

# CANCER BIOLOGY

Courses offered by the Cancer Biology Program are listed under the subject code CBIO on the (<http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=CBIO&filter-catalognumber-CBIO=on>) Stanford Bulletin's (<http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=CBIO&filter-catalognumber-CBIO=on>) ExploreCourses web site (<http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=CBIO&filter-catalognumber-CBIO=on>).

The Cancer Biology Ph.D. program was established in 1978 at Stanford University. During the past four decades, the understanding of cancer has increased dramatically with the discovery of oncogenes and tumor suppressor genes, pathways of DNA damage and repair, cell cycle regulation, angiogenesis and responses to hypoxia, and the molecular basis of metastasis, among others. In addition, methods of parallel analysis including genomic and proteomic approaches have begun to refine and redefine the taxonomy of cancer diagnosis. This explosion of basic and clinical science has, in turn, resulted in the first successful cancer chemotherapies and immunotherapies based on knowledge of specific molecular targets. Stanford presents a unique environment to pursue interdisciplinary cancer research because the School of Medicine, the School of Humanities and Sciences, and the School of Engineering are located on a single campus, all within walking distance of one another.

The goal of the Cancer Biology Ph.D. program is to provide students with education and training that will enable them to make significant contributions to this remarkable field. Coursework 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 clinical diagnosis and treatment 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 the first year, each student has chosen his/her research advisor and has begun work on his/her dissertation project. A qualifying examination must be completed before the end of December of the second year. An annual Cancer Biology Conference provides students with an opportunity to present their research to one another and to the faculty in the program. The expected time to degree is four to five years.

Students are not limited to a single department in choosing their research advisors. The Cancer Biology Ph.D. program currently has approximately 65 graduate students located in a variety of basic science and clinical departments throughout the School of Medicine and School of Humanities and Sciences. Many students are supported by a training grant from the National Cancer Institute.

The Cancer Biology Ph.D. program is committed to fostering a diverse community of students. The program welcomes all individuals and strives to support them so they achieve their full potential. It values the diversity of its students because culture, socioeconomic and educational background, race, ethnicity, gender, sexual orientation, physical ability, life experiences, hobbies, and interests allow the program as a group to reach a greater level of innovation in cancer research.

## 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 advisor prior to the end of Summer Quarter, the 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:

		<b>Units</b>
<b>Required Courses</b>		
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 and 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
<b>Electives (total of 10 units)</b>		
<b>Computational/Systems Cancer Biology Track</b>		
<b>Core Knowledge</b>		
CBIO 290	Curricular Practical Training	1-2
STATS 60	Introduction to Statistical Methods: Precalculus	5
GENE 218	Computational Analysis of Biological Information: Introduction to Python for Biologists	2
NENS 230	Analysis Techniques for the Biosciences Using MATLAB	2
CS 106A	Programming Methodology	3-5
BIOS 205	Stem Cells, Immunology and Regenerative Medicine (Introduction to R; no longer offered)	1
GENE 211	Genomics	3
CBIO 243	Principles of Cancer Systems Biology	3
BIOS 201	Next Generation Sequencing and Applications	2
<b>Additional Courses</b>		
CS 106B	Programming Abstractions	3-5
STATS 116	Theory of Probability	4
STATS 202	Data Mining and Analysis	3
STATS 216	Introduction to Statistical Learning	3
BIOMEDIN 214	Representations and Algorithms for Computational Molecular Biology	3-4
IMMUNOL 207	Essential Methods in Computational and Systems Immunology	3
CS 161	Design and Analysis of Algorithms	3-5
GENE 245		3
<b>Other Cancer Biology Related Graduate-Level</b>		
BIO 214	Advanced Cell Biology	4
S BIO 241	Biological Macromolecules	3-5
CSB 210	Cell Signaling	4

IMMUNOL 201	Advanced Immunology I	3
DBIO 201	Cells and Signaling in Regenerative Medicine	2
MI 215	Principles of Biological Technologies	3
CBIO 275	Tumor Immunology	3

- Other elective course is determined in consultation with the student's advisor and/or the Program Director.
- Presentation of research results at the annual Cancer Biology Conference and Pizza Talks.
- 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 but does not include the student's dissertation advisor. The composition of this committee is chosen by the student and thesis advisor and must be submitted to and approved by the Program Directors prior to the end of Autumn Quarter, second year. The qualifying examination must be taken prior to the end of December of the 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 advisor 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 advisor 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 advisor'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 advisor.

## COVID-19 Policies

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

The Senate decided that all undergraduate and graduate courses offered for a letter grade must also offer students the option of taking the course for a "credit" or "no credit" grade and recommended that deans,

departments, and programs consider adopting local policies to count courses taken for a "credit" or "satisfactory" grade toward the fulfillment of degree-program requirements and/or alter program requirements as appropriate.

## Graduate Degree Requirements

### Grading

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

### Advising Expectations

The mission of the Cancer Biology Ph.D. program is to train graduate students so that they may ultimately launch careers related to the study and treatment of cancer. A major goal of the program is to assist students in their growth and development by constructing meaningful educational plans. The program believes that students will become outstanding cancer researchers through frequent and collegial personal contacts with their primary research advisors, members of their thesis committee, and other faculty in the program. Scientific interactions between students and faculty foster the development of motivated students who are independent thinkers and responsible decision makers. The program expects faculty thesis advisors to have an active role in the advising process, including by monitoring progress frequently and by helping define and develop realistic educational career plans through regular interactions with the advisee. Faculty thesis advisors should refer students to other institutional resources as needed. The program expects students to clarify their academic and career goals with their advisors and to be equal partners in the advising process, including by scheduling regular meetings with their advisors and by adhering to institutional policies, procedures, and requirements. These expectations, which are detailed in the program handbook, ensure the successful completion of degree requirements and timely graduation.

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

*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), Erinn Rankin (Radiation Oncology, Obstetrics and Gynecology), Julien Sage (Pediatrics and Genetics), Kevin Wang (Dermatology), Monte Winslow (Genetics)

*Admissions Committee on Cancer Biology:* Laura Attardi (Radiation Oncology and Genetics), Michelle Monje (Neurology), Carolyn Lee (Dermatology), Anthony Oro (Dermatology), Sharon Pitteri (Radiology), Julien Sage (Pediatrics and Genetics), Katrin Svensson (Pathology), Kevin Wang (Dermatology), Monte Winslow (Genetics), Jiangbin Ye (Radiation Oncology and Biology)

### Participating Departments and Faculty

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

*Bioengineering:* Jennifer Cochran (Professor)

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

*Biomedical Data Science:* Andrew Gentles (Assistant Professor), Purvesh Khatri (Associate Professor), Aaron Newman (Assistant Professor)

*Chemical And Systems Biology:* James K. Chen (Professor), Gheorghe Chistol (Assistant Professor), Karlene Cimprich (Professor), Mary Teruel (Assistant Professor)

*Chemical Engineering and Genetics:* Monther Abu-Remaih (Assistant Professor)

*Dermatology:* Howard Y. Chang (Professor), Paul A. Khavari (Professor), Carolyn Lee (Assistant Professor), Anthony Oro (Professor), Kevin Wang (Assistant Professor)

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

*Genetics:* Michael Bassik (Assistant Professor), Anne Brunet (Professor), Christina Curtis (Associate Professor), Julien Sage (Professor; Co-Director of Stanford Cancer Biology Program), Alice Ting (Professor), Monte Winslow (Associate Professor)

*Medicine/Endocrinology/Gerontology/Metabolism:* Justin Annes (Associate Professor), Katrin Chua (Associate Professor)

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

*Medicine/Hematology:* Steven Artandi (Professor; Director, Stanford Cancer Institute), Calvin Kuo (Professor), Ravindra Majeti (Professor)

*Medicine/Oncology:* Ash Alizadeh (Associate Professor), Gilbert Chu (Professor), Michael Clarke (Professor), Dean Felsher (Professor), Hanlee Ji (Associate Professor), Ronald Levy (Professor)

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

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

*Neurosurgery:* Albert J. Wong (Professor)

*Orthopedic Surgery:* Nidhi Bhutani (Associate Professor)

*Otolaryngology:* John Sunwoo (Professor)

*Pathology:* Robert Angelo (Assistant Professor), Jeff Axelrod (Professor), Sean Bendall (Assistant Professor), Matthew Bogoy (Professor), Michael Cleary (Professor), Gerald Crabtree (Professor), Edgar Engleman (Professor), Andrew Fire (Professor), Joseph Lipsick (Professor), Bingwei Lu (Professor), Jonathan Long (Assistant Professor), Jonathan Pollack (Professor), Capucine van Rechem (Assistant Professor), Ansuman Satpathy (Assistant Professor), Katrin Svensson (Assistant Professor), Irving Weissman (Professor; Virginia & D.K. Ludwig Professor for Clinical Investigation in Cancer Research, Professor of Developmental Biology), Marius Wernig (Professor)

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

*Pediatrics/Hematology/Oncology:* Charles Gawad (Associate Professor), Crystal Mackall (Professor), Matthew Porteus (Professor), Kathleen Sakamoto (Professor)

*Psychiatry and Behavioral Sciences:* Erin Gibson (Associate Professor)

*Radiation Oncology/Radiation and Cancer Biology:* Laura Attardi (Professor; Co-Director of Stanford Cancer Biology Program), Richard Frock (Assistant Professor), Edward Graves (Associate Professor), Sharon Pitteri (Associate Professor), Erinn Rankin (Assistant Professor), Jiangbin Ye (Assistant Professor)

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

*Radiology/Diagnostic Radiology:* Parag Mallick (Associate Professor, Research), Sylvia Plevritis (Professor), Tanya Stoyanova (Assistant 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 and 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 246. Clinical Cancer Research Internship Program. 1 Unit.**

As this is a limited enrollment course, graduate students interested in this course will contact must be affiliated with Cancer Biology Ph.D. Program and must contact the primary instructor Dr. Majeti and the course director Drs. Attardi and Sage by email. A prerequisite for the course is the successful completion of the online training component for HIPAA certification. In addition, the following is required: 1. Documented proof of Measles, Mumps & Rubella immunity in the form of vaccine dates or positive blood tests. 2. Documented proof of Varicella (chicken pox) immunity in the form of vaccine dates or positive blood tests. 3. Annual TB screening (PPD for US born or born in Canada and QFT for foreign born of high risk TB countries) 4. Annual Influenza vaccine (between Nov 1-March 31) In the first component of the course, Dr. Majeti will identify an oncologist (adult or pediatrics) actively working in the clinic that the student can shadow that quarter for a minimum of 4 hours and will put the student in contact with the clinician. Shadowing hours can be at any time of the week or the weekend. The clinician will contact Dr. Majeti to confirm that the student has shadowed him/her for 4 hours. In the second component of the course, Dr. Majeti will inform the student when the oncology clinical tumor board meets. The student must attend at least 3 tumor board sessions in the quarter (1h30 each). In the third component of the course, the student will write a one-page analysis of a clinical paper related to cancer biology.

**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. 3 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 microenvironment, tumor induced immunosuppression, tumor immunotherapy (including cancer vaccines, CARs, TILs, checkpoint antibodies, monoclonal antibodies and bispecific antibodies, as well as bone marrow transplantation and radiation therapy). 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 290. Curricular Practical Training. 1-2 Unit.**

**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.**

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