

# CANCER BIOLOGY

Courses offered by the Cancer Biology Program are listed under the subject code CBIO on the Stanford Bulletin's ExploreCourses web site.

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 genomics and proteomics approaches, 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 end of first 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 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 65 graduate students located in basic science and clinical departments throughout the School of Medicine and the School of Humanities and Sciences.

## Doctor of Philosophy in Cancer Biology

University requirements for the Ph.D. are described under the "Graduate Degrees (<http://exploreddegrees.stanford.edu/graduatedegrees>)" 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.

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:

### REQUIRED

BIOS 200	Foundations in Experimental Biology (for students entering in 2012 or later. Students who entered in 2011 or earlier took GENE 203, Advanced Genetics.)	5
CBIO 240	Molecular Genetic Basis of Cancer	4
CBIO 242	Cellular and Clinical Aspects of Cancer	4
CBIO 280	Cancer Biology Journal Club (required for first- and second-year graduate students in Autumn, Winter, and Spring quarters, totaling 6 units)	1
CBIO 245	Lecture Seminar Series in Cancer Biology Program (required for first- and second-year graduate student in Autumn, Winter, and Spring quarters, totaling to 6 units)	1
MED 255	The Responsible Conduct of Research	1
BIO 214	Advanced Cell Biology	4
<b>Select one from the following courses</b>		
BIOMEDIN 214	Representations and Algorithms for Computational Molecular Biology	3-4
BIOMEDIN 217	Translational Bioinformatics	4
CSB 210	Cell Signaling	4
GENE 211	Genomics	3
GENE 212	Introduction to Biomedical Informatics Research Methodology	3
SBIO 241	Biological Macromolecules	3-5

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 F31 NRSA-style written grant proposal not to exceed seven 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 progress during the past year and a plan of study for the coming year are presented orally 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.

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 must be from outside the Cancer Biology Program faculty and 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.

*Program Co-Directors:* Laura Attardi (Radiation Oncology and Genetics) and Julien Sage (Pediatrics and Genetics)

*Executive Committee on Cancer Biology:* Laura Attardi (Radiation Oncology and Genetics), Edward Graves (Radiation Oncology), Peter Jackson (Microbiology and Immunology; Pathology), Julien Sage (Pediatrics and Genetics), Monte Winslow (Genetics)

*Committee on Cancer Biology:* Steven Artandi (Medicine, Hematology), Jeffrey Axelrod (Pathology), Katrin Chua (Medicine, Endocrinology), Max Diehn (Radiation Oncology), Amato Giaccia (Radiation Oncology), Ashby Morrison (Biology), Sylvia Plevritis (Radiology), Jonathan Pollack (Pathology), Alejandro Sweet-Cordero (Pediatrics)

### Participating Departments and Faculty

*Biochemistry:* Philip Beachy (Professor), Mark Krasnow (Professor), Julia Salzman (Assistant Professor)

*Bioengineering:* Jennifer Cochran (Associate Professor), Jan Liphardt, (Associate Professor), Lei Stanley Qi (Assistant Professor)

*Biology (School of Humanities and Sciences):* Martha Cyert (Professor), Scott J. Dixon (Assistant Professor), Judith Frydman (Professor), Or Gozani (Professor), Ashby Morrison (Assistant Professor), W. James Nelson (Professor), Jan M Skotheim (Associate Professor), Tim Stearns (Professor)

*Chemical And Systems Biology:* James K. Chen (Professor), Karlene Cimprich (Professor), James E. Ferrell (Professor), Tobias Meyer (Professor), Mary Teruel (Assistant Professor)

*Dermatology:* Howard Y. Chang (Professor), Paul A. Khavari (Professor), M. Peter Marinkovich (Associate Professor), Anthony Oro (Professor), Kevin Wang (Assistant Professor)

*Developmental Biology:* Margaret Fuller (Professor), Seung Kim (Professor), Stuart Kim (Professor), Roeland Nusse (Professor)

*Genetics:* Michael Bassik (Assistant Professor), Anne Brunet (Professor), Michele Calos (Professor), Stanley Cohen (Professor), Christina Curtis (Assistant Professor), Monte Winslow (Assistant Professor)

*Medicine/Endocrinology/Gerontology/Metabolism:* Katrin Chua (Associate Professor), Andrew R. Hoffman (Professor)

*Medicine/Gastroenterology and Hepatology:* Christine Cartwright (Professor), Anson Lowe (Associate Professor)

*Medicine/Hematology:* Steven Artandi (Professor), Linda Boxer (Professor), Calvin Kuo (Professor), Ravindra Majeti (Associate Professor)

*Medicine/Oncology:* Ash Alizadeh (Assistant Professor), Gilbert Chu (Professor), Michael Clarke (Professor), Dean Felsner (Professor), James Ford (Associate Professor), Hanlee Ji (Associate Professor), Ronald Levy (Professor), Beverly S. Mitchell (Professor; Director, Stanford Cancer Institute), Mark Pegram (Professor), Rajat Rohatgi (Associate Professor), Branimir Sikic (Professor)

*Microbiology and Immunology:* Helen M. Blau (Professor), Peter Jackson (Professor), Garry Nolan (Professor)

*Neurology and Neurological Sciences:* Thomas Rando (Professor)

*Neurology and Neurosurgery:* Michelle Monje (Assistant Professor)

*Neurosurgery:* Albert J. Wong (Professor)

*Orthopaedic Surgery:* Nidhi Bhutani (Assistant Professor)

*Otolaryngology:* John Sunwoo (Associate Professor)

*Pathology:* Jeff Axelrod (Professor), Sean Bendall (Assistant Professor), Matthew Bogoy (Professor), Michael Cleary (Professor), Gerald Crabtree (Professor), Edgar Engleman (Professor), Andrew Fire (Professor), Isabella Graef (Assistant Professor), Joseph Lipsick (Professor), Bingwei Lu (Professor), Jonathan Pollack (Professor), Irving Weissman (Professor; Virginia & D.K. Ludwig Professor for Clinical Investigation in Cancer Research, Professor of Developmental Biology), Marius Wernig (Associate Professor)

*Pediatrics/Cancer Biology:* Matthew Porteus (Associate Professor), Julien Sage (Professor; Co-Director of Stanford Cancer Biology Program), Alejandro Sweet-Cordero (Associate Professor)

*Pediatrics/Cardiology:* Marlene Rabinovitch (Professor)

*Pediatrics/Endocrinology:* Brian Feldman (Assistant Professor)

*Pediatrics/Human Gene Therapy:* Mark Kay (Professor)

*Pediatrics/Hematology/Oncology:* Harvey Cohen (Professor), Kathleen Sakamoto (Professor)

*Pediatrics/Neonatal & Developmental Medicine:* Christopher Contag (Professor)

*Radiation Oncology/Radiation Biology:* Laura Attardi (Professor; Co-Director of Stanford Cancer Biology Program), Amato Giaccia (Professor)

*Radiation Oncology/Radiation Physics:* Edward Graves (Associate Professor)

*Radiation Oncology/Radiation Therapy:* Max Diehn (Assistant Professor), Susan Knox (Associate Professor), Albert Koong (Professor), Quynh-Thu Le (Professor)

*Radiology/Diagnostic Radiology:* Parag Mallick (Assistant Professor, Research), Sylvia Plevritis (Professor), Jianghong Rao (Associate Professor)

*Structural Biology:* William Weis (Professor)

*Urology:* Donna Peehl (Professor, Research), Zijie Sun (Professor)

## Courses

### CBIO 101. Cancer Biology. 4 Units.

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. Satisfies Central Menu Areas 1 or 2 for Bio majors. Prerequisite: Biology or Human Biology core or equivalent, or consent of instructor.

Same as: PATH 101

**CBIO 240. Molecular Genetic Basis of Cancer. 4 Units.**

Required for first-year Cancer Biology graduate students. Focus is on fundamental concepts in the molecular biology of cancer, including oncogenes, tumor suppressor genes, and cellular signaling pathways. Emphasis will be given to seminal discoveries and key experiments in the field of cancer molecular biology. Course consists of two 1 hour lectures and one 2 hour discussion per week. Enrollment of undergraduates requires consent of the course director.

**CBIO 241. Cellular Basis of Cancer. 4 Units.**

Focus on tumor cell biology including angiogenesis, metastasis, metabolism, stem cells, and other topics. Prerequisite: CBIO240.

**CBIO 242. Cellular and Clinical Aspects of Cancer. 4 Units.**

Required for first-year Cancer Biology graduate students, and for first- and second-year medical students intending to complete the Cancer Biology Scholarly Concentration. Focus is on the cellular biology of cancer, including discussion of basic biology including tumor angiogenesis, metabolism, and immunology, as well as clinical oncology and cancer therapeutics. Emphasis will be given to seminal discoveries and key experiments in the field of cancer biology and oncology. Course consists of two 1 hour lectures and one 2 hour discussion per week. Enrollment of undergraduates requires consent of the course director.

**CBIO 243. Principles of Cancer Systems Biology. 3 Units.**

Focus is on major principles of cancer systems biology research that integrates experimental and computational biology in order to systematically unravel the complexity of cancer. The opportunity to embark on cancer systems biology research has been enabled by the rapid emergence of numerous and increasingly accessible technologies that provide global DNA, RNA and protein expression profiles of cells under a variety of conditions following environmental, drug and genetic perturbations. Course addresses the challenge of how to analyze high-dimensional and highly-multiplexed data in order to synthesize biologically and clinically relevant insights and generate hypotheses for further functional testing. Aims to broaden student exposure to the experimental and computational skills needed to apply the emerging principles of systems biology to the study of cancer.

**CBIO 244. Lecture Series in Cancer Systems Biology. 1 Unit.**

Presents new concepts in the field of cancer systems biology, demonstrating the integration of novel experimental and computational approaches for addressing outstanding critical questions in cancer biology. Invited speakers share insights about state-of-the-art trends and advice on navigating a career in cancer systems biology. Course required for CSBS Fellows.

**CBIO 245. Lecture Seminar Series in Cancer Biology Program. 1 Unit.**

Invited speakers share insights about state-of-the-art trends. Presents new concepts in the field of cancer biology. Science talks presented by students.

**CBIO 260. Teaching in Cancer Biology. 1-10 Unit.**

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.

**CBIO 275. Tumor Immunology. 2 Units.**

Tumor Immunology focuses on the mechanisms by which tumors can escape from and subvert the immune system and conversely on the ability of innate and adaptive arms of the immune system to recognize and eliminate tumors. Topics include: tumor antigens, tumor immunosurveillance and immunoediting, tumor immunotherapy (including CAR-T and checkpoint antibodies) and cancer vaccines. Tracks the historical development of our understanding of modulating tumor immune response and discusses their relative significance in the light of current research findings. Prerequisite: for undergraduates, human biology or biology core.

Same as: IMMUNOL 275

**CBIO 280. Cancer Biology Journal Club. 1 Unit.**

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.

**CBIO 299. Directed Reading in Cancer Biology. 1-18 Unit.**

Prerequisite: consent of instructor.

**CBIO 399. Graduate Research. 1-18 Unit.**

Students undertake investigations sponsored by individual faculty members. Cancer Biology Ph.D. students must register as soon as they begin dissertation-related research work.

**CBIO 801. TGR Project. 0 Units.**

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**CBIO 802. TGR Dissertation. 0 Units.**

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