Basis of Behavior—Advanced seminar. The principles of information processing in the vertebrate central nervous system, and the relationship of functional properties of neural systems with perception and behavior. Emphasis is on the visual and auditory systems. Original papers; student presentations. Prerequisite: 206 or consent of instructor.
4 units, Spr (Raymond, J; Knudsen, E), alternate years, not given next year

NBIO 220. Central Mechanisms in Vision-based Cognition—Contemporary visual neuroscience, emphasizing the neural mechanisms underlying primate vision and visually guided behavior. Seven foundational topics in visual neuroscience; current papers concerning each topic. Student presentations. Computer-based demonstration exercises.
2-4 units, alternate years, not given this year (Newsome, W; Moore, T)

NBIO 221. Frontiers in Translational Medicine—Small group course for first-year MSTP and M.D./Ph.D. students only. Pathways for combining science and medicine during graduate and postdoctoral training and in one's career. Practical aspects of translational medicine. Guest lecturers are physician-scientists who have advanced the frontiers of translational medicine, including Drs. Gilbert Chu, Jamie Topper, Irv Weissman, Ching Wang, Linda Giudice, Geoff Duyk, William Mobley, Judy Shizuru, and David Cox. Prerequisite: consent of instructor.
1 unit, Spr (Barres, B)

NBIO 222. Imaging: Biological Light Microscopy—(Same as BIOSCI 152, MCP 222.) Survey of instruments which use light and other radiation for analysis of cells in biological and medical research. Topics: basic light microscopy through confocal fluorescence and video/digital image processing. Lectures on physical principles; involves partial assembly and extensive use of lab instruments. Lab. Prerequisites: some college physics, Biological Sciences core.
3 units, Spr (Smith, S; Dolmetsch, R)

NBIO 227. Understanding Techniques in Neuroscience—Techniques commonly used in neuroscience, including molecular/genetic, electrophysiological, and whole brain imaging. Presentations by senior graduate students and examples from the literature. Optional laboratory demonstrations.
2 units, Aut (Carter, M; Villeda, S; Shieh, J)

NBIO 254. Molecular and Cellular Neurobiology—(Same as BIOSCI 154/254.) For advanced undergraduates and graduate students. Cellular and molecular mechanisms in the organization and functions of the nervous system. Topics: wiring of the neuronal circuit, synapse structure and synaptic transmission, signal transduction in the nervous system, sensory systems, molecular basis of behavior including learning and memory, molecular pathogenesis of neurological diseases. Prerequisite for undergraduates: Biological Sciences core or equivalent, or consent of instructors.
4-5 units, alternate years, not given this year

NBIO 258. Information and Signaling Mechanisms in Neurons and Circuits—(Same as MCP 258.) How synapses, cells, and neural circuits process information relevant to a behaving organism. How phenomena of information processing emerge at several levels of complexity in the nervous system, including sensory transduction in molecular cascades, information transmission through axons and synapses, plasticity and feedback in recurrent circuits, and encoding of sensory stimuli in neural circuits.
5 units, Aut (Baccus,S; Tsien R)

NBIO 299. Directed Reading in Neurobiology—Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

NBIO 300. Professional Development and Integrity in Neuroscience—Required of Neurosciences Ph.D. students every quarter. Develops professional skills in critical assessment and oral presentation of findings from current neuroscience literature in the visual presentation of quantitative data and writing research grants. The role of animals in lab research, fraud in science, the responsibility of authors and reviewers, science in a multicultural environment, and the relationship between student and mentor. Student and faculty presentations and discussions.
1-2 units, Aut, Win, Spr (Dolmetsch, R)

NBIO 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.
1-18 units, Aut, Win, Spr, Sum (Staff)

COGNATE COURSES

See respective department listings for course descriptions. See degree requirements above or the program's student services office for applicability of these courses to a major or minor program.

PSYCH 204A. Computational Neuroimaging
1-3 units, Spr (Wandell, B)

PSYCH 250. High-level Vision
1-3 units, Spr (Grill-Spector, K), alternate years, not given next year

NEUROSCIENCES PROGRAM

Director: John R. Huguenard (Professor, Neurology and Neurological Sciences)

Committee: Corinna Darian-Smith, Craig Garner, Miriam Goodman, Shaul Hestrin, John R. Huguenard, Jennifer Raymond, Kang Shen, Krishna Shenoy, Anthony Wagner

Participating Faculty:

Anesthesia: Rona Giffard (Professor), M. Bruce MacIver (Associate Professor, Research), Sean Mackey (Assistant Professor), David Yeomans (Associate Professor)

Applied Physics: Mark Schnitzer (Assistant Professor)

Bioengineering: Kwabena Boahen (Associate Professor), Karl Deisseroth (Assistant Professor)

Biological Sciences: Bruce Baker (Professor), Russell D. Fernald (Professor), William F. Gilly (Professor), H. Craig Heller (Professor), Ron Kopito (Professor), Liqun Luo (Professor), Susan McConnell (Professor), Robert M. Sapolsky (Professor), Mark Schnitzer (Assistant Professor), Kang Shen (Assistant Professor), Stuart Thompson (Professor)

Chemical and Systems Biology: Tobias Meyer (Professor), Daria Mochly-Rosen (Professor)

Comparative Medicine: Paul S. Buckmaster (Associate Professor), Corinna Darian-Smith (Assistant Professor), Shaul Hestrin (Associate Professor)

Developmental Biology: Ben Barres (Professor), Matthew P. Scott (Professor)

Electrical Engineering: Krishna Shenoy (Assistant Professor)

Genetics: Anne Brunet (Assistant Professor), David R. Cox (Professor)

Microbiology and Immunology: Helen Blau (Professor)

Molecular and Cellular Physiology: Miriam B. Goodman (Assistant Professor), Brian Kobilka (Professor), Richard S. Lewis (Professor), V. Daniel Madison (Associate Professor), Merritt C. Maduke (Assistant Professor), Stephen Smith (Professor), Richard Tsien (Professor)

Neurobiology: Stephen Baccus (Assistant Professor), Ben Barres (Professor), Tom Clandinin (Assistant Professor), Ricardo Dolmetsch (Assistant Professor), Eric I. Knudsen (Professor), U. J. McMahan (Professor), Tirin Moore (Assistant Professor), William T. Newsome (Professor), Jennifer Raymond (Assistant Professor)

Neurology and Neurological Sciences: Ben Barres (Professor), Paul Buckmaster (Associate Professor), Robert S. Fisher (Professor), Ting-Ting Huang (Assistant Professor, Research), John A. Huguenard (Associate Professor), Frank Longo (Professor), William C. Mobley (Professor), David A. Prince (Professor), Thomas A. Rando (Associate Professor), Lawrence Recht (Professor), Richard Reimer (Assistant Professor), Terence Sanger (Assistant Professor), Robert M. Sapolsky (Professor), Lawrence Steinman (Professor), Tony Wyss-Coray (Associate Professor, Research), Yanmin Yang (Assistant Professor)

Neurosurgery: Pak H. Chan (Professor), Theo Palmer (Assistant Professor), Gary K. Steinberg (Professor)

Otolaryngology: Stefan Heller (Associate Professor), Anthony Ricci (Associate Professor)

Pathology: Isabella Graef (Assistant Professor), Bingwei Lu (Assistant Professor), Raymond Sobel (Professor)

Pediatrics: Judy Illes (Assistant Professor), Anna Penn (Assistant Professor), Lawrence Steinman (Professor)

Psychiatry and Behavioral Sciences: Karl Deisseroth (Assistant Professor), Luis de Lecea (Associate Professor), Craig Garner (Professor), Terrence A. Ketter (Associate Professor), Robert C. Malenka (Professor), Vinod Menon (Associate Professor, Research), Emmanuel Mignot (Professor), Allan L. Reiss (Professor), Edith Sullivan (Professor, Research)

Psychology: Lera Boroditsky (Assistant Professor), Ian Gotlib (Professor), Kalanit Grill-Spector (Assistant Professor), James J. Gross (Associate Professor), Brian Knutson (Assistant Professor), James McClelland (Professor), Anthony Wagner (Assistant Professor), Brian Wandell (Professor), Jeffrey J. Wine (Professor)

Radiology: Gary H. Glover (Professor)

Structural Biology: U. J. McMahan (Professor)

Program Offices: Alway Building, M-103D
Mail Code: 94305-5121
Phone: (650) 723-9855
Web Site: http://neuroscience.stanford.edu/

Courses given in the Neurosciences Program have the subject code NEPR. For a complete list of subject codes, see Appendix.

GRADUATE PROGRAM

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described in the "Graduate Degrees" section of this bulletin.

The interdepartmental Neurosciences Program offers instruction and research opportunities leading to a Ph.D. in Neurosciences. The requirements for a Ph.D. degree follow those of the University and in addition are tailored to fit the background and interests of the student. Accepted students receive an award covering tuition, a basic health plan, and a living stipend. Qualified applicants should, where possible, apply for the predoctoral fellowships in open competition, especially those from the National Science Foundation. December 16 is the deadline for receipt in the Neurosciences Program office of applications with all supporting material.

Applicants should familiarize themselves with the research interests of the faculty and indicate their preferences clearly on the application form.

Since students enter with differing backgrounds, and the labs in which they may elect to work cover several different disciplines, the specific program for each student is developed individually with an advisory committee. All students are required to complete the basic introduction to neurobiology (NBIO 206 or equivalent). Students must also take five advanced courses, four of which must be distributed among four of the following core areas: systems and behavioral neuroscience, molecular and cellular neuroscience, developmental neuroscience, clinical neuroscience, and computational neuroscience. The fifth advanced course is chosen by the student in an area related to the student's research interest, and may be selected from outside the Neurosciences core with prior approval from the program director and the student's adviser.

Students usually rotate through several labs during their first year, although they may choose to begin thesis research on entry. After the first rotation, students may rotate both within and outside the Neurosciences Program. Required course work should be completed by the end of the second year. Passing of a comprehensive oral preliminary examination given by the student's advisory committee is required for admission to Ph.D. candidacy. This examination is usually taken by the end of the second year. The student is required to present a Ph.D. dissertation, which is the result of independent investigation contributing to knowledge in an area of neuroscience, and to defend his or her dissertation in a University oral examination, which includes a public seminar.

Medical students may participate in this program provided they meet the prerequisites and satisfy all the requirements of the graduate program as listed above. The timing of the program may be adjusted to fit their special circumstances.

COURSES

Course and lab instruction in the Neurosciences Program conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

NEPR 299. Directed Reading in Neurosciences—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

NEPR 399. Graduate Research—Investigations sponsored by individual faculty members.

1-18 units, Aut, Win, Spr, Sum (Staff)

OBSTETRICS AND GYNECOLOGY

Chair: Jonathan S. Berek

Courses given in Gynecology have the subject code OBGYN. For a complete list of subject codes, see Appendix.

The Department of Obstetrics and Gynecology does not offer degrees; however, qualified medical, graduate, or undergraduate students with an interest in basic research in reproductive biology may apply to arrange individual projects under the supervision of the faculty. The focus for the Division of Reproductive Biology is the study of the molecular and cellular biology of male and female reproductive organs.

COURSES

OBGYN 78Q. Darwin's Evolution and Genomic Revolution—Stanford Introductory Seminar. Preference to sophomores. Topics include evolution based on fossil and genetic evidence, mechanisms of natural selection, the impact of genomic revolution on the study of gene evolution, new gene discovery, human-accelerated selection, Darwinian medicine, and the social implications of evolution.

3 units, Win (Hsueh, A)

OBGYN 199. Undergraduate Research in Reproductive Biology—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

OBGYN 202. Assisted Reproductive Technologies—(Same as DBIO 202.) Primary literature in basic and clinical science, and demonstrations of assisted reproductive technologies (ART). Techniques include in vitro fertilization covering micromanipulation procedures such as intracytoplasmic sperm injection and the culture of blastocysts, using mouse gametes, and pre-embryos. Class only may be taken for 1 unit. 2 units includes papers and attendance at clinical demonstrations. 3 units includes a term paper. Prerequisite: DBIO 201 recommended, or consent of instructors.

1-3 units, Win (Porzig, E; Behr, B)

OBGYN 399. Graduate Research - Reproductive Biology—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

PATHOLOGY

Emeriti: (Professor) Ronald Dorfman; Richard L. Kempson; *(Professor, Clinical)* P. Joanne Cornbleet, Lawrence F. Eng, Luis Fajardo, Heinz Furthmayr, F. Carl Grumet

Chair: Stephen J. Galli

Professors: Daniel Arber, Ellen Jo Baron, Gerald J. Berry, Eugene C. Butcher, Michael L. Cleary, Gerald R. Crabtree, Edgar G. Engleman, Andrew Fire, Steven Foung, Stephen J. Galli, Lawrence Tim Goodnough, Michael R. Hendrickson, Sabine Kohler, Jon C. Kosek, Joseph S. Lipsick, Robert V. Rouse, Richard K. Sibley, Raymond Sobel, Howard H. Sussman, Dolly Tyan, Matt van de Rijn, Hannes Vogel, Teresa S. F. Wang, Roger A. Warnke, Irving L. Weissman, James Zehnder

Associate Professors: Jeffrey D. Axelrod, Athena M. Cherry, Tina Cowan, James D. Faix, Dean Felsher, Susan A. Galel, Sharon M. Geaghan, Peter K. Jackson, Teri A. Longacre, Sara A. Michie, Yasodha Natkunam, Bruce Patterson, Donald P. Regula, Arend Sidow

Assistant Professors: Matthew Bogyo, Raffick Bowen, Andrew Connolly, Soheil Dadras, Magali Fontaine, Tracy George, John P. Higgins, Kristin Jensen, Neeraja Kambham, Christina Kong, Bingwei Lu, Jonathan R. Pollack, Iris Schrijver, Erich Schwartz, Uma Sundram, Robert West

Courtesy Professors: Bertil Glader, Lucy Tompkins

Courtesy Associate Professors: Donna Bouley, Robert Shafer

Clinician Educators: Susan Atwater, David Bingham, Barbara Egbert, Dita Gratzinger, Terri Haddix, Melanie Manning, Reetesh Pai, Shalini Pereira, Run Shi, Brent Tan, Maurene Viele

Instructors: Niaz Banaei, Daniel Kraft, Michaela Liedtke

Adjunct Clinical Faculty: Robert Archibald, Jerome S. Burke, Glenn Cockerham, Stephen Shi-Hua Chen, Seth Haber, Maie K. Herrick, Paul W. Herrmann, Simon Hirschl, Charles Lombard, John E. McNeal, Judy Melinek, Joseph O'Hara, Mahendra Ranchod, Thomas W. Rogers, Joshua Sickel

Department Offices: Medical Center, Lane Building, L-235
Mail Code: 94305-5324
Phone: (650) 723-5255
Web Site: http://pathology.stanford.edu

Courses given in Pathology have the subject code PATH. For a complete list of subject codes, see Appendix.

PROGRAMS OF STUDY

The Department of Pathology offers advanced courses in aspects of pathology. The department does not offer advanced degrees in pathology, but qualified graduate students who are admitted to department-based or interdepartmental graduate programs may elect to pursue their thesis requirements in the department's research laboratories. The discipline of pathology has served as a bridge between the preclinical and clinical sciences and is concerned with the application of advances in the basic biological sciences, both to the diagnosis of human disease and the elucidation of the mechanisms of normal molecular, cellular, and organ structure and function that manifest themselves in clinical disease. Accordingly, the department's research interests extend from fundamental molecular biology to clinical-pathological correlations, with an emphasis on experimental oncology.

Investigation in the department includes basic studies in areas using molecular biological, biochemical, and genetic cell biological techniques: DNA replication in yeast and cultured eukaryotic cells, cell cycle control in animal cells and yeast, identification and pathogenetic role of chromosomal aberrations in human malignancies and mechanisms of activation of oncogenes in human and animal cells, lymphocyte and neutrophil-interactions with endothelial cells, cell type specification and signal transduction pathways leading to specific gene expression or modulation of cytoskeletal behavior; cytoskeletal architecture, cell-matrix interaction, developmental biology of hematopoietic stem cells and thymus, regulation of the immune system, mechanisms of immune and other responses in the central nervous system, and neuro-degenerative diseases. Various studies focus on the development of novel diagnostic and immunotherapeutic treatment modalities and techniques for solid tumors, lymphomas, HIV, and genetic diseases. Research training in all of these areas is available for qualified medical and graduate students by individual arrangement with the appropriate faculty member. A summary of the research interests of the department faculty is available at http://pathology.stanford.edu.

COURSES

Course and lab instruction in the Department of Pathology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

PATH 101. Cancer Biology—(Same as CBIO 101.) Experimental approaches to understanding the origins, diagnosis, and treatment of cancer. Focus on key experiments and discoveries with emphasis on genetics, molecular biology, and cell biology. Topics include carcinogens, tumor virology, oncogenes, tumor suppressor genes, cell cycle regulation, angiogenesis, invasion and metastasis, cancer genomics, cancer epidemiology, and cancer therapies. Discussion sections based on primary research articles that describe key experiments in the field. Prerequisite: Biological Sciences or Human Biology core or equivalent, or consent of instructor.

4 units, Spr (Lipsick, J)

PATH 103Q. Lymphocyte Migration—Stanford Introductory Seminar. Preference to sophomores. How lymphocytes leave the blood stream and enter tissues to participate in immune surveillance and the development of inflammation. Known as lymphocyte migration, this process involves a complex series of adhesion, activation and diapedesis events. The cellular mechanisms involved in lymphocyte migration, including lymphocyte adhesion molecules that interact with their counter-receptors on endothelial cells, and molecules, including cytokines and chemokines, that attract or activate lymphocytes. The roles of these molecules in the development of human diseases such as asthma, type 1 diabetes, and multiple sclerosis.

1 unit, Aut (Michie, S)

PATH 105Q. Final Analysis: The Autopsy as a Tool of Medical Inquiry—Stanford Introductory Seminar. Preference to sophomores. Based on review of patient medical histories and examination of formalin-fixed and unfixed tissues from autopsy. Student-directed problem-solving; students develop learning objectives for each case, and present findings. The effect of disease on normal structure and function, ethics of patient care, allocation of medical resources, efficiency of therapy, and medical error. Prerequisite: hepatitis-B vaccination; free vaccinations during the winter for accepted students.

3 units, Spr (Regula, D)

PATH 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

PATH 206. Epigenetics—(Same as GENE 206.) For graduate students; undergraduates by consent of instructor. Mechanisms by which phenotypes not determined by the DNA sequence are stably inherited in successive cell divisions. From the discovery of position-effect variegation in Drosophila in the 20s to present-day studies of covalent modifications of histones and DNA methylation. Topics include: position effect, gene silencing, heterochromatin, centromere identity, genomic imprinting, histone code, variant histones, and the role of epigenetics in cancer. Prerequisite: background in genetics and molecular biology.

2 units, Win (Lipsick, J)

PATH 210. Stem Cells in Development and Disease—Molecular and cellular mechanisms underlying the basic self-renewal and differentiation properties of stem cells in multiple tissues and organisms. How abnormal stem cell behavior may contribute to diseases such as cancer. How to manipulate stem cell behavior in vitro or in vivo for therapeutic purposes. Classical papers and recent literatures in the field of stem cell biology. Open to graduate, medical, and advanced undergraduate students. Prerequisite: consent of instructor.

1-2 units, Spr (Lu, B)

PATH 218. Computational Analysis of Biological Images—Physical and computational tools for acquisition, processing, interpretation, and archiving of biological images. Emphasis is on digital microscopy.

2 units, alternate years, not given this year

PATH 233. The Biology of Small Modulatory RNAs—(Same as GENE 233, MI 233.) Open to graduate and medical students. How recent discoveries of miRNA, RNA interference, and short interfering RNAs reveal potentially widespread gene regulatory mechanisms mediated by small modulatory RNAs during animal and plant development. Required paper proposing novel research.

2 units, Aut (Fire, A; Chen, C), alternate years, not given next year

PATH 296. Stem Cell Biology and Regenerative Medicine—(Same as DBIO 296.) For graduate and medical students. Embryonic and adult stem cells, including origin, regulation, self-renewal, differentiation, fate, and relationship to cancer; biological mechanisms and methods to translate findings to therapeutic applications. Medical students must enroll for 5 units; graduate students may choose to take only the basic science part for 3 units. Prerequisites: DBIO 201 and 210, or consent of instructor.

3-5 units, Win (Weissman, I; Fuller, M; Nusse, R)

PATH 299. Directed Reading in Pathology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

PATH 399. Graduate Research—Investigations sponsored by individual faculty members. Opportunities at the molecular, cellular, and clinicopathologic levels. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

COGNATE COURSE

See department listings for course description. See degree requirements above or the program's student services office for applicability of this course to a major or minor program.

MI 211. Advanced Immunology I—(Same as IMMUNOL 201.)

3 units, Win (Chien, Y)

RADIATION ONCOLOGY

Emeriti: Malcolm A. Bagshaw, Peter Fessenden, Don R. Goffinet, George M. Hahn, Kendric Smith

Chair: Richard T. Hoppe

Professors: J. Martin Brown, Sarah S. Donaldson, Amato J. Giaccia, Steven L. Hancock, Richard T. Hoppe, Quynh-Thu Le, Daniel S. Kapp, Steven A. Liebel

Associate Professors: Iris C. Gibbs, Paul Keall, Christopher R. King, Susan J. Knox, Gary Luxton, Lei Xing

Assistant Professors: Laura Attardi, Daniel Chang, Nicholas Denko, Edward Graves, Albert C. Koong

Consulting Professor: Robert M. Sutherland

Courses given in Radiation Oncology have the subject code RADO. For a complete list of subject codes, see Appendix.

Radiation Oncology focuses on the use of radiation for cancer therapy and research. The department does not offer degrees; however, its faculty teach courses open to medical students, graduate students, and undergraduates. The department also accepts students in other curricula as advisees for study and research. Graduate students in Biophysics and Cancer Biology may perform their thesis research in the department. Undergraduates may arrange individual research projects under supervision of faculty.

At the present time, the major areas of basic research investigation in the department include: DNA repair in mammalian cells after ionizing irradiation; studies of the mechanism of tumor hypoxia in animal tumors; development of new anti-cancer drugs to exploit tumor hypoxia; cytogenetic and molecular methods of predicting the sensitivity of individual tumors to cancer therapy; radiolabeled monoclonal antibodies for cancer detection and treatment; studies of oxygen levels in human tumors using polarographic electrodes; clinical trials of a new hypoxic cytotoxic agent (tirapazamine); studies of the late effects of cancer therapy; and techniques of conformal and intensity modulated radiation therapy.

COURSES

Course and lab instruction in the Department of Radiation Oncology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

The following are open to undergraduates and graduate students.

RADO 101. Readings in Radiation Biology

1-18 units, Aut, Win, Spr, Sum (Staff)

RADO 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

RADO 299. Directed Reading in Radiation Oncology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

RADO 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

RADIOLOGY

Emeriti: (Professors) Herbert L. Abrams, Gerald Friedland, David A. Goodwin, Henry H. Jones, Albert Macovski, William H. Northway, Lewis Wexler, Leslie M. Zatz

Chair: Gary M. Glazer

Professors: Scott W. Atlas, Richard A. Barth, Christopher F. Beaulieu, Sanjiv Sam Gambhir, Gary M. Glazer, Gary H. Glover, Michael L. Goris, Robert J. Herfkens, R. Brooke Jeffrey, Barton Lane, Ann Leung, Michael Marks, I. Ross McDougall, Robert E. Mindelzun, Michael Moseley, Sandy Napel, Matilde Nino-Murcia, Norbert J. Pelc, Geoffrey Rubin, George Segall, F. Graham Sommer

Associate Professors: Patrick D. Barnes, Francis Blankenberg, Bruce Daniel, Terry Desser, Huy M. Do, Nancy Fischbein, Dominik Fleischmann, Garry E. Gold, Lawrence Hofmann, Debra M. Ikeda, Beverley Newman, Eric W. Olcott, Daniel M. Spielman, Daniel Y. Sze

Associate Professors (Research): Kim Butts-Pauly, Craig Levin, Sylvia Plevritis

Assistant Professors: Sandip Biswal, Frandics P. Chan, Nishita Kothary, William Kuo, Andrew Quon, Kathryn J. Stevens, Joseph Wu, Greg Zaharchuk

Assistant Professors (Research): Roland Bammer, Xiaoyuan Chen, Rebecca Fahrig, Samira Guccione, Brian Hargreaves, David Paik

Web Site: http://www-radiology.stanford.edu/

Courses given in Radiology have the subject code RAD. For a complete list of subject codes, see Appendix.

The Department of Radiology does not offer degrees; however, its faculty teach courses open to medical students, graduate students, and undergraduates. The department also accepts students in other curricula as advisees for study and research. Undergraduates may also arrange individual research projects under the supervision of the department's faculty. This discipline focuses on the use of radiation, ultrasound, and magnetic resonance as diagnostic, therapeutic, and research tools. The fundamental and applied research within the department reflects this broad spectrum as it relates to anatomy, pathology, physiology, and interventional procedures. Original research and development of new clinical applications in medical imaging is supported within the Radiological Sciences Laboratory.

COURSES

The following courses are open to undergraduates and graduate students.

RAD 101. Readings in Radiology Research—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

RAD 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

RAD 208. Experimental Nuclear Medicine—Computer applications in medicine, particularly in the use of radioisotopes as tracers. Recommended: some knowledge of physiology and calculus.

2 units, Win, Sum (Goris, M)

RAD 220. Introduction to Imaging and Image-Based Human Anatomy—(Same as BIOE 220.) The physics of medical imaging and human anatomy through medical images. Emphasis is on normal anatomy, contrast mechanisms, and the relative strengths of each imaging modality. Labs reinforce imaging techniques and anatomy. Recommended: basic biology, physics, and math.

3 units, Win (Gold, G; Butts-Pauly, K)

RAD 222A. Multimodality Molecular Imaging in Living Subjects I-(Same as BIOE 222A.) Instruments for imaging molecular and cellular events using novel assays. Instrumentation physics, chemistry of molecular imaging probes, and applications to preclinical models and clinical disease management.

4 units, Aut (Gambhir, S; Rao, J)

RAD 222B. Multimodality Molecular Imaging in Living Subjects II—(Same as BIOE 222B.) In vivo imaging techniques and applications to preclinical models and clinical disease management. Focus on cancer research, neurobiology, cardiovascular and musculoskeletal diseases.

4 units, Win (Gambhir, S; Rao, J)

RAD 226. In Vivo Magnetic Resonance Spectroscopy and Imaging—Collections of identical independent nuclear spins are described by the classical vector model of magnetic resonance imaging (MRI); however, interactions among spins, as occur in many in vivo processes, require a more complete description. Physics and engineering principles of these in vivo magnetic resonance phenomena with emphasis on current research questions and clinical applications. Topics: quantum mechanical description of magnetic resonance, density matrix theory, product operator formalism, relaxation theory and contrast mechanisms, spectroscopic imaging, spectral editing, and multinuclear studies. Prerequisites: EE 369B or familiarity with magnetic resonance, working knowledge of linear algebra.

3 units, Win (Spielman, D)

RAD 227. Functional MRI Methods—(Same as BIOPHYS 227.) 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. Recommended: neuroscience.

3 units, alternate years, not given this year

RAD 228. Magnetic Resonance Imaging Programming Seminar—Primarily for students working on research projects involving MRI pulse sequence programming. Introductory and student-initiated topics in seminars and hands-on labs. Image contrast mechanisms achieved by pulse sequences that control radiofrequency and gradient magnetic fields in real time, while acquiring data in an organized manner for image reconstruction. Prerequisites: EE 369B and consent of instructor.

2 units, Aut (Staff), Spr (Hargreaves, B)

RAD 299. Directed Reading in Radiology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

RAD 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

STRUCTURAL BIOLOGY

Chair: Joseph D. Puglisi

Associate Chair: Michael Levitt

Professors: Roger D. Kornberg, Michael Levitt, David B. McKay, Peter Parham, Joseph D. Puglisi, William I. Weis

Associate Professor: K. Christopher Garcia

Associate Professor (Research): Yahli Lorch

Professor (Teaching): Patricia Cross

Courtesy Professor: Axel Brunger, Uel J. McMahan

Courtesy Associate Professor: Vijay Pande

Courtesy Assistant Professor: Zev Bryant

Department Offices: Fairchild Building, D100

Mail Code: 94305- 5126

Phone: (650) 723-7576

Email: structuralbio@med.stanford.edu

Web Site: http://www.med.stanford.edu/school/structuralbio

Courses given in Structural Biology have the subject code SBIO. For a complete list of subject codes, see Appendix.

The department offers course work and opportunities for research in structural biology. Courses fall into two categories: (1) a series of one quarter courses that treat topics of current interest in structural biology and biophysics at an advanced level; and (2) INDE 216, Cells to Tissues, a course for medical students that includes lectures on structure-function relationships of mammalian cells and tissues and a lab on medical histology.

The emphasis of research in the department is on understanding fundamental cellular processes in terms of the structure and function of biological macromolecules and their assemblies. Techniques used include standard methods of biochemistry, cell culture, single-molecule fluorescence spectroscopy, genetic engineering, and three dimensional structure determination by x-ray diffraction, nuclear magnetic resonance spectroscopy and electron microscopy, coupled with the development of computational methods.

GRADUATE PROGRAMS

DOCTOR OF PHILOSOPHY

University requirements for the Ph.D. are described in the "Graduate Degrees" section of this bulletin.

The graduate program in Structural Biology leads to the Ph.D. degree. The department also participates in the Medical Scientists Training Program (MSTP) in which individuals are candidates for both Ph.D. and M.D. degrees.

The graduate program is intended to prepare students for careers as independent investigators in cell and molecular biology. The principal requirement of a Ph.D. degree is the completion of research constituting an original and significant contribution to the advancement of knowledge. The requirements and recommendations for the Ph.D. degree include:

1. Training in physics or chemistry 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:
   a) CHEM 131, 171, 173, and 175
   b) BIOC 200, 201
3. Completion of the following courses or their equivalents:
   a) SBIO 241 and 242
   b) At least four additional graduate-level courses in physical or biological science
   c) MED 255
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 Winter 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 Department of Structural Biology. 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 and expressing a contribution to knowledge in the field of structural biology.
7. The student must pass the University oral examination, taken only after the student has substantially completed the research. The examination is preceded by a public seminar in which the research is presented by the candidate.

Applicants to the program should have a bachelor's degree and should have completed at least a year of course work in biology, mathematics, organic chemistry, physical chemistry, and physics. Application forms must be received by the department before December 15 for notification by April 15. Application to the National Science Foundation for fellowship support is also encouraged. Remission of fees and a personal stipend are available to graduate students in the department. Prospective applicants should contact the Department of Structural Biology for further information.

Current topics of research in the department lie in the areas of gene expression; theoretical, crystallographic, and genetic analysis of protein structure; and cell-cell interaction. See http://www.med.stanford.edu/school/structuralbio/ for further information.

COURSES

Course and lab instruction in the Department of Structural Biology conforms to the "Policy on the Use of Vertebrate Animals in Teaching Activities," the text of which is available at http://www.stanford.edu/dept/DoR/rph/8-2.html.

SBIO 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

SBIO 228. Computational Structural Biology—(Same as BIOPHYS 228.) 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.

3 units, Aut, Spr (Levitt, M)

SBIO 229. The Eukaryote Chromosome—The principles of chromosome structure and function including the structure, dynamics, and topological forms of DNA; units and hierarchies of DNA coiling in chromosomes; centromeres, telomeres, and basis of chromosome maintenance and sorting in mitosis; mechanism of gene activation with particular regard to enhancer, promoter, and terminator sequences; basis of sequence-specific protein-DNA interaction; and organization and assembly of the cell nucleus. Prerequisite: knowledge of basic biochemistry and cell biology.

3 units, not given this year

SBIO 241. Biological Macromolecules—(Same as BIOC 241, BIOPHYS 241.) The physical and chemical basis of macromolecular function. Forces that stabilize biopolymers with three-dimensional structures and their functional implications. Thermodynamics, molecular forces, and kinetics of enzymatic and diffusional processes, and relationship to their practical application in experimental design and interpretation. Biological function and the level of individual molecular interactions and at the level of complex processes. Case studies. Prerequisites: introductory biochemistry and physical chemistry or consent of instructor.

3-5 units, Aut (Herschlag, D; Puglisi, J; Garcia, K; Ferrell, J; Block, S; Pande, V; Weis, W; Harbury, P)

SBIO 242. Methods in Molecular Biophysics—(Same as BIOPHYS 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. Prerequisite: physical chemistry or consent of instructor.

3 units, alternate years, not given this year

SBIO 274. Topics in Nucleic Acid Structure and Function—Principles of nucleic acid structure and function. Methods for investigating nucleic acid structure. Limited to graduate students and postdoctoral fellows in structural biology. Prerequisite: consent of instructor.

2 units, Spr (Puglisi, J)

SBIO 299. Directed Reading in Structural Biology—Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

SBIO 399. Graduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

SURGERY

Chair: Thomas M. Krummel
Division Heads: Craig Albanese (Pediatric General Surgery), James Chang (Plastic and Reconstructive Surgery), Ronald Dalman (Vascular Surgery), Carlos Esquivel (Transplant Surgery), Ralph Greco (General Surgery), Michael Longaker (Research), Robert Norris (Emergency Medicine)
Department Office: 701B Welch Road, Suite 225
Mail Code: 94305-5784
Phone: (650) 498-4292
Website: http://surgery.stanford.edu

Courses given in Surgery have the subject code SURG. For a complete list of subject codes, see Appendix.

COURSES

The following courses are open to undergraduates. For graduate and Medical School course offerings, see http://medcatalog.stanford.edu/.

SURG 67Q. Medical Experience in Foreign Lands—Stanford Introductory Seminar. Preference to sophomores. Topics may include the history and international development of Interplast, a nonprofit organization providing free reconstructive surgery for needy children and adults in developing nations; health care at King Faisal Hospital, Saudi Arabia; medical conditions in S. India; eye care in Africa; teaching experiences in Dar es Salaam; and rural health care in Latin America. The role such activities play in U.S. international relationships.

3 units, Win (Wang, N; Laub, D)

SURG 68Q. Current Concepts in Transplantation—Stanford Introductory Seminar. Preference to sophomores. Biological aspects of cell and organ transplantation, including issues that arise in the media. Diseases for which transplantation is a treatment, the state of the art in human transplantation, transplantation of animal tissue into humans (xenotransplantation), development of new tissue and organs in the laboratory (tissue engineering and cloning), and development of drugs and biological strategies to promote long-term survival of the tissue or organ (tolerance). How to write a scientific abstract, critique scientific literature, and research and present topics in contemporary transplantation. Write-2

3 units, Spr (Martinez, O; Krams, S)

SURG 69Q. It's All in the Head: Understanding Diversity, Development, and Deformities of the Face—Stanford Introductory Seminar. Preference to sophomores. How the face conveys moods and emotions, and elicits reactions when disease or genetic disorders leave behind disfigurement. New work by evolutionary and molecular biologists concerning how variations in facial form are elicited; how tissues and molecules interact to form the face. How differences in facial anatomy affect an individual's self-perception and their acceptance in our beauty-conscious society. Write-2

3-4 units, Win (Helms, J)

SURG 101. Regional Study of Human Structure—Preference to seniors. Lectures in regional anatomy and dissection of the human cadaver; the anatomy of the trunk and limbs through the dissection process, excluding the head and neck.

5 units, Win (Gosling, J; Whitmore, I)

SURG 111A/211A. Emergency Medical Technician (EMT-1): Training and Application—(Graduate students register for 211A.) Basics of life support outside the hospital setting; readiness training for emergencies on- or off-campus. Topics include emergency patient assessments, and cardiac, respiratory, and neurological emergencies. Lectures, practicals, and applications. Upon completion of SURG 111A,B,C or 211A,B,C, students are eligible to sit for the National Registry EMT licensure exam.

3 units, Aut (Gilbert, G; Richards, C)

SURG 111B/211B. Emergency Medical Technician (EMT-1): Training and Application—(Graduate students register for 211B.) Continuation of 111A/211A. Approach to traumatic injuries. Topics include head, neck, and trunk injuries, bleeding and shock, burn emergencies, and environmental emergencies. Lectures, practicals, and applications. Upon completion of SURG 111A,B,C or 211A,B,C, students are eligible to sit for the National Registry EMT licensure exam. Prerequisite: 111A/211A.

3 units, Win (Gilbert, G; Richards, C)

SURG 111C/211C. Emergency Medical Technician (EMT-1): Training and Application—(Graduate students register for 211C.) Continuation of 111B/211B. Topics include pediatric, obstetric, and gynecologic emergencies, EMS operations, mass casualty incidents, and assault. Lectures, practicals, and applications. Upon completion of SURG 111A,B,C or 211A,B,C, students are eligible to sit for the National Registry EMT licensure exam. Prerequisite: 111B/211B.

3 units, Spr (Gilbert, G; Richards, C)

SURG 112/212. Advanced Topics in EMS and Training in Teaching BLS Skills—(Graduate students register for 212.) Topics include advanced airway and stroke management, abdominal emergencies, and prehospital pharmacology. Prerequisites: SURG 111 or 211 A-C (or equivalent), EMT -I and CPR certifications, and consent of instructor.

2-3 units, Aut, Win, Spr (Gilbert, G; D'Souza, P; Richards, C)

SURG 199. Undergraduate Research—Investigations sponsored by individual faculty members. Prerequisite: consent of instructor.

1-18 units, Aut, Win, Spr, Sum (Staff)

SURG 223. Wilderness Medicine—Wilderness-related illnesses and injuries; framework for dealing with emergencies in the backcountry. Hands-on workshops. Topics include high altitude medicine, diving medicine, hypothermia, snake and spider envenomations, search and rescue, and travel medicine. Open to all students.

2 units, Spr (Weiss, E)

SURG 267. International Health—Issues in public health with an international perspective. Topics include: colonialism and development, reproductive health, women's health issues, environmental health, maternal child health, primary health care and its evolution, health policy, infectious disease, human rights, and social justice. Guest speakers from UCSF and Berkeley School of Public Health.

1 unit, not given this year