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GRADUATE PROGRAM IN BIOCHEMISTRY

The goal of the Biochemistry Program (BCHM) is for students to acquire advanced knowledge of the biochemical principles that underlie how cells function in both the normal and diseased states. Because these principles form the basis for research into all cellular processes, the knowledge gained by our students through coursework and thesis research prepares them to enter careers in biomedical research, teaching in universities, professional schools and government labs, biotechnology industry research and management as well as other fields.

View a list of Biochemistry Program Faculty.

CURRICULUM OVERVIEW

During the first year, students interested in the Biochemistry Program participate in the Integrated Studies Program (ISP), a single portal of entry and common first-year curriculum for four Sackler programs: Biochemistry; Cell, Molecular and Developmental Biology; Cellular and Molecular Physiology, and Neuroscience. In the first year, students complete required ISP didactic courses (BCHM 223 and 230, CNP 209 and 210), an ethics course and a statistics course. They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations. A complete description of the Integrated Studies Program can be found here.

Students electing to pursue a PhD in Biochemistry declare this intention when they select a thesis adviser at the end of May in the first year of graduate school. During the second and subsequent years, students complete an additional required didactic course (BCHM 231), two elective credits, and an ethics course if they did not do so during their first year. Students also participate in Biochemistry journal clubs and seminars and must pass a qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY

Students must pass a qualifying examination by May of their first year in the Biochemistry Program. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the fall semester following their first year in the Biochemistry Program. Admission to candidacy is based on achievements in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.

RESEARCH AND DISSERTATION

Students begin preliminary research when they enter the Biochemistry Program and their dissertation laboratory. The student and mentor, in consultation with the student adviser and program director, select a thesis advisory committee of at least three Biochemistry Program faculty members. A précis of the thesis
project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student meets with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the thesis research committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis research committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

TEACHING
In the third year, graduate students assist in conference and tutorial group teaching of medical students as part of their training.

PUBLICATION
Students are expected to publish their research in scientific journals appropriate to their topic and typically all students publish one or more papers.

COURSES
BCHM 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to a committee of the faculty. Spring. Program faculty

BCHM 223: GRADUATE BIOCHEMISTRY (2 CR)
This course provides a graduate-level discussion of the structure and function of biologically important molecules. Problems of protein and nucleic acid biochemistry are emphasized. Fall. Schaffhausen, Program faculty

BCHM 230: BIOCHEMISTRY OF GENE EXPRESSION AND SIGNAL TRANSDUCTION (2 CR)
This course covers the molecular mechanisms of gene expression and signal transduction. The fundamental mechanisms underlying transcription, RNA processing, translation, and DNA replication are highlighted, and the integration of these fundamental mechanisms into molecular and cellular regulation of proliferation and signal transduction is discussed. Current literature is emphasized. Spring. Yee, Program faculty

BCHM 230A: BIOCHEMISTRY OF GENE EXPRESSION (1 CR)
The fundamental mechanisms underlying transcription, RNA processing, translation, and DNA replication are highlighted in this course. Current literature is emphasized. This course represents the first part of Biochemistry 230 and may be taken as a separate course. Spring. Yee, Program faculty

BCHM 230B: BIOCHEMISTRY OF SIGNAL TRANSDUCTION (1 CR)
The integration of fundamental mechanisms into molecular and cellular regulation of proliferation and signal transduction is discussed. Current literature is emphasized. This course represents the second part of Biochemistry 230 and may be taken as a separate course. Spring. Yee, Program faculty
BCHM 231: MOLECULAR RECOGNITION IN BIOLOGY AND DRUG DESIGN (1 CR)
This course includes discussion of the association of biological molecules. Complexes of proteins with
other proteins, with lipids, and with nucleic acids are emphasized. There will also be discussions on drug
screening and optimization techniques as they have been applied in a number of detailed, real-world cases.
Spring. Bachovchin, Program faculty

BCHM 231A: MOLECULAR RECOGNITION IN BIOLOGY (0.5 CR)
This course represents the first part of a discussion of the association of biological molecules. Complexes
of proteins with other proteins, with lipids, and with nucleic acids are emphasized. Spring. Bohm,
Program faculty

BCHM 231B: DRUG DESIGN (0.5 CR)
This course represents the second part of a discussion of drug screening and optimization techniques as
they have been applied in a number of detailed, real-world cases. Spring. Bachovchin, Program faculty

BCHM 234: MACROMOLECULAR CRYSTALLOGRAPHY (0.5 CR)
This course is an introduction to practical macromolecular crystallography. It includes some theoretical
material but emphasizes the practical aspects of the technique. Students will grow protein crystals and use
them to learn crystallographic data collection, phasing, and molecular replacement methods. Spring. Bohm

BCHM 235: FUNDAMENTALS OF NUCLEAR MAGNETIC RESONANCE (0.5 CR)
Fundamentals of NMR is a course designed to teach advanced topics in NMR spectroscopy at a deep and
fundamental level. Fall. Baleja

BCHM 275: APPLIED ETHICS FOR SCIENTISTS (0.5 CR)
This course is a series of discussions, with active student participation, in definition and evaluation of both
positive and problematic ethical issues in research. Issues considered include: ethical underpinnings of
science; recognition, reporting, and evaluation of apparent misconduct; authorship, credit, and intellectual
property; conflict of interest in reviews of papers, grants, and in commerce; animals and humans as subjects
in research; and ethical choice of research projects. Spring. Program faculty

BCHM 291, 292: GRADUATE SEMINAR (0.5 CR)
Presentations of scientific research by visiting speakers from the Boston community and beyond. Fall and
Spring. Program faculty

BCHM 293, 294: SPECIAL TOPICS (0.5 CR)
Advanced seminars. Topics have included protein phosphorylation, G protein function, and molecular
structure determination by NMR. Students may also pursue guided individual study of an approved topic.
Fall and Spring. Program faculty

BCHM 295, 296: JOURNAL CLUB (0.5 CR)
Presentation of individual reports on literature topics to a seminar group for discussion. Fall and Spring.
Program faculty

BCHM 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Guided research on a topic suitable for a doctoral dissertation. Fall, Spring and Summer. Program faculty

BCHM 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Program faculty
GRADUATE PROGRAM IN CELL, MOLECULAR AND DEVELOPMENTAL BIOLOGY

The Graduate Program in Cell, Molecular and Developmental Biology (CELL) supports rigorous training of pre-doctoral students in developmental biology. This discipline integrates the study of dynamic cellular and molecular processes into an organismal context and forms the basis for investigation of reproductive and embryonic, fetal and neonatal, genetic and teratologic diseases. Most importantly, research focused on development and developmental diseases often reveals the mechanisms underlying normal and aberrant tissue remodeling in the mature organism; e.g. in wound healing, the menstrual cycle, cardiovascular disease, tissue regeneration, and in fundamental disturbances in cell behavior such as aging and cancer. Our trainees will be prepared to solve problems through experimental approaches and be ready to pursue postdoctoral training leading to positions in academia or the biotechnology industry upon completion of their studies.

View a list of Cell, Molecular and Developmental Biology Faculty.

CURRICULUM OVERVIEW

During the first year, students interested in the Cell, Molecular and Developmental Biology Program participate in the Integrated Studies Program (ISP), a single portal of entry and common first-year curriculum for four Sackler programs: Biochemistry; Cell, Molecular and Developmental Biology; Cellular and Molecular Physiology, and Neuroscience. In the first year, students complete required ISP didactic courses (BCHM 223 and 230, CNP 209 and 210), an ethics course and a statistics course. They also participate in weekly ISP journal clubs and seminars and complete four laboratory rotations. A complete description of the Integrated Studies Program can be found here.

Students electing to pursue a PhD in the Cell, Molecular and Developmental Biology Program declare this intention when they select a thesis adviser at the end of May in the first year of graduate school. During the second and subsequent years, students must complete an additional required didactic course (CELL 235), one elective credit, and an ethics course if they did not do so during their first year. Students also participate in Molecular and Developmental Biology journal clubs and seminars and must pass a qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY

Students must pass a qualifying examination by February of their first year in the Cell, Molecular and Developmental Biology Program. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the spring semester of their first year in the Cell, Molecular and Developmental Biology Program. Admission to candidacy is based on achievement in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.
RESEARCH AND DISSERTATION
Students begin preliminary research when they enter the Cell, Molecular and Developmental Biology Program and their dissertation laboratory. The student and mentor, in consultation with the student adviser and program director, select a thesis advisory committee of at least three Cell, Molecular and Developmental Biology Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student meets with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the thesis research committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis research committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

TEACHING
Each student has the option (with the approval of the Program Director and the thesis adviser) to participate in mentored teaching of a one-semester professional course. All course assignments are determined by a consensus of the student, his/her adviser, the course director, and the Program Director. To promote the acquisition of communication skills in this phase of the program, the student is expected to be actively involved in laboratories, tutorials and teaching meetings, and to prepare and deliver introductions to laboratories and/or formal lectures.

PUBLICATION
Students are expected to publish their research in scientific journals appropriate to their topic and typically all students publish one or more papers.

COURSES
CELL 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented to three faculty members chosen by the Program Director. Spring. Program faculty

CELL 203: MEDICAL HISTOLOGY (2 CR)
This is an elective course that introduces the student to the organization of a variety of cells, tissues, and organ systems. The lectures present information on the relationships between structure and function (e.g., physiology, biochemistry, and development), while the laboratories involve tissue and organ identification, providing both a practical background in cell and tissue biology. Fall. Castellot

CELL 235: DEVELOPMENTAL BIOLOGY (1 CR)
This course introduces students to modern developmental biology with an emphasis on the cellular and molecular mechanisms involved. General topic areas include fertilization and early development, mechanisms of cell determination and differentiation, and cell-cell and cell-matrix interactions. Fall. Hatini
CELL 291, 292: GRADUATE SEMINAR (0.5 CR)
Weekly reports of ongoing research given and attended by all members of the Cell, Molecular and Developmental Biology program, including students, faculty, and postdoctoral fellows. Fall and Spring. 
Program faculty

CELL 293, 294: SPECIAL TOPICS (0.5 CR)
Reading courses on selected topics. Fall and Spring. Program faculty

CELL 295, 296: JOURNAL CLUB (0.5 CR)
Students present detailed analyses of current research articles from several fields within cell biology, molecular biology, developmental biology, reproductive biology, neurobiology, and other related research areas. Fall and Spring. Program faculty

CELL 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Guided research on a topic suitable for a doctoral dissertation. Fall, Spring and Summer. Program faculty

CELL 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Program faculty
GRADUATE PROGRAM IN CELLULAR AND MOLECULAR PHYSIOLOGY

The Graduate Program in Cellular and Molecular Physiology (CMP) seeks to train outstanding scientists and physician-scientists to pursue careers in biomedical research in both academic and industrial settings. The program focuses on basic cellular processes and their relationship to human disease. Situated on the Health Sciences campus of Tufts University, home to the School of Medicine, School of Dental Medicine, Friedman School of Nutrition Science and Policy, the USDA Human Nutrition Research Institute on Aging and Tufts Medical Center, the program takes advantage of an extensive array of disease-related research. The program’s trainees will learn to incorporate current medical problems into their research and enhance their ability to impact human health.

View a list of Cellular and Molecular Physiology Faculty.

CURRICULUM OVERVIEW

During the first year, students interested in the Cellular and Molecular Physiology Program participate in the Integrated Studies Program (ISP), a single portal of entry and common first-year curriculum for four Sackler programs: Biochemistry; Cell, Molecular and Developmental Biology; Cellular and Molecular Physiology, and Neuroscience. In the first year, students complete required ISP didactic courses (BCHM 223 and 230, CNP 209 and 210), an ethics course and a statistics course. They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations. A complete description of the Integrated Studies Program can be found here.

Students electing to pursue a PhD in Cellular and Molecular Physiology declare this intention when they select a thesis adviser at the end of May in the first year of graduate school. During the second and subsequent years, students must complete an additional required didactic course (CMP 230), two elective courses, and an ethics course if they did not do so during their first year. Students also participate in Cellular and Molecular Physiology journal clubs and seminars and must pass a qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY

Students must pass a qualifying examination by March of their first year in the Cellular and Molecular Physiology Program. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the spring semester of their first year in the Cellular and Molecular Physiology Program. Admission to candidacy is based on achievement in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.
RESEARCH AND DISSERTATION
Students begin preliminary research when they enter the Cellular and Molecular Physiology Program and their dissertation lab. The student and mentor, in consultation with the student adviser and program director, select a thesis advisory committee of three Cellular and Molecular Physiology Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student meets with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the thesis research committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis research committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION
Students are required to publish a first author paper based on their thesis work before defending their thesis.

COURSES

CMP 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to the faculty. Spring. Program faculty

CMP 230: PATHOBIOLOGY (1 CR)
A discussion-based course that introduces graduate students to human disease, familiarizes them with pathological specimens and patients, provides examples of how scientific discovery and clinical practice have influenced each other, and uses clinical problems as a starting point for hypothesis-driven research. Fall. Liscum, Simon

CMP 245: BIOINFORMATICS AND GENOMICS IN BIOMEDICAL RESEARCH (1 CR)
Information and in-depth training in the use of bioinformatics and genomics-related tools and resources as they relate to biological research. Topics include working with biological databases, gene sequence analysis, prediction of protein structure, molecular modeling, model genomes, expression array technology, proteomics and functional genomics, and molecular evolution. Prerequisites: familiarity with genetic approaches or consent of the course director. Spring. Sahagian

CMP 275: APPLIED ETHICS FOR SCIENTISTS (0.5 CR)
A series of case studies promote an open dialogue between faculty, students and postdoctoral fellows on the subject of responsible conduct in science, including mentoring, fraud, misconduct, conflicts of interest and intellectual property. Spring-alternate years. Jay

CMP 291, 292: GRADUATE SEMINAR (0.5 CR)
Presentations of scientific research by visiting speakers from the Boston community and beyond. Fall and Spring. Program faculty

CMP 293, 294: SPECIAL TOPICS (0.5 CR)
A reading course in which the student and a faculty member (other than their dissertation adviser) review and critique current research articles on a chosen topic relevant to the themes of the program. Fall and Spring. Program faculty
CMP 295, 296: JOURNAL CLUB (0.5 CR)
Students select articles from the current literature, analyze their significance, and present them for discussion in a seminar group. Fall and Spring. Faust

CMP 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Guided research on a topic suitable for a dissertation. Fall, Spring and Summer. Program faculty

CMP 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Program faculty
GRADUATE PROGRAM IN CLINICAL RESEARCH

The Clinical Research Program (CRES) trains physicians or other clinicians who will be leaders and innovators to develop, evaluate, apply and implement clinical research techniques that will improve and enhance patient care, and trains those with careers in health services research. Our goals are achieved by teaching core research methods and skills and by facilitating each trainee's successful completion of an independent research project in an environment where innovation and excellence are expected and opportunities are plentiful. The Clinical Research Program confers MS and PhD degrees in Clinical Research and also offers a Certificate Program. These programs are intended for individuals already trained in the medical sciences, primarily fully-trained physicians, but also others with analogous backgrounds (e.g., DDS, DVM) that have completed their clinical training and want further training for research careers.

View a list of Clinical Research Faculty.

MASTER’S AND PHD CURRICULUM OVERVIEW

The Clinical Research Master’s Program provides a strong foundation of core methods and skills through required didactic courses (CRES 523, 525, 527, 535, 540, 561, 566, and 581), 2.5 elective credits, seminars, hands-on computer labs, workshops and mentored research projects. Participants acquire a rigorous foundation that includes research methods, statistics, research conduct, research ethics, manuscript and grant writing, and other specialized areas. Because the ability to self-initiate and execute independent research is key to success as a researcher, a central requirement is the completion of an independent research project that leads to a master’s thesis. Students have the opportunity to select one of six areas for focused concentration: Bench-to-Bedside Translational Research, Clinical Investigation, Epidemiology and Biostatistics, Evidence-based Medicine, Health Services and Outcomes Research, and Medical Informatics. For the Master’s degree, 19.5 credits are required; 11 credits in the core curriculum, six credits for a publishable thesis, and 2.5 credits of electives. The Master’s Degree typically takes two years to complete. The majority of students are postdoctoral fellows or faculty based at Tufts Medical Center, with others based at other Tufts affiliated hospitals and at other local institutions and in industry.

Students interested in pursuing PhD degrees in Clinical Research typically sit for their qualifying exams during the end of the first year or the beginning of the second year in the MS program. After satisfactory performance on the qualifying exam, PhD candidates complete additional courses deemed necessary by the students and faculty advisers, and create original dissertations of publishable quality. For the PhD degree, 37.5 credits are required: 11 credits in the core curriculum, 21 credits for a publishable thesis, and 2.5 credits for electives. PhD degrees typically take at least four years to complete.

As students progress in the MS or PhD programs, they will select Chairs for their thesis committees. Often, a Project Mentor with whom the student worked in the first year will agree to chair a thesis committee. The Thesis Committee Chair must be a member of the Sackler School Faculty. The Thesis Mentor should be identified by the end of the first semester of study. The purpose of the thesis or dissertation is to demonstrate research competence as a culminating project of the Clinical Research graduate program. Working under the supervision of the Thesis Committee, the student’s work must be original and rigorous, and approved by the student’s Thesis Committee and the Clinical Research Program Advisory Committee in order to graduate.
PUBLICATION
Publishing research is an important element of the scientific research process for both the Master’s and PhD degrees. To encourage publication of the thesis or dissertation research findings, the Clinical Research Program will accept either a publishable manuscript format or a traditional monograph format. Students are encouraged to use the publishable format as a way to enhance their scholarship record. One article is required for the master’s thesis (original research findings) and a minimum of three articles are required for the doctoral dissertation (at least one of which must present original research findings).

CERTIFICATE CURRICULUM OVERVIEW
The Clinical Research Certificate Program is specifically designed for junior faculty of Tufts-affiliated hospitals, fellows in training, and mid-career clinicians who are considering a career change and want to strengthen their clinical research skills. The program begins in the summer and continues part-time for the next nine months. The curriculum includes required didactic courses (CRES 504, 523, 525, 540, 561, 566, and 581), seminars, workshops, and customized final research projects. For the Certificate Program, eight credits are required: seven credits in the core curriculum and one credit of research. Research efforts should result in a publishable manuscript/brief report, proposal for pilot project, etc.

COURSES
CRES 000: PhD QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to a committee of the faculty. Fall and Spring. Program faculty

CRES 402: MASTER’S DEGREE ONLY (0 CR)
Master’s thesis preparation. Summer. Program faculty

CRES 403, 404: PhD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring or Summer. Program faculty

CRES 500: STUDY DESIGN SEMINAR (0.5 CR)
This year-long seminar meets weekly for one hour and uses proposed and ongoing research projects to explore issues in study design. The course format provides investigators and trainees the opportunity to present an ongoing research-related problem that they are encountering and engages students in a discussion of the approach to the problem and construction of an appropriate plan of action. Fall and Spring. Kent, Wilson

CRES 501: TRANSLATIONAL AND MOLECULAR EPIDEMIOLOGY (0.5 CR)
This course will aim to address some of the main challenges of current translational research in the interface of epidemiology and molecular medicine. Spring. Ioannidis

CRES 502: BRIDGING THE BENCH-TO-BEDSIDE GAP (0.5 CR)
This course seeks to diminish the "bench-to-bedside" gap by bringing clinical graduate students into the world of basic science research. Students focus on the major questions that are ripe for future scientific investigation; how scientific discoveries have influenced clinical practice and how clinical practice has affected basic research. Examination of active projects at Tufts Medical Center will introduce students to translational science in action. Spring. Simon
CRES 504: UNDERSTANDING BIOSTATISTICAL METHODS (1 CR)
This course presents the practical application of biostatistical methods for exploring and analyzing health data. Methods for working with data and exploring basic associations are presented through case examples and clinical research projects. Summer. Griffith

CRES 510: PREDICTIVE MODELS FOR HEALTH OUTCOMES (1 CR)
This course explores the use of statistical models to predict clinical outcomes for retrospective review and as prospective decision aids. Emphasis is placed on integrating statistical and clinical thinking to construct models that are both statistically and clinically sound and that give accurate predictions when generalized to other populations. Fall. Griffith, Selker

CRES 515: CLINICAL RESEARCH PROJECT/THESIS RESEARCH - FIRST YEAR (1 CR)
The fundamental precept of this graduate program is for the student to complete a comprehensive independent clinical research project, which includes framing a research question and specific project aims, identifying useful data sources, developing appropriate methods, identifying and defending against sources of bias, implementing/managing a project and writing up a thesis in the form of a publishable article or monograph. Fall and Spring. Program faculty

CRES 516: CLINICAL RESEARCH PROJECT/THESIS RESEARCH - SECOND YEAR (2 CR)
The fundamental precept of this graduate program is for the student to complete a comprehensive independent clinical research project, which includes framing a research question and specific project aims, identifying useful data sources, developing appropriate methods, identifying and defending against sources of bias, implementing/managing the project and writing up the thesis in the form of a publishable article or monograph. Fall and Spring. Program faculty

CRES 517: CLINICAL RESEARCH PROJECT/THESIS RESEARCH – PHD CANDIDATES (4 CR)
The fundamental precept of this graduate program is for the student to complete a comprehensive independent clinical research project, which includes framing a research question and specific project aims, identifying useful data sources, developing appropriate methods, identifying and defending against sources of bias, implementing/managing the project and writing up the thesis in the form of a publishable article or monograph. Fall, Spring, and Summer. Program faculty

CRES 518: CLINICAL RESEARCH ADVANCED THESIS RESEARCH (1-4 CR)
The course is for students who do not complete their theses in the customary timeframe and wish to pursue further research. The Program Director, in consultation with the student’s thesis committee and program mentor, will determine the number of credits. Fall, Spring, and Summer. Program faculty

CRES 519: CONCENTRATION PRACTICUM (0.5-2 CR)
Students are required to take core courses essential to developing the necessary competencies to become an independent clinical researcher. In addition, students may elect a concentration: Bench-to-Bedside, Clinical Investigation, Epidemiology and Biostatistics, Evidence-Based Medicine, Health Services and Outcomes Research and Medical Informatics to develop a greater depth of knowledge and skills in a selected area. Spring. Program faculty

CRES 523: INTRODUCTION TO CLINICAL EPIDEMIOLOGY (1 CR)
This course provides students with an overview of the epidemiologic approach to the study of disease causation and its natural history as well as into epidemiologic methods. This course reviews the application
of various observational and experimental research designs and strategies utilized in clinical and epidemiological research. Didactic instruction, readings, and problem sets (including lab-based analyses) are used to create each module: investigation of disease outbreaks, sources of health information, observational studies, randomized clinical trials, measures of morbidity and mortality, sources of and controls for bias evaluation of diagnostic and screening tests, and development of surveillance studies. The course concludes with several content based lectures. Student evaluation is based on in-class presentations, a laboratory exercise write up and class participation. Fall. Goldberg

CRES 525: INTRODUCTION TO CLINICAL CARE RESEARCH (2 CR)
This course, meeting three hours daily over a four-week summer session, teaches students how to formulate a clinical research hypothesis and to develop it into a clinical research project. Students acquire an understanding of basic and advanced principles of study design and issues in conducting biomedical research involving human subjects. Summer. Kent

CRES 527: BIOSTATISTICS I (1 CR)
This course introduces basic principles and applications of statistics to problems in clinical research. Topics covered include descriptive statistics, probability and random variation, sampling, hypothesis testing, proportions, measures of frequency, t-tests, chi-square tests, one-way analysis of variance, correlation, linear regression and nonparametric statistics. Fall. Schmid

CRES 530: BIOSTATISTICS III (1 CR)
This seminar covers topics selected by the instructor based on the statistical research needs of students. Possible choices include factor and principal components analysis, longitudinal data models, neural networks, time-series analysis and advanced survival analytic methods. Spring. Program faculty

CRES 535: BIOSTATISTICS II (1 CR)
This course surveys regression techniques for outcomes common in public health data, including continuous, binary, count and survival data. Emphasis is on developing a conceptual understanding of the application of these techniques to solving problems and to cogently summarize the results, rather than numerical details. Spring. Schmid

CRES 537: SCIENTIFIC MANUSCRIPT WRITING (0.5 CR)
This course focuses on principles of scientific manuscript writing. The student will learn how to develop a manuscript by reviewing the specific issues of style, authorship and volume of information that should be incorporated into a research paper. Spring. Goldberg

CRES 538: SCIENTIFIC GRANT WRITING (0.5 CR)
The purpose of this course is to teach the principles of clinical research grant writing. Participants will learn the importance of, and how to select, investigators and co-investigators as well as the identification of potential funding sources and other important aspects of grant writing. Spring. Goldberg

CRES 539: SCIENTIFIC WRITING, PEER REVIEW AND PRESENTATIONS (0.5 CR)
Students will focus on principals of scientific review and grant peer review. This will involve critiquing manuscripts and reviewing research grants for mock study section meetings. Students will also be encouraged and given an opportunity to present their scientific writings and oral presentations for critique on an ongoing basis. Fall and Spring. Program faculty
CRES 540: ETHICS OF CLINICAL INVESTIGATION (0.5 CR)
The goal of this course is to increase awareness of research ethics and their practical applications by medical practitioners and researchers—specifically with regard to clinical investigations. The curriculum will address the interrelationships between ethics, law and professional practice standards and will explore the role and workings of Institutional Review Boards (IRBs). Summer. Zucker

CRES 545: PSYCHOMETRICS AND OUTCOMES MEASUREMENT (1 CR)
This course will review health assessment tools and other patient-reported outcome measures that are used to ascertain functional health, well-being and health-related quality of life. Spring. Lerner

CRES 555: PRINCIPLES OF DRUG DEVELOPMENT (1 CR)
This course will examine the important economic, political, legal and scientific issues that face academic clinical investigators who work in partnership with industry sponsors and government regulators to design and conduct clinical studies. Fall. Kaitin

CRES 556: PRINCIPLES OF PHARMACOECONOMICS (0.5 CR)
This is an elective course on methods and uses of pharmacoeconomic analyses and other economic evaluations of medical technologies in health care. Pharmacoeconomics is the application of economic evaluation (i.e., cost analysis, cost-effectiveness, cost-benefit analysis, etc.) to pharmaceutical therapies. Spring. Neumann

CRES 561: INTRODUCTION TO CLINICAL TRIALS (0.5 CR)
This course considers the various problems and options available in the design and conduct of clinical trials, including classical efficacy trials and "effectiveness trials." Issues to be covered include ethics, experimental design, coordination and operations, database development, interim analysis, safety monitoring and analysis, and reporting. Fall. Snydman

CRES 562: SPECIAL TOPICS IN CLINICAL TRIALS (0.5 CR)
This is a seminar course that will explore special topics in clinical trials. Topics include internet-based clinical trials, N of 1 trials, trials in special populations and overseas, industry sponsored trials and multicenter trials. Spring. Snydman

CRES 566: INTRODUCTION TO HEALTH SERVICES RESEARCH (0.5 CR)
This course will introduce students to the concepts and methods that distinguish health services and health policy research from other fields. Faculty will cover major topics in health services/health policy research including outcomes research design and methods, health economics, pharmacoeconomics, access and payment for health services, healthcare quality and quality improvement. Spring. Lerner, Hermann, Neumann, Parsons, Wilson

CRES 567: HEALTH POLICY (1 CR)
This course examines the forces that influence the health policy process in terms of policy formulation, implementation and outcomes. Consideration is given to the roles of various stakeholders: healthcare professionals, consumers and public and private payers. Spring. Lerner

CRES 570: EPIDEMIOLOGIC INVESTIGATION OF DISEASE OUTBREAKS (1 CR)
The purpose of this course is to provide skills for collecting and analyzing data from epidemics and disease-outbreak investigations. This course will provide future public health professionals with the skills
needed to analyze and interpret data gathered from public health surveillance studies and to understand the uses and limitations of monitoring disease occurrence. Spring. Program faculty

CRES 581: EVIDENCE-BASED MEDICINE (0.5 CR)
This course covers the principles of systematic review processes, evaluation of studies and bodies of evidence as used in the conduct of systematic reviews, meta-analyses and the development of evidence-based clinical practice guidelines. The course will focus on studies of treatment efficacy. Spring. Lau, Program faculty

CRES 582: GENETIC EPIDEMIOLOGY (1 CR)
This course is an introduction to the concepts and methodology of genetic epidemiology, including novel methods of molecular biology, quantitative genetics, study design for genetic traits, segregation analysis and linkage analysis. Spring. Program faculty

CRES 584: INTRODUCTION TO DECISION ANALYSIS (0.5 CR)
This course is a working overview of the principles of decision analysis as applied to medicine, making optimal choices in the face of uncertainty. Formal decision analysis has become a well-recognized and accepted research discipline for examining clinical options facing patients, physicians and policymakers. Spring. Pauker, Wong

CRES 593, 594: SPECIAL TOPICS (0.5 CR)
In-depth information on selected topics. Fall and Spring. Program faculty
GRADUATE PROGRAM IN GENETICS

The Graduate Program in Genetics (GENE) is designed to train scientists in the basic principles and applications of classical and molecular genetics for careers in research, teaching and biotechnology. Our goal is to train talented individuals to think critically, identify important issues in genetics, and design and conduct original research. Our interdisciplinary program includes courses and thesis research in prokaryotic, eukaryotic, mammalian and human genetics. Strong emphasis is placed on the laboratory experience and hands-on research training. The Program in Genetics is affiliated with the postgraduate training program in Clinical Genetics based at Tufts Medical Center. This program offers training in reproductive genetics, cytogenetic technology, genetic counseling, perinatal genetics, dysmorphology, psychiatric genetics and perinatal diagnosis.

View a list of Genetics Program Faculty.

CURRICULUM OVERVIEW

Students in the Genetics Program complete a series of required and elective didactic courses designed to provide a strong knowledge base for their research. Required didactic courses include BCHM 223, GENE 201, 203, 205 and an ethics course. Students must complete two elective courses. They also participate in weekly journal clubs, seminars and research presentations and must pass a qualifying examination. Students typically select their research mentor at the end of May of the first year and begin dissertation research after completing four lab rotations and successfully passing the qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY

Students must pass a qualifying examination in the summer of the first year. The examination involves preparing an original research proposal and defending the proposal in an oral examination before a committee of faculty with relevant expertise. The exam requires the preparation and defense of an original research proposal addressing an important question in genetics. The question cannot be related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the fall semester of their second year. Admission to candidacy is based on achievements in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.

RESEARCH AND DISSERTATION

Students enter their dissertation lab and begin thesis research after completing the final laboratory rotation. The student and mentor, in consultation with the student adviser and program director, select a thesis advisory committee of three Genetics Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student meets with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the advisory committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis committee
determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION
Students are expected to publish their research in scientific journals appropriate to their topic and typically all students publish one or more papers.

COURSES
GENE 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to the faculty. Summer. Program Director

GENE 201: GENETIC ANALYSIS (1 CR; \=[MBM 220])
A survey course with an emphasis on the application of genetic techniques to the study of both eukaryotic and prokaryotic organisms and their viruses. Students are introduced to genetic approaches through a combination of problem solving, group discussion and lectures. Student presentations of classical and modern research papers are used to familiarize the class with the manner in which genetic approaches can be applied experimentally. Fall. Kumamoto, Camilli

GENE 203: CANCER GENETICS (1 CR)
The course reviews widely-held ideas and current research on the genetic aspects of carcinogenesis. An introduction to cancer concepts is followed by a focus on specific mechanisms and models illustrating the ways in which normal cellular processes are disrupted in particular types of cancers. The course emphasizes problem solving and readings from the current literature. Spring-alternate years. Rosenberg

GENE 205: MAMMALIAN GENETICS (1.5 CR)
The course reviews the genetic principles that apply to mammals and explores the methodologies that are currently used to perform genetic analysis of mammals. Genetic phenomena that are addressed include mechanisms of sex determination, genetic imprinting, and mitochondrial inheritance. Throughout the course, attention is focused on the ways in which mutation is manifested in disease phenotypes in humans. The course is taught in a format that includes faculty lectures, student presentations, and discussion. Spring. Poltorak

GENE 215, 216: RESEARCH TECHNIQUES (1 CR)
Laboratory rotations for first-year students are designed to provide experience with the diverse research conducted within program laboratories and to teach students techniques in genetics, hypothesis development and research design. Fall and Spring. Moore

GENE 225, 226: STUDENT PRESENTATIONS (0.5 CR)
Students present progress reports on their research for questions and constructive criticism as well as gain experience in presenting data and leading discussion. Fall and Spring. Moore

GENE 291, 292: GRADUATE SEMINAR (0.5 CR)
Students attend weekly program seminars and periodically present reports of their own research to the program faculty and students. Fall and Spring. Selsing
GENE 293, 294: SPECIAL TOPICS (0.5 CR)
In-depth information on selected topics. Fall and Spring. Program faculty

GENE 295, 296: JOURNAL CLUB (0.5 CR)
Students select recent research papers on topics in genetics and analyze the significance of the findings and present the work in an interactive seminar format. A faculty mentor provides advice and feedback. Fall and Spring. Selsing

GENE 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Students perform laboratory research under the direction of the rotation laboratory faculty or the dissertation adviser. Fall, Spring and Summer. Moore, Program faculty

GENE 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Moore, Program faculty
The Graduate Program in Immunology (IMM) offers training focused on immunologic aspects of disease. The faculty brings together talented investigators studying infectious disease, autoimmunity and normal and abnormal development of the immune system; they are committed to training the future intellectual leaders who will drive discovery and translate basic immunological concepts into new treatment approaches. Our trainees learn to define and solve such problems and become expert in the laboratory techniques required to achieve these goals. We expect them to design critical experiments, be creative but self-critical, and to make original scientific contributions that will enhance our understanding of important questions in immunologically-related research. When they finish the program, our graduates will be ready for rigorous postdoctoral research training that will place them in positions of leadership in academic medical centers, universities, or in the biotechnology and pharmaceutical industry.

View a list of Immunology Program Faculty.

CURRICULUM OVERVIEW
Students in the Immunology Program complete a series of required and elective didactic courses designed to provide a strong knowledge base for their research. Required didactic courses include BCHM 223, IMM 212, 215/216, 225/226, 227/228 and 275. Students must complete one elective course. They also participate in weekly journal clubs, seminars and research presentations and must pass a qualifying examination. Students typically select their research mentor at the end of May of the first year and begin dissertation research after completing four lab rotations and successfully passing the qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY
In June of the first year, the student must pass a qualifying exam before beginning full-time research toward a dissertation. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution, and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the fall of their second year. Admission to candidacy is based on achievement in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes for admission to candidacy.

RESEARCH AND DISSERTATION
Students enter their dissertation lab and begin thesis research after completing the final laboratory rotation. The student and mentor, in consultation with the student advisor and program director, select a thesis advisory committee of three Immunology Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student meets with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the advisory committee, which prepares a written assessment of
progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

TEACHING
Advanced students are required to participate in teaching a semester of immunology courses to graduate students. Students typically complete this requirement in the third or fourth year of study. These are generally small group tutorials and discussion sections that help to provide valuable training and experience.

PUBLICATION
Students are required to publish a first author paper based on their thesis work before defending their thesis. They are also expected to have presented their work at one or more national or international meetings before defending their thesis.

COURSES
IMM 000: QUALIFYING EXAMINATION (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to the faculty. Spring. Thorley-Lawson, Program faculty

IMM 202, 203: INTRODUCTION TO IMMUNOLOGIC METHODOLOGY (1 CR)
Rotations of 8–10 weeks in four laboratories provide exposure to a range of technologies and topics for research. The student adviser assists students in selecting laboratories. Fall and Spring. Imanishi-Kari, Program faculty

IMM 206A: JOURNAL CLUB (1 CR)
First-year students meet with the course director to discuss articles essential for an understanding of contemporary immunology. The development of analytic skills is emphasized. Fall and Spring. Imanishi-Kari

IMM 206B: GRADUATE SEMINAR (0.5 CR)
Scientists, who also meet with students, present their current work. Includes speakers invited by students. Fall and Spring. Program faculty

IMM 206C: WORK MEETING (0.5 CR)
Students present progress reports on their research for questions and constructive criticism as well as experience in presenting data and leading discussion. Fall and Spring. Imanishi-Kari, Program faculty

IMM 206D: ADVANCED JOURNAL CLUB (0.5 CR)
Students in the research portion of their training meet to present and discuss recent papers of importance. Fall and Spring. Bunnell, Program faculty
IMM 212: INTRODUCTION TO IMMUNOLOGY (1 CR)
A survey based on lectures, texts, problem-solving and small group tutorials. Topics include the cellular basis of innate and adaptive immune responses, the mechanism of antigen receptor gene rearrangement, principles of tissue transplantation and the genetic and mechanistic problems underlying autoimmune and hypersensitivity diseases. Fall. Wortis, Brodeur, Bunnell, Poltorak

IMM 215, 216: IMMUNOLOGICAL MECHANISMS IN DISEASE I AND II (1 CR)
The course covers the pathogenesis of major infectious diseases including current knowledge of immune responses and approaches to prevention, diagnosis and treatment. Current studies of autoimmunity, hypersensitivity, leukemia and lymphoma are also covered. Fall. Perrin, Program faculty

IMM 225, 226: IMMUNOGENETICS I AND II (1 CR)
The course covers the genetic basis for lymphocyte differentiation, receptor gene rearrangement, T and B cell antigen-receptor diversity and selection, tolerance, autoimmunity and gene expression. Fall and Spring. Huber, Selsing, Roy, Poltorak

IMM 227, 228: IMMUNOCHEMISTRY I AND II (0.5 CR)
The chemical basis for specificity of antigen-antibody reactions and structure/function analysis of lymphocyte proteins is addressed. As part of the course, each student prepares and delivers a presentation describing the development and use of an FDA-approved therapeutic antibody. Fall and Spring. Brodeur, Thorley-Lawson

IMM 275: ETHICAL ASPECTS OF SCIENCE (0.5 CR)
Issues of continuing concern such as conflicts of interest, plagiarism, fraud, responsibilities to patients, animal experimentation, harassment and racism are studied using a case-based approach. Spring. Wortis, Program faculty

IMM 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Mentored research on a topic suitable for a doctoral dissertation. (Previously IMM 208) Fall, Spring and Summer. Program faculty

IMM 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Program faculty
INTEGRATED STUDIES PROGRAM
The Integrated Studies Program (ISP) is the joint admissions and first year academic portal of four basic science PhD programs — Biochemistry; Cell, Molecular and Developmental Biology; Cellular and Molecular Physiology and Neuroscience. Students considering specializations in any of these areas of biomedical sciences require a basic core of knowledge, and the ISP is tailored to meet these needs. The ISP blends problem-based and didactic learning with abundant hands-on laboratory experience. This balanced approach is designed to empower the students as they make decisions about which area of research specialization they will choose at the end of their first year. To learn more about the PhD programs that make up the ISP, see their sections in this publication.

CURRICULUM OVERVIEW
Students in the ISP complete an integrated series of courses that prepare them to enter any of four Sackler programs: Biochemistry; Cell, Molecular and Developmental Biology; Cellular and Molecular Physiology, and Neuroscience. Courses are integrated across the curriculum to avoid duplication and are sequenced so that students will be prepared for advanced courses in the discipline they select. In the first year, students complete required ISP didactic courses (BCHM 223 and 230, CNP 209 and 210), an ethics course and a statistics course. They also participate in journal club and seminar, and complete four laboratory rotations.

Students select rotations from the entire faculty of all four participating programs. Students in the ISP select their graduate program and their dissertation adviser in May of their first year in graduate school. Specific requirements for each of the PhD programs and an overview of the curricula of these programs can be found in the sections that describe the four programs.

COURSES
ISP 215, 216: LABORATORY ROTATIONS (1 CR)
An intensive laboratory rotation in which students are tutored individually by faculty members in the research laboratory. Emphasis is on experimental design and theoretical aspects of the research problems under investigation in the various laboratories. Fall and Spring. Program faculty

ISP 291, 292: GRADUATE SEMINAR (0.5 CR)
Weekly reports of ongoing research given and attended by all members of the ISP program including advanced graduate students, faculty and postdoctoral fellows. Fall and Spring. Program faculty

ISP 293, 294: SPECIAL TOPICS (0.5 CR)
In-depth information on selected topics. Fall and Spring. Program faculty

ISP 295, 296: JOURNAL CLUB (0.5 CR)
In-depth study and discussion of specific topics, involving the critical review of current literature in a small group format. Fall and Spring. Program faculty
GRADUATE PROGRAM IN MOLECULAR MICROBIOLOGY
The interdisciplinary Graduate Program in Molecular Microbiology (MBM) offers rigorous theoretical and experimental training in molecular biology and genetics of bacterial and viral growth and pathogen-host interactions, accomplished through a broad range of graduate courses and laboratories for academic study and scientific development. The program of study includes classes in genetics and biochemistry and courses or seminars in microbial genetics and physiology, microbial pathogenesis, eukaryotic gene expression, molecular virology, physical biochemistry, immunology and many other topics.

View a list of Molecular Microbiology Faculty.

CURRICULUM OVERVIEW
Students in the Molecular Microbiology Program complete a series of required and elective didactic courses designed to provide a strong knowledge base for their research. Required didactic courses include BCHM 223 and 231A, MBM 220 and 275. Students must complete one selective course from each of these four areas: prokaryotic molecular genetics (MBM 206 or 207B); eukaryotic molecular genetics (MBM 214 or BCHM 230); pathogenic microbiology (MBM 210, 211 or 214) and microbial physiology (MBM 207B). They also participate in weekly journal clubs, seminars and research presentations and must pass a qualifying examination. Students typically select their research mentor at the end of May of the first year and begin dissertation research after completing four lab rotations. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY
Students must pass a qualifying examination by August of their second year. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree by either the fall or spring of their second year. Admission to candidacy is based on achievement in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.

RESEARCH AND DISSERTATION
Students enter their dissertation lab and begin thesis research after completing the final laboratory rotation. The student and mentor, in consultation with the student adviser and program director, select a thesis committee of three other Molecular Microbiology Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student must meet with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the thesis research committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When
the thesis research committee determines that the aims of the project have been met, the thesis is prepared and defended. The thesis research committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

TEACHING
As part of their training, students serve as discussion leaders, tutors, or lab instructors in courses given in the Schools of Medicine and Dental Medicine; two such experiences are required. Additional teaching experience is available for those who have a special interest in perfecting their teaching skills. In addition to serving as instructors and tutors for the medical, dental or graduate school, students may participate in programs outside Tufts that seek to bring science to neighborhood schools.

PUBLICATIONS
Students are required to publish a first author paper based on their thesis work before defending their thesis.

COURSES
MBM 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to the faculty. Fall and Spring. Program faculty

MBM 202, 203: EXPERIMENTS IN MOLECULAR BIOLOGY (1 CR)
Intensive laboratory rotations in which students are tutored individually by faculty members in the research laboratory. Emphasis is on experimental design and theoretical aspects of the research problems under investigation in the various laboratories. Fall and Spring. Program faculty

MBM 206: MOLECULAR BIOLOGY OF EPISOMES AND PLASMIDS (0.5 CR)
This course covers fundamental properties of F-factors and drug resistance factors; roles of transposons in antibiotic resistance and plasmid evolution; detailed examinations of DNA processing for transfer in prokaryotic systems; regulatory mechanisms for fertility, replication, and incompatibility; and use of plasmids in genetic engineering. Spring-alternate years. Malamy

MBM 207B: MICROBIAL PHYSIOLOGY AND DIFFERENTIATION (1 CR)
This course covers cellular controls of biosynthesis of DNA, RNA, and proteins; kinetics of cell division in bacteria; regulation of metabolism; and bacterial differentiation as a model system for development in higher organisms. Global regulatory mechanisms responsible for the control of gene expression are emphasized. Spring-alternate years. Sonenshein

MBM 210: HOST-PATHOGEN INTERFACE (0.5 CR)
The goal of this course is to critically read and evaluate the scientific literature on bacterial pathogens and host defenses, with particular but not exclusive emphasis on innate immune defenses. Students will be required to read at least two papers per topic and discuss them in the group. Spring-alternate years. Mecsas

MBM 211: BACTERIAL-HOST CELL INTERACTION (0.5 CR)
The goal of this course is to critically read and evaluate the scientific literature on the cellular biology of bacterial pathogens, with particular emphasis on cultured cell models of microbial diseases. Students will be required to read at least two papers per topic and discuss them in the group. Spring-alternate years. Isberg
MBM 214: ANIMAL VIROLOGY (1 CR)
Molecular aspects of viral replication and host-cell interactions are emphasized. Topics include virion structure; mechanisms of nucleic acid replication, transcription, and translation; virion assembly and release; genetics; mechanisms of transformation by oncogenic viruses; responses of the host to viral infection, tumor viruses and tumor cells; and mechanisms of persistent and slow virus infections. Prerequisites: a course in molecular biology or working knowledge of molecular techniques. Spring-alternate years. Coffin, Rosenberg

MBM 220: GENETIC ANALYSIS (1 CR; = [GENE 201])
A survey course with an emphasis on the application of genetic techniques to the study of both eukaryotic and prokaryotic organisms and their viruses. Students are introduced to genetic approaches through a combination of problem solving, group discussion and lectures. Student presentations of classical and modern research papers are used to familiarize the class with the manner in which genetic approaches can be applied experimentally. Fall. Kumamoto, Camilli

MBM 275: APPLIED ETHICS FOR SCIENTISTS (0.5 CR)
A discussion/seminar course that treats selected topics related to ethical behavior in scientific work. Topics covered include fraud, plagiarism, data selection and analysis, record keeping, animal welfare, personnel issues, genetic screening and gene therapy, and conflict of interest. Enrollment is restricted to third and fourth year graduate students. Spring. Program faculty

MBM 291, 292: GRADUATE SEMINAR (0.5 CR)
Weekly reports of ongoing research given by faculty, postdoctoral fellows and advanced graduate students Attended by all program members. Fall and Spring. Heldwein

MBM 293, 294: SPECIAL TOPICS (0.5 CR)
In-depth information on selected topics. Fall and Spring. Program faculty

MBM 295, 296: JOURNAL CLUB (0.5 CR)
In-depth study and discussion of specific topics involving the critical review of current literature in a small group format. Given by faculty and graduate students (years two through four) and attended by all program members. Fall and Spring. Coffin

MBM 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Guided research on a topic suitable for a doctoral dissertation. Fall, Spring and Summer. Program faculty

MBM 403, 404: PhD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Program faculty
GRADUATE PROGRAM IN NEUROSCIENCE

The Graduate Program in Neuroscience (NRSC) provides interdisciplinary training that emphasizes classical neurobiological and modern neurogenetic approaches. The program provides a broad exposure to multi-disciplinary studies that are at the forefront of neuroscience research. Students first acquire a strong basic science background and then are trained to use a variety of new techniques and methodologies important to this rapidly developing field. A major strength of the program is its cohesive faculty committed to maintaining an open, eclectic, intellectual environment.

View a list of Neuroscience Program Faculty.

CURRICULUM OVERVIEW

During the first year, students interested in the Neuroscience Program participate in the Integrated Studies Program (ISP), a single portal of entry and common first-year curriculum for four Sackler programs: Biochemistry; Cell, Molecular and Developmental Biology; Cellular and Molecular Physiology, and Neuroscience. In the first year, students complete required ISP didactic courses (BCHM 223 and 230, CNP 209 and 210), an ethics course and a statistics course. They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations. A complete description of the Integrated Studies Program can be found here.

Students electing to pursue a PhD in Neuroscience declare this intention when they select a thesis adviser at the end of May in the first year of graduate school. During the second and subsequent years, students complete an additional required didactic course (NRSC 212), two elective courses, and an ethics course if they did not do so during their first year. Students also participate in Neuroscience journal clubs and seminars and must pass a qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY

Students must pass a qualifying examination by May of their first year in the Neuroscience program. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the spring semester of their first year in the Neuroscience Program. Admission to candidacy is based on achievements in didactic courses and lab rotations, participation in seminars and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.

RESEARCH AND DISSERTATION

Students begin preliminary thesis research when they enter the Neuroscience Program and their dissertation laboratory. The student and mentor, in consultation with the student adviser and program director, select a
thesis advisory committee of at least three Neuroscience Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each student meets with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the thesis research committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis research committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION
Students are expected to publish their research in scientific journals appropriate to their topic and typically all students publish one or more papers.

COURSES
NRSC 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal defining an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to the committee. Spring. Program faculty

NRSC 205: DEVELOPMENTAL NEUROBIOLOGY (1 CR)
An exploration of the features of regulation and specificity in the developing nervous system, including various model systems. Morphological, biochemical, immunological, and molecular approaches are examined. Spring. Jacob

NRSC 212: BASIC PRINCIPLES OF SYSTEMS NEUROBIOLOGY (1 CR)
The focus is on neuronal integrative mechanisms; CNS and PNS organization; sensory systems; pain and analgesia; neuronal development; simple models of learning and behavior and neurological diseases. Fall. Vetter

NRSC 213: SYNAPSE NEUROBIOLOGY (1 CR)
This course will provide students with an in-depth understanding of how synapses function, how activity modulates function, and how synaptic ensembles coordinate simple behaviors. With its focus on the physiological function of synapses, this course is a natural adjunct to Developmental Neurobiology (NRSC 205), an elective course that focuses on the mechanisms underlying the formation and strengthening of synaptic contacts during development. Spring. Dunlap

NRSC 220: SCIENTIFIC WRITING PRINCIPLES (0.5 CR)
The principles involved in the production of succinct, informative writing are discussed. This course centers on the improvement of each student’s existing skills through interactive writing exercises. Enrollment is limited to 10 students. Spring. Program faculty

NRSC 289, 290: STUDENT PRESENTATIONS (0.5 CR)
Students present progress reports on their research for question and constructive criticism as well as experience in presenting data and leading discussion. Fall and Spring. Jacob
NRSC 291, 292: GRADUATE SEMINAR (0.5 CR)
Presentations of scientific research by visiting speakers from the Boston community and beyond. Following the seminar, first-year students participate in a discussion period led by a faculty member. Students write brief reports based on the seminar material to develop skills in analysis, organization, and presentation of ideas. Fall and Spring. *Program faculty*

NRSC 293, 294: ADVANCED TOPICS IN NEUROSCIENCE (0.5 CR)
In-depth information on selected topics. Fall and Spring. *Program faculty*

NRSC 295, 296: JOURNAL CLUB (0.5 CR)
Discussion by students and advisory faculty of selected articles from the current literature. In alternate years, one section is devoted to scientific ethics. Fall and Spring. *Program faculty*

NRSC 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Dissertation research with selected adviser. Fall, Spring and Summer. *Program faculty*

NRSC 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. *Program faculty*
GRADUATE PROGRAM IN PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

The Graduate Program in Pharmacology and Experimental Therapeutics (PHRM) is designed to prepare scientists who will be able to understand mechanisms of drug action in biochemical, cellular, and molecular terms and to develop new therapeutic modalities. The Program focuses on the interrelationship of pharmacology, therapeutics, toxicology and the pathophysiological basis of disease and includes training in the most up-to-date methods of pharmacokinetics and drug metabolism. Because the interests of the faculty cover a broad range of subjects and much of the research is interdisciplinary, the program is flexible enough to meet the needs of students from different backgrounds. Individuals with previous training in medicine, veterinary medicine, dentistry or pharmacy are particularly welcome. Students who complete the program are equipped for careers in teaching and research in academic, clinical, governmental and industrial settings. The program emphasizes basic research on the Health Sciences campus of Tufts University, located in downtown Boston. The Center for the Study of Drug Development is an additional resource.

View a list of Pharmacology Program Faculty.

CURRICULUM OVERVIEW

Students in the Pharmacology and Experimental Therapeutics complete a series of required and elective didactic courses designed to provide a strong knowledge base for their research. Required didactic courses include BCHM 223, PHRM 211, 212, 232, 233 and 275. Students must complete four elective courses. They also participate in weekly journal clubs and seminars and must pass a qualifying examination. Students typically select their research mentor at the end of May of the first year and begin dissertation research after completing four lab rotations and successfully passing the qualifying examination. During the second and subsequent years, emphasis is placed on dissertation research. When the aims of the research project have been achieved, students write and defend their dissertations.

QUALIFYING EXAM AND CANDIDACY

Students must pass a qualifying examination by summer of their first year. The exam requires the preparation and defense of an original research proposal that is not related to future dissertation work or to prior research experiences. The exam is designed to measure originality and independence and requires that the student suggest a feasible research project on a biologically significant problem, outline a potential experimental approach to its solution and discuss the likely data that could be obtained. An oral defense of this proposal is designed to probe the ability of the student to integrate and evaluate material learned in more abstract settings.

Typically, students are considered for candidacy for the doctoral degree in the spring semester following their first year. Admission to candidacy is based on achievements in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Based on these measures, the faculty evaluates the student’s potential and ability to do original research and votes on admission to candidacy.

RESEARCH AND DISSERTATION

Students enter their dissertation lab and begin thesis research after completing the final laboratory rotation. The student and mentor, in consultation with the student adviser and program director, select a thesis committee of three other Pharmacology Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for dissertation research. Each
student must meet with the committee at least once a semester. The student prepares a report describing progress and goals for consideration by the thesis research committee, which prepares a written assessment of progress. The student also presents a research seminar to the faculty and student body once a year. When the thesis research committee determines that the aims of the project have been met, the thesis is prepared and defended. The thesis research committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

TEACHING
After the first year, graduate students may assist in lecture and tutorial group teaching in Pharmacology courses where appropriate as part of their training. Participation is voluntary.

PUBLICATION
Students are required to publish a first author paper based on their thesis work before defending their thesis.

COURSES

PHRM 000: QUALIFYING EXAM (0 CR)
Students present and defend a proposal for research consisting of a statement of an original research problem in which a scientific question is asked and the experimental approach to answering the question is explained in a written proposal. The proposal is presented orally to the faculty. Spring. Program faculty

PHRM 211: TRANSLATIONAL PHARMACOLOGY I (2 CR)
This course is a survey of some of the major classes of drugs, with particular emphasis on mechanisms of action and relevant organ systems and cellular physiology. Students are introduced to the central concepts, models and techniques in Pharmacology. Fall. Shader, Pothos, Program faculty

PHRM 212: CLINICAL PHARMACOLOGY (1 CR)
This course is devoted to the discussion and presentation of therapeutic topics and the basic principles of therapeutic pharmacology. Subjects that are highlighted include: therapeutic drug monitoring, evaluation of side effects and toxicity, critical evaluation of clinical trial data, pharmacokinetic design of dose regimens, drugs in special populations and medical and legal issues in clinical pharmacology. A mixture of lecture and clinical case-oriented problem-solving is used. Extensive independent study and reading is required. Spring. Greenblatt, Program faculty

PHRM 215, 216: PHARMACOLOGICAL TECHNIQUES (1 CR)
Students participate in four rotations, each lasting 8-10 weeks, in which students gain experience in different laboratories. These rotations are designed to familiarize students with the methodology of modern pharmacological research. Fall and Spring. Program faculty

PHRM 218: PRINCIPLES OF IMMUNOPHARMACOLOGY (1 CR)
This course investigates the appraisal of molecular mechanisms by which drugs can affect cellular processes underlying clinical syndromes such as hypersensitivity, rejection, autoimmunity and neuroimmune disorders. Emphasis is placed on select cases of how certain compounds were chosen for drug development and why many such promising drugs failed. Spring-alternate years. Theoharides, Program faculty
PHRM 219: BEHAVIORAL PHARMACOLOGY (1 CR)
This course is an in-depth examination of the mechanisms by which selected psychoactive agents alter mood and behavior with emphasis on the role of neurotransmitters and their receptors. Fall-alternate years. Shuster, Miczek

PHRM 220: ADVANCES IN NEUROCHEMISTRY AND NEUROPHARMACOLOGY (1 CR)
This course focuses on the problem-based approach to the actions of neurotransmitters and neuromodulators and related drugs at the molecular and cellular level. Spring-alternate years. Beinfeld, Program faculty

PHRM 221: PHARMACOKINETICS IN BIOLOGICAL SYSTEMS (1 CR)
This course focuses on the uptake and clearance of drugs, using problem-solving exercises and computer modeling to analyze data from original experiments. Fall-alternate years. Greenblatt, Program faculty

PHRM 222: TOXICOLOGY (1 CR)
This course is an in-depth examination of the basic principles of toxicology based on discussion and presentation of selected examples. Subjects considered include apoptosis/necrosis, molecular mechanisms of neurotoxicities, species difference in toxicities, and chemical mutagenesis. Offered on request. Ofner, Shuster, Program faculty

PHRM 224: NEUROPEPTIDES (1 CR)
This course entails detailed reading and critical review of the classical and modern literature on the discovery, chemistry, anatomical distribution, biosynthesis, physiology, pharmacology and current and possible future clinical uses of neuropeptides. Spring-alternate years. Beinfeld, Program faculty

PHRM 225: AN INTRODUCTION TO DRUG METABOLISM (1 CR)
This is a readings and presentation course designed to illustrate the processes involved with drug metabolism, to describe the non-drug (non-substrate) factors influencing drug metabolism, and to review and critique methods used for the study of drug metabolism. Fall and Spring-alternate years. Court, Greenblatt, Shader

PHRM 232: TRANSLATIONAL PHARMACOLOGY II (2 CR)
This course continues with the topics covered in Translational Pharmacology I. It covers major classes of drugs and the concepts, models and techniques in Pharmacology. Spring. Shader, Pothos, Program faculty

PHRM 233: SCIENTIFIC WRITING AND PRESENTATION SKILLS (0.5 CR)
This course will provide graduate students with the opportunity to develop the basic skills essential to the effective oral and written communication of scientific findings and research proposals. The course will be a combination of lectures, writing assignments, and oral communication practice sessions with feedback provided by the faculty and staff of the Program in Pharmacology and Experimental Therapeutics. Fall. Court, Program faculty

PHRM 275: APPLIED ETHICS FOR SCIENTISTS (0.5 CR)
This course is a series of discussions with active student participation in definition and evaluation of both positive and problematic ethical issues in research. Issues considered include: ethical underpinnings of science; recognition, reporting, and evaluation of apparent misconduct; authorship, credit, and intellectual
property; conflict of interest in reviews of papers, grants, and in commerce; animals and humans as subjects in research and ethical choice of research projects. Fall-alternate years. Shader. Program faculty

PHRM 291, 292: GRADUATE SEMINAR (0.5 CR)
Members of the department and outside speakers give presentations on topics of broad interests to the department and the community. Fall and Spring. Greenblatt

PHRM 293, 294: SPECIAL TOPICS (0.5 CR)
Advanced seminars. Students may also pursue guided individual study of an approved topic. Fall and Spring. Program faculty

PHRM 295, 296: JOURNAL CLUB (0.5 CR)
Oral presentation and critical evaluation by students and faculty of current topics in pharmacology. This course is intended to help students develop skills related to the preparation and presentation of oral reports. Students are introduced to the critical evaluation of research literature and will be required to present research topics and proposals. Fall and Spring. Shader. Program faculty

PHRM 297, 298, 299: GRADUATE RESEARCH (ARRANGED CR)
Dissertation research with selected adviser. Fall, Spring and Summer. Program faculty

PHRM 403, 404: PHD DEGREE ONLY (0 CR)
Doctoral dissertation preparation. Fall, Spring and Summer. Program faculty
SACKLER INTER-PROGRAM COURSE OFFERINGS
Several courses contain content that spans two or more program areas. These courses are taught by a team of inter-program faculty, required by some programs, and open to all Sackler graduate students. The Molecular Cell Biology courses are jointly-sponsored by the Cell, Molecular, and Developmental Biology Program; Neuroscience Program; and Cellular and Molecular Physiology Program. The designator for these courses is CNP.

COURSES
CNP 209: MOLECULAR CELL BIOLOGY I (2 CR)
Course provides a thorough survey of major topics in cell biology, including membrane structure and function; transport systems, ion channels, and membrane excitability; protein trafficking and organelle biogenesis; structure and function of the cytoskeleton, including cell motility and mitosis; cell-cell and cell-matrix interactions; and receptor-mediated endocytosis. Fall. Castellot, Cox, Forgac

CNP 210: MOLECULAR CELL BIOLOGY II (1 CR)
This course addresses signal transduction pathways; molecular genetics; cell cycle and cell proliferation control mechanisms; and basic concepts in developmental biology. Spring. Castellot, Cox, Forgac

CNP 210A: CELL AND MOLECULAR GENETICS (0.5 CR)
This course covers molecular genetics and basic concepts in developmental biology. Spring. Castellot, Cox, Forgac

CNP 210B: MOLECULAR CELL BIOLOGY OF SIGNAL TRANSDUCTION (0.5 CR)
This course covers signal transduction pathways, cell cycle and cell proliferation control mechanisms. Spring. Castellot, Cox, Forgac

SK 201: MOLECULAR BIOPHYSICS (0.5 CR)
This course covers Thermodynamics, CD, and DLS as well as Analytical Ultracentrifugation and Advanced Fluorescence Techniques and Surface Plasmon Resonance. Summer. Program faculty

SK 202: STRUCTURAL BIOLOGY (0.5 CR)
This course covers the basic theory and practice of Macromolecular Crystallography and NMR. Summer. Bohm, Baleja

SK 203: TISSUE ENGINEERING (0.5 CR)
This course covers Stem Cell Biology and Tissue Scaffolds, the Principles of Bioreactor Design and Integrative Approaches to Tissue Engineering. Summer. Kaplan

SK 204: IMAGING TECHNIQUES (0.5 CR)
This course covers Light Microscopy/Immunofluorescence, Confocal Microscopy and Electron Microscopy. Computer-based image analysis is incorporated into these modules. The samples generated during the Tissue Engineering module are used. Summer. Castellot

SK 205: MENTORED UNDERGRADUATE TEACHING (0.5 CR)
This course offers an opportunity for Sackler students to obtained mentored teaching experience. Each Sackler student collaborates with a TUSM and a Friedman student to develop a syllabus and three lectures
on one of five disease topics (osteoporosis, breast cancer, asthma, metabolic syndrome, heart disease). Lectures are delivered to undergraduate Biology majors at Pine Manor College, Chestnut Hill, MA. Prerequisites: Year 3 or above. Spring, Liscum

SK 206: CLINICAL CONNECTIONS (1 CR)
MD/PhD students work with a physician in a specialty of their choosing for the equivalent of eight periods (32 hours) during the course of one semester each year. This course helps the MD/PhD student to remain connected to clinical medicine during their PhD training. It is also designed to help students explore different aspects of clinical medicine before they return to medical school full time. Fall, Spring and Summer, Rosenberg

SK 209, 210: CLINICAL IMPLICATIONS OF BASIC RESEARCH (0.5 CR)
This journal club course for MD/PhD students is organized around the “Clinical Implications of Basic Research” column published in the New England Journal of Medicine. Students read a primary paper(s) highlighted in the column or one that is similar to those highlighted and discuss the work. The primary goal of this course, which meets for one hour every other week, is to encourage and teach students to continually ask how basic research can impact clinical medicine. The format also encourages students to sharpen their communication skills in a relaxed atmosphere. Fall and Spring, Rosenberg

SK 299: BIOMEDICAL TECHNIQUES & RESEARCH (0 CR)
Research with selected adviser. Visiting Students Only. Fall, Spring and Summer, Program faculty