

# Tufts University Sackler School of Graduate Biomedical Sciences

## CATALOG

2012 – 2013

### Programs of Study, Courses and Requirements

#### Graduate Programs

(Press the Control key then click on the Program you wish to select.)

[BIOCHEMISTRY](#)

[CELL, MOLECULAR, AND DEVELOPMENTAL BIOLOGY](#)

[CELLULAR AND MOLECULAR PHYSIOLOGY](#)

[CLINICAL AND TRANSLATIONAL SCIENCE](#)

[GENETICS](#)

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[MOLECULAR MICROBIOLOGY](#)

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## BIOCHEMISTRY

The goal of the [Graduate Program in Biochemistry](#) 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 such as biomedical research, teaching, professional schools and government labs, biotechnology industry research, and management. View a list of [Biochemistry Program Faculty](#).

### PHD COURSE REQUIREMENTS AND PROGRESSION

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 Sackler programs in Biochemistry; Cell, Molecular and Developmental Biology; and Cellular and Molecular Physiology. In the first year, students complete required ISP didactic courses (BCHM 0223 and 0230; ISP 209A, 209B, 210A, 210B and 0220; and SK 0275). They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations. A complete description of the Integrated Studies Program and the course offerings 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 0231) and two elective credits. 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 research. When the aims of the research project have been achieved, students write and defend their theses.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

#### FIRST YEAR PhD

##### Fall

BCHM 0223 Graduate Biochemistry  
ISP 209A Membranes and Trafficking  
ISP 0234 Laboratory Rotations  
ISP 0291 Graduate Seminar  
ISP 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### Spring

BCHM 0230 Gene Expression & Signal Transduction  
ISP 209B Cell Behavior  
ISP 210A Cell and Molecular Genetics  
ISP 210B Molecular Cell Biology of Development  
ISP 0220 Probability and Statistics for Basic Scientists  
ISP 0235 Laboratory Rotations  
ISP 0292 Graduate Seminar  
ISP 0296 Journal Club

##### Summer

BCHM 0299 Graduate Research

## SECOND YEAR PhD

### Fall

BCHM 0291 Graduate Seminar  
BCHM 0295 Journal Club  
BCHM 0297 Graduate Research

*Elective*

### Spring

BCHM 0000 Qualifying Examination  
BCHM 0231 Molecular Recog. in Biology & Drug Design  
BCHM 0292 Graduate Seminar  
BCHM 0296 Journal Club  
BCHM 0298 Graduate Research

*Elective*

### Summer

BCHM 0299 Graduate Research

After the second year, students continue to enroll in Graduate Seminar (0291/0292), Journal Club (0295/0296), and Graduate Research (0297/0298/0299) until they have completed their thesis research.

## MD/PHD COURSE REQUIREMENTS AND PROGRESSION

The progression for students entering the Biochemistry Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include BCHM 0224, 0230, 0231 and SK 0275. Biochemistry MD/PhD students are not usually required to take any electives.

## FIRST YEAR MD/PhD

### Fall

BCHM 0224 Advanced Graduate Biochemistry  
BCHM 0291 Graduate Seminar  
BCHM 0295 Journal Club  
BCHM 0297 Graduate Research  
SK 0275 Applied Ethics for Scientists  
SKMD 0209 Clinical Implications of Basic Research

### Spring

BCHM 0000 Qualifying Examination  
BCHM 0230 Gene Expression & Signal Transduction  
BCHM 0231 Molecular Recog. in Biology & Drug Design  
BCHM 0292 Graduate Seminar  
BCHM 0296 Journal Club  
BCHM 0298 Graduate Research  
SKMD 0210 Clinical Implications of Basic Research

After the first year, students continue to enroll in Graduate Seminar (0291/0292), Journal Club (0295/0296), Graduate Research (0297/0298/0299), and Clinical Implication of Basic Research (0209/0210) until they have completed their thesis research.

## QUALIFYING EXAMINATION AND CANDIDACY

Students must pass a qualifying examination during Spring 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 thesis 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.

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 THESIS

Students begin preliminary research when they enter the Biochemistry Program and their thesis 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 thesis 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

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. Typically, students publish one or more papers.

#### COURSES

##### BCHM 0000: 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. S/U. *Program Director*

##### BCHM 0223: 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. A-F. *Schaffhausen*

##### BCHM 0224: ADVANCED GRADUATE BIOCHEMISTRY (1 CR)

Advanced Graduate Biochemistry is intended to allow students with strong biochemistry backgrounds to explore areas of biochemistry relevant to their interests in a more detailed way. It is offered in parallel with BCHM223 Graduate Biochemistry. It is intended for MD/PhD students who have taken Medical Foundations I and for PhD students coming to the Sackler School with a substantial background in biochemistry. PhD students would be allowed to substitute (transfer to) this course after the first BCHM223 examination if they meet the performance requirements set by the Course Director. Fall. A-F. *Schaffhausen*

##### BCHM 0230: 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. A-F. *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. A-F. *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. A-F. *Yee, Program faculty*

BCHM 0231: 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 are discussions on drug screening and optimization techniques as they have been applied in a number of detailed, real-world cases. Spring. A-F. *Bohm, Bachovchin, Program faculty*

BCHM 0231A: 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. This course represents the first part of Biochemistry 231 and may be taken as a separate course. Spring. A-F. *Bohm, Program faculty*

BCHM 0231B: 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. This course represents the second part of Biochemistry 231 and may be taken as a separate course. Spring. A-F. *Bachovchin, Program faculty*

BCHM 0234: 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 grow protein crystals and use them to learn crystallographic data collection, phasing, and molecular replacement methods. Spring. A-F. *Bohm*

BCHM 0235: FUNDAMENTALS OF NUCLEAR MAGNETIC RESONANCE (0.5 CR)

Fundamentals of NMR is a course designed to teach advanced topics in NMR spectroscopy. Fall. A-F. *Baleja*

BCHM 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Program faculty*

BCHM 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

BCHM 0295, 0296: 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. S/U. *Program Faculty*

BCHM 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. A-F. *Program faculty*

BCHM 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

## CELL, MOLECULAR AND DEVELOPMENTAL BIOLOGY

The [Graduate Program in Cell, Molecular and Developmental Biology](#) supports rigorous training of 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. Research focused on development and developmental diseases often reveals the mechanisms underlying normal and aberrant tissue remodeling in the mature organism in areas such as 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](#).

### PHD COURSE REQUIREMENTS AND PROGRESSION

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 Sackler programs in Biochemistry; Cell, Molecular and Developmental Biology; and Cellular and Molecular Physiology. In the first year, students complete required ISP didactic courses (BCHM 0223 and 0230; ISP 209A, 209B, 210A, 210B and 0220; and SK 0275). They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations. A complete description of the Integrated Studies Program and the course offerings 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 0235) and one elective credit. Students also participate in Cell, Molecular and Developmental Biology journal clubs and seminars and must pass a qualifying examination. During the second and subsequent years, emphasis is placed on research. When the aims of the research project have been achieved, students write and defend their theses.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

#### FIRST YEAR PhD

##### Fall

BCHM 0223 Graduate Biochemistry  
ISP 209A Membranes and Trafficking  
ISP 0234 Laboratory Rotations  
ISP 0291 Graduate Seminar  
ISP 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### Spring

BCHM 0230 Gene Expression & Signal Transduction  
ISP 209B Cell Behavior  
ISP 210A Cell and Molecular Genetics  
ISP 210B Molecular Cell Biology of Development  
ISP 0220 Probability and Statistics for Basic Scientists  
ISP 0235 Laboratory Rotations  
ISP 0292 Graduate Seminar  
ISP 0296 Journal Club

##### Summer

CELL 0299 Graduate Research

**SECOND YEAR PhD****Fall**

CELL 0235 Developmental Biology  
 CELL 0291 Graduate Seminar  
 CELL 0295 Journal Club  
 CELL 0297 Graduate Research

*Elective*

**Spring**

CELL 0000 Qualifying Examination  
 CELL 0292 Graduate Seminar  
 CELL 0296 Journal Club  
 CELL 0298 Graduate Research

**Summer**

CELL 0299 Graduate Research

After the second year, students continue to enroll in Journal Club (0295/0296) for two more years, and continue Graduate Seminar (0291/0292) and Graduate Research (0297/0298/0299) until they have completed their thesis research.

**MD/PHD PROGRAM PROGRESSION**

The progression for students entering the Cell, Molecular, and Developmental Biology Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include ISP 209B, ISP 210B, CELL 0235, and SK 0275. CMDDB MD/PhD students are not usually required to take electives.

**FIRST YEAR MD/PhD****Fall**

CELL 0291 Graduate Seminar  
 CELL 0295 Journal Club  
 CELL 0297 Graduate Research  
 SK 0275 Applied Ethics for Scientists  
 SKMD 0209 Clinical Implications of Basic Research

**Spring**

CELL 0000 Qualifying Examination  
 CELL 0292 Graduate Seminar  
 CELL 0296 Journal Club  
 CELL 0298 Graduate Research  
 ISP 209B Cell Behavior  
 ISP 210B Molecular Cell Biology of Development  
 SKMD 0210 Clinical Implications of Basic Research

**SECOND YEAR MD/PhD****Fall**

CELL 0235 Developmental Biology

CELL 0235 is taken at the first opportunity. The course is offered at least every other year, and will be offered next in Fall, 2013. After the first year, students continue to enroll in Journal Club (0295/0296) for three more years, and Graduate Seminar (0291/0292), Graduate Research (0297/0298/0299), and Clinical Implication of Basic Research (0209/0210) until they have completed their research.

**QUALIFYING EXAMINATION AND CANDIDACY**

Students must take a qualifying exam during the spring 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 thesis 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.

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 THESIS

Students begin preliminary research when they enter the Cell, Molecular and Developmental Biology Program and their thesis 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 thesis 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

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. Typically, students publish one or more papers.

#### COURSES

##### CELL 0000: 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. S/U. *Program faculty*

##### CELL 0203: MEDICAL HISTOLOGY (2 CR)

This elective Medical School course 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 (i.e., physiology, biochemistry, and development), while the laboratories involve tissue and organ identification, providing both a practical background in cell and tissue biology. Fall. A-F. *Castellot*

##### CELL 0235: 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, alternate years. A-F. *Program Faculty*

CELL 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Program faculty*

CELL 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

CELL 0295, 0296: 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. S/U. *Program Faculty*

CELL 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. S/U. *Program faculty*

CELL 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

## CELLULAR AND MOLECULAR PHYSIOLOGY

The [Graduate Program in Cellular and Molecular Physiology](#) 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 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](#).

### PHD COURSE REQUIREMENTS AND PROGRESSION

During the first year, students interested in the Cellular and Molecular Program participate in the Integrated Studies Program (ISP), a single portal of entry and common first-year curriculum for Sackler programs in Biochemistry; Cell, Molecular and Developmental Biology; and Cellular and Molecular Physiology. In the first year, students complete required ISP didactic courses (BCHM 0223 and 0230; ISP 209A, 209B, 210A, 210B and 0220; and SK 0275). They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations. A complete description of the Integrated Studies Program and the course offerings 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 0230) and two elective credits. Students must pass a qualifying examination, participate in Cellular and Molecular Physiology journal club during their second and third years, and attend research seminars throughout their program. During the second and subsequent years, emphasis is placed on thesis research. When the aims of the research project have been achieved, students write and defend their thesis.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

#### FIRST YEAR PhD

##### Fall

BCHM 0223 Graduate Biochemistry  
ISP 209A Membranes and Trafficking  
ISP 0234 Laboratory Rotations  
ISP 0291 Graduate Seminar  
ISP 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### Spring

BCHM 0230 Gene Expression & Signal Transduction  
ISP 209B Cell Behavior  
ISP 210A Cell and Molecular Genetics  
ISP 210B Molecular Cell Biology of Development  
ISP 0220 Probability and Statistics for Basic Scientists  
ISP 0235 Laboratory Rotations  
ISP 0292 Graduate Seminar  
ISP 0296 Journal Club  
ISP 0220 Probability and Statistics for Basic Scientists

##### Summer

CMP 0299 Graduate Research

## SECOND YEAR PhD

### Fall

CMP 0230 Pathobiology  
CMP 0291 Graduate Seminar  
CMP 0295 Journal Club  
CMP 0297 Graduate Research

*Elective*

### Spring

CMP 0292 Graduate Seminar  
CMP 0296 Journal Club  
CMP 0298 Graduate Research  
*Elective*

### Summer

CMP 0299 Graduate Research

After the second year, students continue to enroll in Journal Club (0295/0296) for two more years, Graduate Seminar (0291/0292) and Graduate Research (0297/0298/0299) until they have completed their thesis research.

## MD/PHD PROGRAM PROGRESSION

The progression for students entering the Cell and Molecular Physiology Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include SK 0275 plus three credits chosen from ISP 209A, ISP 209B, ISP 210A, ISP 210B, BCHM 0224 and BCHM 0230. CMP MD/PhD students are also required to take one credit of elective coursework.

## FIRST YEAR MD/PhD

### Fall

*BCHM 0224 Advanced Graduate Biochemistry*  
CMP 0291 Graduate Seminar  
CMP 0295 Journal Club  
CMP 0297 Graduate Research  
*ISP 209A Membranes and Trafficking*  
SK 0275 Applied Ethics for Scientists  
SKMD 0209 Clinical Implications of Basic Research

*Choose three credits from the italicized courses.*

### Spring

*BCHM 0230 Gene Expression & Signal Transduction*  
CMP 0000 Qualifying Examination  
CMP 0292 Graduate Seminar  
CMP 0296 Journal Club  
CMP 0298 Graduate Research  
*ISP 209B Cell Behavior*  
*ISP 210A Cell and Molecular Genetics*  
*ISP 210B Molecular Cell Biology of Development*  
SKMD 0210 Clinical Implications of Basic Research  
*Elective*

After the first year, students continue to enroll in Journal Club (0295/0296) for two more years, and Graduate Seminar (0291/0292), Graduate Research (0297/0298/0299), and Clinical Implication of Basic Research (0209/0210) until they have completed their research.

## QUALIFYING EXAMINATION AND CANDIDACY

Students must pass a qualifying examination by spring of their first year in the Cellular and Molecular Physiology Program.

## RESEARCH AND THESIS

Students begin preliminary research when they enter the Cellular and Molecular Physiology Program and their thesis 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 thesis 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. Typically, students publish one or more papers.

#### COURSES

##### CMP 0000: 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. S/U. *Program Faculty*

##### CMP 0230: PATHOBIOLOGY (1 CR)

This is 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. A-F. *Liscum*

##### CMP 0245: BIOINFORMATICS AND GENOMICS IN BIOMEDICAL RESEARCH (1 CR)

This course provides 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. A-F. *Sahagian*

##### CMP 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. A-F. *Program faculty*

##### CMP 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

##### CMP 0295, 0296: 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. A-F. *Faust*

##### CMP 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. A-F. *Program faculty*

##### CMP 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

## CLINICAL AND TRANSLATIONAL SCIENCE

The [Graduate Programs in Clinical and Translational Science](#) train physicians and 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 and Translational Science Program confers MS and PhD degrees and also offers a Certificate Program. The Program is intended for individuals already trained in the medical sciences, most commonly fully-trained physicians. Others with similar backgrounds (e.g., DDS, DVM or PharmD) or advanced biomedical or clinical degrees may also be considered. View a list of [Clinical and Translational Science Faculty](#).

### MASTER'S AND PHD COURSE REQUIREMENTS AND PROGRESSION

The Clinical and Translational Science Master's Program curriculum provides a strong foundation of core methods and skills. Required didactic courses include CRES 0500, 0523, 0525, 0527, 0535, 0537, 0538, 0540, 0561, 0566, and 0581. Students also participate in seminars, hands-on computer labs, workshops, and mentored research projects. Participants acquire a rigorous foundation that includes research methods, statistics, research conduct, research ethics, and manuscript and grant writing. 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. 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 elective credits. The Master's Degree typically takes two years to complete.

#### FIRST YEAR MASTER'S

##### **Summer**

CRES 0525 Intro to Clinical Care Research

##### **Fall**

CRES 0500 Study Design Seminar

CRES 0515 Mentored Research Project/Thesis

CRES 0523 Intro Clinical Epidemiology

CRES 0527 Biostatistics I

CRES 0537 Scientific Manuscript Writing

CRES 0561 Intro to Clinical Trials

##### **Spring**

CRES 0500 Study Design Seminar

CRES 0515 Mentored Research Project/Thesis

CRES 0535 Biostatistics II

CRES 0537 Scientific Manuscript Writing

CRES 0540 Ethics of Clinical Investigation

CRES 0566 Intro to Health Services Research

CRES 0581 Intro to Evidence-based Medicine

*Elective*

#### SECOND YEAR MASTER'S

##### **Fall**

CRES 0500 Study Design Seminar

CRES 0516 Mentored Research Project/Thesis

CRES 0538 Scientific Grant Writing

*Elective*

##### **Spring**

CRES 0500 Study Design Seminar

CRES 0516 Mentored Research Project/Thesis

CRES 0538 Scientific Grant Writing

*Elective*

Students interested in pursuing PhD degrees in Clinical and Translational Science typically sit for their qualifying exams during the summer after their first year in the MS program. After satisfactory performance on the qualifying exam, PhD candidates complete the Master's curriculum, with any additional courses deemed necessary by the students and faculty advisers, and create original theses of publishable quality. For the PhD degree, 39.5 credits are required: 15 credits in the core

curriculum, 22 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 thesis is to demonstrate research competence as a culminating project of the Clinical and Translational Science 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 and Translational Science 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 thesis research findings, the Clinical and Translational Science 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 thesis (at least one of which must present original research findings).

#### CERTIFICATE COURSE REQUIREMENTS AND PROGRESSION

The Clinical and Translational Science 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 seven credits in required didactic courses (CRES 0500, 0506, 0507, 0523, 0525, 0540, 0561, 0566, and 0581), seminars, workshops, and a one-credit research project. Research efforts should result in a publishable manuscript/brief report or proposal for pilot project.

#### CERTIFICATE PROGRAM

##### **Summer**

CRES 0506 Intro to Biostatistics  
CRES 0525 Intro to Clinical Care Research

##### **Fall**

CRES 0500 Study Design Seminar  
CRES 0507 Intro to Biostatistics II  
CRES 0523 Intro Clinical Epidemiology  
CRES 0561 Intro to Clinical Trials

##### **Spring**

CRES 0500 Study Design Seminar  
CRES 0514 Clinical Research Project  
CRES 0540 Ethics of Clinical Investigation  
CRES 0566 Intro to Health Services Research  
CRES 0581 Intro to Evidence-based Medicine  
*Elective*

Note that students who choose to continue into the Master's degree program upon completion of the certificate requirements do not receive a certificate. All eight required credits transfer to the Master's program; additional elective credits do not.

## COURSES

### CRES 0000: PHD 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. Summer. S/U. *Program faculty*

### CRES 0402: MASTER'S DEGREE ONLY (0 CR)

This course is taken during the summer term after completing all didactic and research courses. Students prepare and write their master's theses, Summer. S/U. *Program faculty*

### CRES 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

### CRES 0500: STUDY DESIGN SEMINAR (0.5 CR)

These seminars meet weekly and use proposed and ongoing research projects to explore issues in study design. The course provides investigators and trainees the opportunity to present a research-related problem they are encountering and engages students in a discussion of the approach to the problem and an appropriate plan of action. Fall and Spring. A-F. *Kent, Pittas, Freund*

### CRES 0501: TRANSLATIONAL AND MOLECULAR EPIDEMIOLOGY (0.5 CR)

This course aims to address some of the main challenges of current translational research in the interface of epidemiology and molecular medicine. Spring. A-F. *Ioannidis*

### CRES 0502: BRIDGING THE BENCH-TO-BEDSIDE GAP (0.5 CR)

This course seeks to diminish the "bench-to-bedside" gap by exposing clinical graduate students to basic science research. Students focus on major questions that are ready 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 introduces students to translational science in action. Spring. A-F. *Simon*

### CRES 0506: INTRODUCTION TO BIOSTATISTICAL METHODS I (0.5 CR)

This course is the first half of a two-part course which 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. A-F. *Finkelman*

### CRES 0507: INTRODUCTION TO BIOSTATISTICAL METHODS II (0.5 CR)

This course is the second half of a two-part course which 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. Fall. A-F. *Finkelman*

### CRES 0510: 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. A-F. *Kent, Ruthazer*

CRES 0511: MACHINE LEARNING IN PREDICTIVE MEDICINE (1 CR)

This course introduces computer science students and clinicians to practical applications of machine learning to solving problems in clinical medicine through creation of collaborative research teams working on unsolved problems with a clinical researcher. The short-term goal is for each team to produce a report presented at the end of the course. The long-term goal is to build collaborative relationships and the advancement of interdisciplinary work between computer scientists and clinical researchers. Spring. S/U. *Program faculty*

CRES 0512: COMPARATIVE EFFECTIVENESS RESEARCH SURVEY (1 CR)

The course describes the current state of CER and evidence-based medicine (EBM). The tools of this kind of work are defined including various forms of CER from clinical trials, registry and observational research, technology assessments, and evidence reports. Methodologies used are explained, for example effectiveness trials, decision analysis, cost-effectiveness analysis, systematic review, and meta-analysis. Spring. S/U. *Selker*

CRES 0514: CLINICAL RESEARCH PROJECT-CERTIFICATE CANDIDATES (1 CR)

Students develop mentored research plans with mentors (or mentoring teams) that permits them to demonstrate these skills through the development of a protocol, a report, or research manuscript. The mentoring teams are required to have at least one member who is on the faculty of the Sackler CTS program. The project design is led by students, so they learn the role of principal investigator. This course is required for the Certificate Program, and is not available to non-certificate students. Spring. S/U. *Program faculty*

CRES 0515: CLINICAL RESEARCH PROJECT/THESIS RESEARCH - FIRST YEAR (1 CR)

First year master's students begin to learn how to complete 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. S/U. *Program faculty*

CRES 0516: CLINICAL RESEARCH PROJECT/THESIS RESEARCH- SECOND YEAR (2 CR)

Second year master's students continue and complete their independent clinical research projects. Students gain additional skills in 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. S/U. *Program faculty*

CRES 0517: CLINICAL RESEARCH PROJECT/THESIS RESEARCH – PHD CANDIDATES (2 OR 4 CR)

PhD students to complete comprehensive independent clinical research doctoral-level 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 and PhD thesis. Fall, Spring, and Summer. S/U. *Program faculty*

CRES 0518: 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, determines the number of credits. Fall, Spring, and Summer. S/U. *Program faculty*

CRES 0519: 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: Clinical Investigation, Evidence-based Clinical Effectiveness Research, and Health Services and Outcomes Research to develop a greater depth of knowledge and skills in a selected area. This course requires written approval of the Program Director in order to register. Spring. S/U. *Program faculty*

CRES 0523: INTRODUCTION TO CLINICAL EPIDEMIOLOGY (1 CR)

This course provides students with an overview of the epidemiologic approach to the study of disease causation, its natural history, and 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 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. Fall. A-F. *Paulus*

CRES 0525: 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. A-F. *Kent*

CRES 0527: 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. A-F. *Delmer, Bassett Midle*

CRES 0530: 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. A-F. *Terrin*

CRES 0535: 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. A-F. *Program Faculty*

CRES 0537: SCIENTIFIC MANUSCRIPT WRITING (0.5 CR)

This course focuses on principles of scientific manuscript writing. The student learns 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. Fall and Spring. A-F. *Goldberg*

CRES 0538: SCIENTIFIC GRANT WRITING (0.5 CR)

The purpose of this course is to teach the principles of clinical research grant writing. Participants 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. Fall and Spring. A-F. *Goldberg*

CRES 0539: SCIENTIFIC WRITING, PEER REVIEW AND PRESENTATIONS (0.5 CR)

Students focus on principals of scientific review and grant peer review. This involves critiquing manuscripts and reviewing research grants for mock study section meetings. Students are encouraged and given an opportunity to present their scientific writings and oral presentations for critique on an ongoing basis. Fall and Spring. A-F. *Program faculty*

CRES 0540: 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 addresses the interrelationships between ethics, law and professional practice standards and explores the role and workings of Institutional Review Boards. Spring. A-F.

*Parsons*

CRES 0545: PSYCHOMETRICS AND OUTCOMES MEASUREMENT (1 CR)

This course reviews 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. A-F. *Program faculty*

CRES 0555: PRINCIPLES OF DRUG DEVELOPMENT (1 CR)

This course examines 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. A-F. *Kaitin*

CRES 0556: PRINCIPLES OF PHARMACOECONOMICS (0.5 CR)

Pharmacoeconomics is the application of economic evaluation (i.e., cost analysis, cost-effectiveness, cost-benefit analysis, etc.) to pharmaceutical therapies. This is an elective course covers methods and uses of pharmacoeconomic analyses and other economic evaluations of medical technologies in health care. Spring. A-F. *Neumann*

CRES 0561: 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. A-F. *Snydman*

CRES 0562: TOPICS IN CLINICAL TRIALS (0.5 CR)

This is a seminar course that explores 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. S/U. *Snydman*

CRES 0566: INTRODUCTION TO HEALTH SERVICES RESEARCH (0.5 CR)

This course introduces students to the concepts and methods that distinguish health services and health policy research from other fields. Faculty 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. A-F. *Hyatt*

CRES 0567: 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. A-F. *Program faculty*

CRES 0571: ADVANCED EPIDEMIOLOGY (1 CR)

This course includes advanced topics in epidemiologic study design and analysis. The first module focuses on study design, beginning with the randomized clinical trial and proceeding to examine observational designs in depth, including prospective and retrospective cohorts, and those sampling from an underlying cohort. Design, sampling and analysis strategies and the biases that are specific to each study type are discussed. The second course module examines topics in study analysis, interpretation and bias, including confounding, matching, propensity scores, instrumental variables, effect modification, misclassification, and directed acyclic graphs for causal inference. A prior introductory course in epidemiology is required for enrollment. Spring. A-F. *Paulus*

CRES 0581: INTRODUCTION TO 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 focuses on studies of treatment efficacy. Spring. A-F. *Terrin*

CRES 0582: 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. A-F. *Program faculty*

CRES 0584: INTRODUCTION TO DECISION ANALYSES (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. A-F. *Pauker, Wong*

CRES 0593, 0594: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

## GENETICS

The [Graduate Program in Genetics](#) 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. View a list of [Genetics Program Faculty](#).

In addition to the traditional PhD program, the Program in Genetics also offers a [Mammalian Genetics](#) track, which is offered in conjunction with The Jackson Laboratory in Bar Harbor, Maine.

### PHD COURSE REQUIREMENTS AND PROGRESSION

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 0223 and 0230A; GENE 0201, 205A, 201B; and SK 0275. Students must also complete two elective courses. Students in the Mammalian Genetics Track, offered in conjunction with The Jackson Laboratory in Bar Harbor, Maine, matriculate in early July and complete GENE 0208 and one laboratory rotation in Bar Harbor during their first summer. All students participate in weekly journal clubs, seminars and research presentations and must pass a qualifying examination. Students typically begin thesis research after completing four lab rotations and successfully passing the qualifying examination. During the second and subsequent years, emphasis is placed on thesis research. When the aims of the research project have been achieved, students write and defend their theses.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

#### FIRST YEAR PhD

##### Fall

BCHM 0223 Graduate Biochemistry  
GENE 0201 Introduction to Genetics  
GENE 205A Mammalian Genetics I  
GENE 0234 Laboratory Rotations  
GENE 0289 Research Presentations  
GENE 0291 Graduate Seminar  
GENE 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### Spring

BCHM 230A Gene Expression  
GENE 205B Mammalian Genetics II  
GENE 0235 Laboratory Rotations  
GENE 0290 Research Presentations  
GENE 0292 Graduate Seminar  
GENE 0296 Journal Club

##### Summer

GENE 0000 Qualifying Examination  
GENE 0299 Graduate Research

#### SECOND YEAR PhD

##### Fall

GENE 0289 Research Presentations  
GENE 0291 Graduate Seminar  
GENE 0295 Journal Club  
GENE 0297 Graduate Research  
*Elective*

##### Spring

GENE 0290 Research Presentations  
GENE 0292 Graduate Seminar  
GENE 0296 Journal Club  
GENE 0298 Graduate Research  
*Elective*

##### Summer

GENE 0299 Graduate Research

FIRST YEAR PhD - Mammalian Genetics Track

**Summer**

GENE 0208 Mammalian & Experimental Genetics

GENE 0236 Laboratory Rotation

**Fall**

BCHM 0223 Graduate Biochemistry

GENE 0201 Introduction to Genetics

GENE 205A Mammalian Genetics I

GENE 0234 Laboratory Rotations

GENE 0289 Research Presentations

GENE 0291 Graduate Seminar

GENE 0295 Journal Club

SK 0275 Applied Ethics for Scientists

**Spring**

BCHM 230A Gene Expression

GENE 205B Mammalian Genetics II

GENE 0235 Laboratory Rotations

GENE 0290 Research Presentations

GENE 0292 Graduate Seminar

GENE 0296 Journal Club

GENE 0298 Graduate Research

**Summer**

GENE 0000 Qualifying Examination

GENE 0299 Graduate Research

SECOND YEAR PhD - Mammalian Genetics Track

**Fall**

GENE 0289 Research Presentations

GENE 0291 Graduate Seminar

GENE 0295 Journal Club

GENE 0297 Graduate Research

*Elective*

**Spring**

GENE 0290 Research Presentations

GENE 0292 Graduate Seminar

GENE 0296 Journal Club

GENE 0298 Graduate Research

*Elective*

**Summer**

GENE 0299 Graduate Research

After the second year, all students continue to enroll in Research Presentations (0289/0290), Journal Club (0295/0296), Graduate Seminar (0291/0292); and Graduate Research (0297/0298/0299) until they have completed their thesis research.

MD/PHD PROGRAM PROGRESSION

The progression for students entering the Genetics Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include BCHM 230A and GENE 0201, 205A, and 205B. Genetics MD/PhD students are not usually required to take electives.

FIRST YEAR MD/PhD

**Fall**

GENE 0201 Introduction to Genetics  
GENE 205A Mammalian Genetics I  
GENE 0289 Research Presentations  
GENE 0291 Graduate Seminar  
GENE 0295 Journal Club  
GENE 0297 Graduate Research  
SK 0275 Applied Ethics for Scientists  
SKMD 0209 Clinical Implications of Basic Research

**Spring**  
BCHM 230A Gene Expression  
GENE 205B Mammalian Genetics II  
GENE 0290 Research Presentations  
GENE 0292 Graduate Seminar  
GENE 0296 Journal Club  
GENE 0298 Graduate Research  
SKMD 0210 Clinical Implications of Basic Research

After the first year, MD/PhD students continue to enroll in Research Presentations (0289/0290), Journal Club (0295/0296), Graduate Seminar (0291/0292); Graduate Research (0297/0298/0299); and Clinical Implication of Basic Research (0209/0210) until they have completed their research.

#### QUALIFYING EXAMINATION AND CANDIDACY

Students must pass a qualifying examination in the summer of the first year. The exam requires the preparation and defense of an original research proposal that is not related to future thesis 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.

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 THESIS

Students enter their thesis 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 thesis 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. Typically, students publish one or more papers.

## COURSES

### GENE 0000: 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. Summer. S/U. *Program Director*

### GENE 0201: INTRODUCTION TO GENETICS (1 CR)

Basic principles and current issues in genetics are the subject of the course. The focus will be on basic genetic principles. Topics will include Mendelian analysis, linkage, recombination/gene conversion, chromosomal abnormalities, crossover and segregation, developmental genetics and differentiation, chromosome structure, chromatin, position effects, meiosis and mitosis. Student presentations of research papers are used to familiarize the class with the manner in which genetic approaches can be applied experimentally. Fall. A-F. *Selsing*

### GENE 205A: MAMMALIAN GENETICS I (0.5 CR)

The course reviews the genetic principles that apply to mammals, including genetic mechanisms of sex determination, genetic imprinting, and mitochondrial inheritance. Attention is focused on the ways in which mutation is manifested in disease phenotypes in humans. Fall. A-F. *Selsing*

### GENE 205B: MAMMALIAN GENETICS II (0.5 CR)

The course explores the methodologies that are currently used to perform genetic analysis of mammals. Spring. A-F. *Handel*

### GENE 0208: MEDICAL AND EXPERIMENTAL MAMMALIAN GENETICS (2 CR)

The course is an intensive workshop-style immersion into mammalian genetics over a period of approximately two weeks. The faculty presents background and current research in important areas of mammalian genetics and its impact on health and disease. This course is offered at The Jackson Laboratory, Bar Harbor, ME, and is restricted to JAX-track students. Summer. A-F. *Handel*

### GENE 0234, 0235, 0236: LABORATORY ROTATIONS (1 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. A-F *Imanishi-Kari*

### GENE 0289, 0290: RESEARCH 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. S/U. *Selsing*

### GENE 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Selsing*

### GENE 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

### GENE 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of “S” is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

GENE 0410: SYSTEMS GENETICS (1.0 CR)

This one-week course covers computational and experimental approaches to genetic studies that utilize whole genome approaches. Lectures and computer workshops are designed to accommodate students with a wide variety of backgrounds. Biologists seeking to gain a deeper understanding of statistical and computational methods as well as quantitative scientists desiring exposure to biological problems are welcome. Topics to be covered include genetic mapping, gene expression microarray analysis and computational modeling of complex systems. This course is offered at The Jackson Laboratory, Bar Harbor, ME. Permission of Genetics program director required. Fall. A-F. *Macauley, Churchill*

GENE 0450: EXPERIMENTAL MODELS OF HUMAN CANCER (1.5 CR)

This ten-day graduate-level genetics course is designed for predoctoral and postdoctoral students as well as established investigators entering the field of mouse genetics. The course focuses on the mouse as an experimental tool in cancer research. This course is offered at The Jackson Laboratory, Bar Harbor, ME. Permission of Genetics program director required. Summer A-F. *Macauley, Mills*

## IMMUNOLOGY

The [Graduate Program in Immunology](#) 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](#).

In addition to the traditional PhD program, Immunology students may also pursue the [MERGE-ID](#) (MEDically-oriented Research in Graduate Education – Infectious Disease) track, which is offered in the Graduate Programs in Immunology and Molecular Microbiology. It is specifically designed to provide strong training in the basic microbiology and immunology of pathogenic organisms and host interactions as well as knowledge of the pathogenesis, diagnosis, prevent, treatment and epidemiology of infectious diseases. Trainees complete a medically relevant thesis that is co-mentored by a basic research scientist and a clinician-scientist, and complete a curriculum specifically designed to provide students with strong grounding in a biomedical scientific discipline as well as the knowledge to understand the clinical implications of their work and move their discoveries to the bedside.

### PHD COURSE REQUIREMENTS AND PROGRESSION

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 0223, IMM 0212, 0215/0216, 0225/0226, 0228\*\* and SK 0275. Students in the Immunology MERGE-ID track matriculate in early July and take MBM 0223 their first summer. They are also required to take MBM 0241 and ISP 0220, but are not required to take IMM 0228\*\*. All students must complete one elective course, and participate in Journal Club through their fourth year in the program. They also participate in 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 thesis research after completing four lab rotations and successfully passing the qualifying examination. During the second and subsequent years, emphasis is placed on thesis research; when the aims of the research project have been achieved, students write and defend their theses.

#### FIRST YEAR PhD

##### Fall

BCHM 0223 Graduate Biochemistry  
IMM 0212 Introduction to Immunology  
IMM 0217 First Year Journal Club  
IMM 0225 Immunogenetics I  
IMM 0234 Laboratory Rotations  
IMM 0289 Research Presentations  
IMM 0291 Graduate Seminar  
SK 0275 Applied Ethics for Scientists

##### Spring

IMM 0000 Qualifying Examination  
IMM 0218 First Year Journal Club  
IMM 0226 Immunogenetics II  
IMM 0228 Immunochemistry II\*\**see note in description*  
IMM 0235 Laboratory Rotations  
IMM 0290 Research Presentations  
IMM 0292 Graduate Seminar

##### Summer

IMM 0299 Graduate Research

SECOND YEAR PhD

**Fall**

IMM 0215 Immunological Mechanisms of Disease I  
IMM 0289 Research Presentations  
IMM 0291 Graduate Seminar  
IMM 0295 Journal Club  
IMM 0297 Graduate Research

*Elective*

**Spring**

IMM 0216 Immunological Mechanisms of Disease II  
IMM 0290 Research Presentations  
IMM 0292 Graduate Seminar  
IMM 0296 Journal Club  
IMM 0298 Graduate Research

**Summer**

IMM 0299 Graduate Research

FIRST YEAR PhD - Immunology MERGE-ID Track

**Summer**

MBM 0223 Introduction to Infectious Diseases

**Fall**

BCHM 0223 Graduate Biochemistry  
IMM 0212 Introduction to Immunology  
IMM 0217 First Year Journal Club  
IMM 0225 Immunogenetics I  
IMM 0234 Laboratory Rotations  
IMM 0289 Research Presentations  
IMM 0291 Graduate Seminar  
MBM 0241 Microbial Genetics & Microbiology I  
SK 0275 Applied Ethics for Scientists

**Spring**

IMM 0000 Qualifying Examination  
IMM 0218 First Year Journal Club  
IMM 0226 Immunogenetics II  
IMM 0235 Laboratory Rotations  
IMM 0290 Research Presentations  
IMM 0292 Graduate Seminar  
MBM 0242 Microbial Genetics & Microbiology II

**Summer**

IMM 0299 Graduate Research

SECOND YEAR PhD – Immunology MERGE-ID Track

**Fall**

IMM 0215 Immunological Mechanisms of Disease I  
IMM 0289 Research Presentations  
IMM 0291 Graduate Seminar  
IMM 0295 Journal Club  
IMM 0297 Graduate Research

*Elective*

**Spring**

IMM 0216 Immunological Mechanisms of Disease II  
IMM 0290 Research Presentations  
IMM 0292 Graduate Seminar  
IMM 0296 Journal Club  
IMM 0298 Graduate Research  
ISP 0220 Probability and Statistics for Basic Scientists

**Summer**

IMM 0299 Graduate Research

After the second year, students continue to enroll in Journal Club (0295/0296) for two more years, and continue Research Presentations (0289/0290), Graduate Seminar (0291/0292) and Graduate Research (0297/0298/0299) until they have completed their thesis research.

## MD/PHD PROGRAM PROGRESSION

The progression for students entering the Immunology Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include BCHM 0224, IMM 0225/0226 and 0228\*\*. Immunology MD/PhD students are not usually required to take electives.

### FIRST YEAR MD/PhD

#### Fall

BCHM 0224 Advanced Graduate Biochemistry  
IMM 0217 First Year Journal Club  
IMM 0225 Immunogenetics I  
IMM 0289 Research Presentations  
IMM 0291 Graduate Seminar  
IMM 0297 Graduate Research  
SK 0275 Applied Ethics for Scientists

#### Spring

IMM 0000 Qualifying Exam  
IMM 0218 First Year Journal Club  
IMM 0226 Immunogenetics II  
IMM 0228 Immunochemistry II\*\* *see note at description*  
IMM 0290 Research Presentations  
IMM 0292 Graduate Seminar  
IMM 0298 Graduate Research

After the first year, MD/PhD students continue to enroll in Journal Club (0295/0296) for three more years and Research Presentations (0289/0290), Graduate Seminar (0291/0292); Graduate Research (0297/0298/0299); and Clinical Implication of Basic Research (0209/0210) until they have completed their research.

## QUALIFYING EXAMINATION AND CANDIDACY

Student must pass a qualifying examination in June of the first year. The exam requires the preparation and defense of an original research proposal that is not related to future thesis 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.

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 THESIS

Students enter their thesis 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 thesis 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 0000: 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. S/U. *Program faculty*

##### IMM 0212: INTRODUCTION TO IMMUNOLOGY (1 CR)

This is 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. A-F. *Wortis, Brodeur, Bunnell, Poltorak*

##### IMM 0215, 0216: 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 and Spring alternate years. A-F. *Perrin, Program faculty*

##### IMM 0217, 0218: FIRST YEAR JOURNAL CLUB (0.5 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. S/U. *Imanishi-Kari*

##### IMM 0225, 0226: IMMUNOGENETICS I AND II (0.5 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. A-F. *Huber, Selsing*

##### IMM 0228: IMMUNOCHEMISTRY 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. Spring. A-F. *Thorley-Lawson*

*\*\*This course description, title, and number are under review and may change in Fall, 2012.*

##### IMM 0233: SCIENTIFIC AND GRANT WRITING (0.5 CR)

This course provides 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 is a combination of lectures, writing assignments, and oral communication practice sessions with feedback provided by the faculty. Summer. S/U. *Hu*

IMM 0234, 0235, 0236: LABORATORY ROTATIONS (1 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. S/U. *Imanishi-Kari, Program faculty*

IMM 0289, 0290: RESEARCH 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. S/U. *Imanishi-Kari, Program faculty*

IMM 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Program faculty*

IMM 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

IMM 0295, 0296: 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. S/U. *Bunnell, Program faculty*

IMM 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. S/U. *Program faculty*

IMM 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committees, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

## INTEGRATED STUDIES

The [Integrated Studies Program](#) (ISP) is the joint admissions and first year academic portal of three basic science PhD programs — Biochemistry; Cell, Molecular and Developmental Biology; and Cellular and Molecular Physiology. 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

All students interested in a PhD in Biochemistry; Cell, Molecular and Developmental Biology; and Cellular and Molecular Physiology Programs apply for entry through the Integrated Studies Program (ISP), a single portal of entry and common first-year curriculum. In the first year, students complete required ISP didactic courses (BCHM 0223 and 0230; ISP 209A, 209B, 210A, 210B and 220; and SK 275). They also participate in weekly ISP journal clubs and seminars, and complete four laboratory rotations

#### FIRST YEAR PhD Entry Track

##### Fall

BCHM 0223 Graduate Biochemistry  
ISP 209A Membranes & Trafficking  
ISP 0234 Laboratory Rotations  
ISP 0291 Graduate Seminar  
ISP 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### Spring

BCHM 0230 Gene Expression & Signal Transduction  
ISP 209B Cell Behavior  
ISP 210A Cell and Molecular Genetics  
ISP 210B Molecular Cell Biology of Development  
ISP 0220 Probability and Statistics for Basic Scientists  
ISP 0235 Laboratory Rotations  
ISP 0292 Graduate Seminar  
ISP 0296 Journal Club

Students select rotations from the entire faculty of all participating programs. Students in the ISP select their graduate program and their thesis 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 209A: MEMBRANES AND TRAFFICKING (1.5 CR)

This 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. Fall. A-F. *Forgac*

#### ISP 209B: CELL BEHAVIOR (0.5 CR)

This course covers major topics in cell biology, including cell motility and mitosis; cell-cell and cell-matrix interactions; and receptor-mediated endocytosis. Spring. A-F. *Castellot*

#### ISP 210A: CELL AND MOLECULAR GENETICS (0.5 CR)

This course covers molecular genetics and basic concepts in developmental biology. Spring. A-F. *Cochran*

ISP 210B: MOLECULAR CELL BIOLOGY OF DEVELOPMENT (0.5 CR)

This course introduces students to the basic cellular and molecular mechanisms involved in gametogenesis, fertilization, early embryonic development, pattern formation, and organogenesis. The course emphasizes how human disease often recapitulates development. Spring. A-F. *Castellot*

ISP 0220: PROBABILITY AND STATISTICS FOR BASIC SCIENTISTS (0.5 CR)

This course provides an introduction to the principles of probability and statistics and emphasizes the application of these disciplines to the analysis of basic science biomedical research data. Topics include: summarizing data, testing for differences between means, analysis of variance, laws of probability, common probability distributions, the analysis of categorical data, correlation, linear regression, nonlinear curve fitting, and exponential processes. Spring. A-F. *Cox*

ISP 0234, 0235, 0236: LABORATORY ROTATIONS (1 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. S/U. *Program faculty*

ISP 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Program faculty*

ISP 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

ISP 0295, 0296: 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. S/U. *Program Faculty*

## **MOLECULAR MICROBIOLOGY**

The [Graduate Program in Molecular Microbiology](#) 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](#).

In addition to the traditional PhD program, Molecular Microbiology students may also pursue the [MERGE-ID](#) (MEDically-oriented Research in Graduate Education – Infectious Disease) track, which is offered in the Graduate Programs in Immunology and Molecular Microbiology. It is specifically designed to provide strong training in the basic microbiology and immunology of pathogenic organisms and host interactions as well as knowledge of the pathogenesis, diagnosis, prevent, treatment and epidemiology of infectious diseases. Trainees complete a medically relevant thesis that is co-mentored by a basic research scientist and a clinician-scientist, and complete a curriculum specifically designed to provide students with strong grounding in a biomedical scientific discipline as well as the knowledge to understand the clinical implications of their work and move their discoveries to the bedside.

### **PHD COURSE REQUIREMENTS AND PROGRESSION**

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 for students in the traditional Molecular Microbiology track include BCHM 0223, BCHM 231A, IMM 0212, MBM 0206, MBM 0207B, MBM 0241/0242 and SK 0275. In addition, students must choose two of the following three elective courses: BCHM 230A, MBM 0210/0211, and MBM 0214.

Students in the MERGE-ID track begin their program in July with MBM 0223. In their first two years, they are required to take BCHM 0223, IMM 0212, ISP 0220, MBM 0241/0242, MBM 0214, and SK 0275. In addition they must complete two elective courses: either IMM 0215/0216 or MBM 0210/0211; and either MBM 0206 or MBM 207B.

Students also participate in weekly journal clubs, seminars and research presentations and must pass a qualifying examination. Students typically select their research mentor after completing four lab rotations at the end of May of the first year and begin thesis research. During the second and subsequent years, emphasis is placed on thesis research. When the aims of the research project have been achieved, students write and defend their theses.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

FIRST YEAR PhD

**Fall**

BCHM 0223 Graduate Biochemistry  
IMM 0212 Introduction to Immunology  
MBM 0234 Laboratory Rotations  
MBM 0241 Microbial Genetics & Microbiology I  
MBM 0291 Graduate Seminar  
MBM 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

**Spring**

BCHM 231A Molecular Recog. in Biology & Drug Design  
MBM 0206 Mol Biology of Episomes and Plasmids  
MBM 0235 Laboratory Rotations  
MBM 0242 Microbial Genetics & Microbiology II  
MBM 0292 Graduate Seminar  
MBM 0296 Journal Club  
*Elective*

**Summer**

MBM 0299 Graduate Research

SECOND YEAR PhD

**Fall**

MBM 0291 Graduate Seminar  
MBM 0295 Journal Club  
MBM 0297 Graduate Research  
*Elective*

**Spring**

MBM 207B Microbial Physiology & Differentiation  
MBM 0292 Graduate Seminar  
MBM 0296 Journal Club  
MBM 0298 Graduate Research  
*Elective*

**Summer**

MBM 0000 Qualifying Examination  
MBM 0299 Graduate Research

FIRST YEAR PhD - Microbiology MERGE-ID Track

**Summer**

MBM 0223 Introduction to Infectious Diseases

**Fall**

BCHM 0223 Graduate Biochemistry  
IMM 0212 Introduction to Immunology  
MBM 0234 Laboratory Rotations  
MBM 0241 Microbial Genetics & Microbiology I  
MBM 0291 Graduate Seminar  
MBM 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

**Spring**

MBM 0235 Laboratory Rotations  
MBM 0242 Microbial Genetics & Microbiology II  
MBM 0292 Graduate Seminar  
MBM 0296 Journal Club  
*Elective*

**Summer**

MBM 0299 Graduate Research

SECOND YEAR PhD - Microbiology MERGE-ID Track

**Fall**

MBM 0291 Graduate Seminar  
MBM 0295 Journal Club  
MBM 0297 Graduate Research

**Spring**

ISP 0220 Probability and Statistics for Basic Scientists  
MBM 0214 Animal Virology  
MBM 0292 Graduate Seminar  
MBM 0296 Journal Club  
MBM 0298 Graduate Research  
*Elective*

**Summer**

MBM 0000 Qualifying Examination  
MBM 0299 Graduate Research

After the second year, students continue to enroll in Journal Club (0295/0296), Graduate Seminar (0291/0292) and Graduate Research (0297/0298/0299) until they have completed their thesis research.

## MD/PHD PROGRAM PROGRESSION

The progression for students entering the Molecular Microbiology Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include BCHM 0224, MBM 0241/0242 and BCHM 231A. Molecular Microbiology MD/PhD students are required to take two elective courses; note that MBM 0210/0211 counts as one elective.

### FIRST YEAR MD/PhD

#### Fall

BCHM 0224 Advanced Graduate Biochemistry  
MBM 0241 Microbial Genetics & Microbiology I  
MBM 0295 Journal Club  
MBM 0291 Graduate Seminar  
MBM 0297 Graduate Research  
SK 0275 Applied Ethics for Scientists  
*Elective*

#### Spring

MBM 0000 Qualifying Examination  
BCHM 231A Molecular Recog. in Biology & Drug Design  
MBM 0242 Microbial Genetics & Microbiology II  
MBM 0296 Journal Club  
MBM 0292 Graduate Seminar  
MBM 0298 Graduate Research  
*Elective*

After the first year, MD/PhD students continue to enroll in Journal Club (0295/0296), Graduate Seminar (0291/0292); Graduate Research (0297/0298/0299); and Clinical Implications of Basic Research (0209/0210) until they have completed their research.

## QUALIFYING EXAMINATION AND CANDIDACY

Students must pass a qualifying examination by summer term of their second year. The exam requires the preparation and defense of an original research proposal that is not related to future thesis work. 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 THESIS

Students enter their thesis 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 thesis 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

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.

## COURSES

### MBM 0000: 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. Summer, S/U. *Program faculty*

### MBM 0206: 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. A-F. *Malamy*

### MBM 0207B: 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. A-F. *Sonenshein*

### MBM 0210: 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 are required to read at least two papers per topic and discuss them in the group. Spring-alternate years. A-F. *Mecsas*

### MBM 0211: 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 are required to read at least two papers per topic and discuss them in the group. Spring-alternate years. A-F. *Isberg*

### MBM 0214: 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. A-F. *Coffin*,

### MBM 0223: INTRODUCTION TO INFECTIOUS DISEASES (1 CR) (Prerequisite: incoming MERGE-ID student)

This course is comprised of three integrated components; a Medical Microbiology Tutorial designed to introduce students to pathogens and pathophysiology of infectious diseases, Infectious Diseases Problem-Based Learning designed to introduce students to clinical cases, and a Teaching Clinic designed to expose students to real clinical cases and treatment options. Summer. A-F. *Camilli, Hu*

MBM 0241 MICROBIAL GENETICS & MICROBIOLOGY I (1 CR)

The goal of this course is to learn about the structure, growth, and genetics of bacteria and lambda bacteriophage. This course consists of text book reading, lectures and presentation and discussion of journal articles. Students are required to read one or two papers per topic and be prepared to discuss them in the group. Fall. A-F. *Camilli*

MBM 0242 MICROBIAL GENETICS & MICROBIOLOGY II (0.5 CR)

The goal of this course is to learn about genetic exchange, antibiotic resistance, small RNAs and special growth conditions of bacteria, as well as the structure, growth, and genetics of fungi, parasites and eukaryotic viruses. This course consists of text book reading, lectures and presentation and discussion of journal articles. Students are required to read one or two papers per topic and be prepared to discuss them in the group. Spring. A-F. *Camilli*

MBM 0234, 0235, 0236: LABORATORY ROTATIONS (1 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. S/U. *Program faculty*

MBM 0275: APPLIED ETHICS FOR SCIENTISTS (0.5 CR)

This course is 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. S/U. *Program faculty*

MBM 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Heldwein*

MBM 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

MBM 0295, 0296: JOURNAL CLUB (0.5 CR)

These courses provide 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. S/U. *Coffin*

MBM 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. S/U. *Program faculty*

MBM 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is automatically awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

## NEUROSCIENCE

The [Graduate Program in Neuroscience](#) provides interdisciplinary training that emphasizes classical neurobiological and modern neurogenetic approaches. The faculty research programs cover a wide range of topics and employ modern molecular/genetic, cellular, behavioral, and bioinformatic approaches to understanding nervous system function and dysfunction. The course of study has been designed to provide students with in-depth, multidisciplinary training that will allow them to unravel the complicated mechanisms underlying the physiology and pathophysiology of nervous system function.. View a list of [Neuroscience Program Faculty](#).

### PHD COURSE REQUIREMENTS AND PROGRESSION

In the first year, students complete the required didactic courses NRSC 0200, 0233, 0251, 0252, 0310 and 312; ISP 209A, 209B, 0220; and SK 0275. They also participate in weekly journal club, research presentation, and graduate seminar. All Neuroscience students also complete three laboratory rotations in their first year.

Students select a thesis adviser at the end of May. During the second and subsequent years, students complete one elective credit. Students also continue to participate in Neuroscience journal clubs, research presentations, graduate seminars, and must pass a qualifying examination. During the second and subsequent years, emphasis is placed on thesis research. When the aims of the research project have been achieved, students write and defend their theses.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

#### FIRST YEAR PhD

##### Fall

ISP 209A Membranes and Trafficking  
NRSC 0200 Cellular & Molecular Tutorials in Neurosci  
NRSC 0233 Neuroscience Research Techniques  
NRSC 0234 Laboratory Rotations  
NRSC 0251 Biochemical Foundations in Neuroscience I  
NRSC 0289 Research Presentations  
NRSC 0291 Graduate Seminar  
NRSC 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### Spring

ISP 209B Cell Behavior  
ISP 0220 Probability and Statistics for Basic Scientists  
NRSC 0235 Laboratory Rotations  
NRSC 0252 Biochemical Foundations in Neuroscience II  
NRSC 0290 Research Presentations  
NRSC 0292 Graduate Seminar  
NRSC 0296 Journal Club  
NRSC 0310 Systems Neuroscience  
NRSC 0312 Tutorials in Neural Systems & Disease Mech

##### Summer

NRSC 0299 Graduate Research

#### SECOND YEAR PhD

##### Fall

NRSC 0289 Research Presentations  
NRSC 0291 Graduate Seminar  
NRSC 0295 Journal Club  
NRSC 0297 Graduate Research  
*Elective*

##### Spring

NRSC 0000 Qualifying Examination  
NRSC 0290 Research Presentations  
NRSC 0292 Graduate Seminar  
NRSC 0296 Journal Club  
NRSC 0298 Graduate Research

##### Summer

NRSC 0299 Graduate Research

After the second year, all students continue to enroll in Research Presentations (0289/0290), Journal Club (0295/0296), Graduate Seminar (0291/0292); and Graduate Research (0297/0298/0299) until they have completed their thesis research.

#### MD/PHD PROGRAM PROGRESSION

The progression for students entering the Neuroscience Program from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include NRSC 0200, 251B, and 0312. Neuroscience MD/PhD students are also required to take one elective credit.

#### FIRST YEAR MD/PhD

##### **Fall**

NRSC 0200 Cellular & Molecular Tutorials in Neurosci

NRSC 251B Receptor/Channel Mechanisms

NRSC 0289 Research Presentations

NRSC 0291 Graduate Seminar

NRSC 0295 Journal Club

NRSC 0297 Graduate Research

SK 0275 Applied Ethics for Scientists

SKMD 0209 Clinical Implications of Basic Research

*Elective*

##### **Spring**

NRSC 0000 Qualifying Examination

NRSC 0290 Research Presentations

NRSC 0292 Graduate Seminar

NRSC 0296 Journal Club

NRSC 0298 Graduate Research

NRSC 0312 Tutorials in Neural Systems & Disease Mech

SKMD 0210 Clinical Implications of Basic Research

##### **Summer**

NRSC 0299 Graduate Research

After the first year, MD/PhD students continue to enroll in Research Presentations (0289/0290), Journal Club (0295/0296), Graduate Seminar (0291/0292); Graduate Research (0297/0298/0299); and Clinical Implication of Basic Research (0209/0210) until they have completed their research.

#### QUALIFYING EXAMINATION AND CANDIDACY

Students must pass a qualifying examination by the end of their first year in their thesis lab. The exam requires the preparation and defense of an original research proposal. 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 second 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 THESIS

Students begin preliminary thesis research when they enter their thesis 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 thesis 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. Typically, students publish one or more papers.

#### COURSES

##### NRSC 0000: 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. S/U. *Program faculty*

##### NRSC 0200: CELLULAR AND MOLECULAR TUTORIALS IN NEUROSCIENCE (0.5 CR)

These small group tutorial sessions will introduce students to key principles in cellular and molecular neuroscience, provide students with the historical context in which key advances have been made, and engage students and faculty in informal, one-on-one discussions to deepen understanding of the material. Fall. S/U. *Jacob*

##### NRSC 0205: DEVELOPMENTAL NEUROBIOLOGY (1 CR)

This is a small group, interactive course exploring the mechanisms underlying the formation of the differentiated nervous system. Morphological, biochemical, immunological, and molecular approaches are examined, with an emphasis on the utility of experimental model systems. Fall. A-F. *Jacob*

##### NRSC 0213: SYNAPSE NEUROBIOLOGY (1 CR)

This small group discussion course provides students with an in-depth understanding of how synapses function, how activity modulates function, and how synaptic ensembles coordinate simple behaviors. Fall. A-F. *Dunlap*

##### NRSC 0220: SCIENTIFIC WRITING PRINCIPLES (0.5 CR)

A discussion and workshop-style course underscoring the fundamental principles underlying expository writing. This course centers on the improvement of each student's existing skills through interactive writing exercises. Enrollment is limited to 10 students. Spring. A-F. *Program faculty*

##### NRSC 0233: NEUROSCIENCE LABORATORY TECHNIQUES (0.5 CR)

The series of workshops exposes student to fundamental laboratory techniques, including tissue culture, genotyping, microscopy, immunohistochemistry, rodent handling, protein quantification, and experimental design, Fall. S/U. *Maguire*

##### NRSC 0234, 0235, 0236: LABORATORY ROTATIONS (0.5 OR 1.0 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. S/U. *Program faculty*

NRSC 0251: BIOCHEMICAL FOUNDATIONS IN NEUROSCIENCE I (1.0 CR)

This course sequence covers fundamental biochemical principles, with special emphasis on mechanisms of particular importance to nervous system function, including neural signaling and non-equilibrium processes. Students will also be exposed to quantitative molecular approaches to studying the nervous system, Fall. A-F. *Moss*

NRSC 0251A: PROTEIN STRUCTURE (0.5 CR)

This course is the first half of the Biochemical Foundations in Neuroscience I course, which focuses on protein structures. Fall. A-F. *Moss*

NRSC 251B: RECEPTOR/CHANNEL MECHANISMS (0.5 CR)

This course is the second half of Biochemical Foundations in Neuroscience I course, which focuses on receptor/channel mechanisms. Fall. A-F. *Moss*

NRSC 0252: BIOCHEMICAL FOUNDATIONS IN NEUROSCIENCE II (1.0 CR)

This course sequence covers fundamental biochemical principles, with special emphasis on mechanisms of particular importance to nervous system function, including neural signaling and non-equilibrium processes. Students will also be exposed to quantitative molecular approaches to studying the nervous system. Spring. A-F. *Moss*

NRSC 0263: NEUROGENETICS (1.0 CR)

The course will review principles of forward and reverse genetics, present several animal model systems that are employed in neurogenetics research, and provide examples of genetic approaches that are used to study the molecules and neural circuits that regulate distinct neurobiological processes or are known to be altered in neurological disease states. Spring, alternate years. S/U. *Jackson*.

NRSC 0289, 0290: RESEARCH 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. S/U. *Jacob*

NRSC 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. Y;S/U. *Program faculty*

NRSC 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

NRSC 0295, 0296: 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. S/U. *Program Faculty*

NRSC 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. A-F. *Program faculty*

NRSC 0310: SYSTEMS NEUROBIOLOGY (FORMERLY NRSC 0212) (1.5 CR)

This course, a cross-listing with Tufts University School of Medicine, focuses on the structural and functional organization of the integrated nervous system with significant exposure to neurological disease processes. Spring. A-F. *Rios, Tesco*

NRSC 0312: TUTORIALS IN NEURAL SYSTEMS & DISEASE MECHANISMS (0.5 CR)

This tutorial is designed as a companion course to NRSC 0310, in order to expand students' understanding of research approaches to common neurological diseases. In preparation for each discussion, students will read historical and recent publications relevant to the class topic, followed by critical discussions of past research advances made and future approaches that might prove most effective in translational research efforts. Spring. A-F. *Rios, Tesco*

NRSC 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is awarded upon completion of the thesis. Fall, Spring, and Summer. *S/U. Program faculty*

## PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

The [Graduate Program in Pharmacology and Experimental Therapeutics](#) 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](#).

### PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the Pharmacology and Experimental Therapeutics 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 0223; PHRM 0211, 0232, and 0233; and SK 0275. Students must complete two elective courses (one course must be in the Pharmacology Program). 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 thesis research after completing four lab rotations and successfully passing the qualifying examination. During the second and subsequent years, emphasis is placed on thesis research. When the aims of the research project have been achieved, students write and defend their theses.

Note that these program progressions are specifically for students entering in 2012-2013. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with the Program Student Adviser about options available before making final course selections.

#### FIRST YEAR PhD

##### **Fall**

BCHM 0223 Graduate Biochemistry  
PHRM 0211 Translational Pharmacology I  
PHRM 0233 Scientific Writing and Presentation Skills  
PHRM 0234 Laboratory Rotations  
PHRM 0291 Graduate Seminar  
PHRM 0295 Journal Club  
SK 0275 Applied Ethics for Scientists

##### **Spring**

PHRM 0232 Translational Pharmacology II  
PHRM 0235 Laboratory Rotations  
PHRM 0292 Graduate Seminar  
PHRM 0296 Journal Club

##### **Summer**

PHRM 0000 Qualifying Examination  
PHRM 0299 Graduate Research

#### SECOND YEAR PhD

##### **Fall**

PHRM 0291 Graduate Seminar  
PHRM 0295 Journal Club  
PHRM 0297 Graduate Research  
*Elective*

##### **Spring**

PHRM 0292 Graduate Seminar  
PHRM 0296 Journal Club  
PHRM 0298 Graduate Research  
*Elective*

##### **Summer**

PHRM 0299 Graduate Research

After the second year, students continue to enroll in Journal Club (0295/0296), Graduate Seminar (0291/0292) and Graduate Research (0297/0298/0299) until they have completed their thesis research.

#### MD/PHD PROGRAM PROGRESSION

The progression for students entering the Pharmacology & Experimental Therapeutics Program (PPET) from the combined MD/PhD degree program is slightly different. Two laboratory rotations are completed in the summers before and during medical school, and students choose their thesis lab prior to their first year of coursework at Sackler. MD/PhD students also have adjusted didactic requirements including the additional Clinical Implications of Basic Research seminar (SKMD 0209/0210), which is taken every semester. Required didactic courses include PHRM 0211, 0232, 0233 and SK 0275. PPET MD/PhD students are also required to take one elective.

#### FIRST YEAR MD/PhD

##### **Fall**

PHRM 0211 Translational Pharmacology I  
PHRM 0233 Scientific Writing and Presentation Skills  
PHRM 0291 Graduate Seminar  
PHRM 0295 Journal Club  
PHRM 0297 Graduate Research  
SK 0275 Applied Ethics for Scientists  
SKMD 0209 Clinical Implications of Basic Research

##### **Spring**

PHRM 0000 Qualifying Examination  
PHRM 0232 Translational Pharmacology II  
PHRM 0292 Graduate Seminar  
PHRM 0296 Journal Club  
PHRM 0298 Graduate Research  
SKMD 0210 Clinical Implications of Basic Research  
*Elective*

After the first year, students continue to enroll in Journal Club (0295/0296), Graduate Seminar (0291/0292), Graduate Research (0297/0298/0299), and Clinical Implication of Basic Research (0209/0210) until they have completed their research.

#### QUALIFYING EXAMINATION AND CANDIDACY

Students must pass a qualifying examination the end of summer term of their first year. The exam requires the preparation and defense of an original research proposal. 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.

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 THESIS

Students enter their thesis 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 and Experimental Therapeutics Program faculty members. A précis of the thesis project is submitted to the committee, which must approve the topic as appropriate for thesis 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

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 0000: 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. S/U. *Program faculty*

### PHRM 0211: 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. A-F. *Beinfeld, Pothos, Program faculty*

### PHRM 0212: 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. A-F. *Greenblatt, Program faculty*

### PHRM 0213: ADDICTION MEDICINE (1 CR)

This course provides an overview of the mechanisms of action of drugs of abuse and their treatment, as well as the fundamentals of treatment of addiction in clinical practice. Spring. A-F. *Pothos*

### PHRM 0218: 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. A-F. *Theoharides, Program faculty*

### PHRM 0219: 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. A-F. *Shuster, Miczek*

### PHRM 0220: 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. A-F. *Beinfeld, Program faculty*

PHRM 0221: 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. S/U. *Greenblatt, Program faculty*

PHRM 0222: 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. A-F. *Ofner, Shuster, Program faculty*

PHRM 0224: 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. A-F. *Beinfeld, Program faculty*

PHRM 0225: 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. A-F. *Greenblatt*

PHRM 0232: 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. A-F. *Beinfeld, Pothos, Program faculty*

PHRM 0233: SCIENTIFIC WRITING AND PRESENTATION SKILLS (0.5 CR)

This course provides 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 is a combination of lectures, writing assignments, and oral communication practice sessions. Fall. S/U. *Fahey*

PHRM 0234, 0235, 0236: LABORATORY ROTATIONS (1 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. A-F. *Program faculty*

PHRM 0291, 0292: GRADUATE SEMINAR (0.5 CR)

Visiting speakers from the Boston community and beyond present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall and Spring. S/U. *Program faculty*

PHRM 0293, 0294: SPECIAL TOPICS (0.5 CR)

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. Fall and Spring. A-F. *Program faculty*

PHRM 0295, 0296: 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. S/U. *Program Faculty*

PHRM 0297, 0298, 0299: GRADUATE RESEARCH (2 OR 4 CR)

These courses provide guided research on a topic suitable for a doctoral thesis. Fall, Spring and Summer. A-F. *Program faculty*

PHRM 0403, 0404, 0405: PHD DEGREE ONLY (0 CR)

Students are enrolled in this course when they receive permission to write from their thesis committee, and represents the effort in the final preparation and writing of the doctoral thesis. A grade of "S" is awarded upon completion of the thesis. Fall, Spring, and Summer. S/U. *Program faculty*

## SACKLER INTER-PROGRAM DOCTORAL 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. Courses in this section which are designated SK are not housed in a particular program, and are open to all Sackler students. Courses with the SKMD designator are inter-program, but registration is restricted to MD/PhD students.

### COURSES

#### SK 0201: 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. A-F. *Program faculty*

#### SK 0202: STRUCTURAL BIOLOGY (0.5 CR)

This course covers the basic theory and practice of Macromolecular Crystallography and NMR. Alternate Summers. A-F. *Bohm, Baleja*

#### SK 0203: 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. A-F. *Kaplan*

#### SK 0204: 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. A-F. *Castellot*

#### SK 0205: MENTORED UNDERGRADUATE TEACHING (0.5 CR)

This course offers an opportunity for Sackler students to obtain 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. S/U. *Liscum*

#### SK 0275: APPLIED ETHICS FOR SCIENTISTS (0.5 CR)

The course is built around case study reading material and requires highly interactive discussion in which students analyze specific scenarios of ethical issues encountered in a research environment. Scheduling for lectures and discussions are flexible to fit the diverse schedules of students across the different Sackler programs. Topics include: academic integrity issues/ fraud and misconduct/plagiarism/ data handling/notebooks, mentoring and conflict resolution and ethical use of animals and human subjects. Entire year. Y, S/U. *Jay*

#### SK 0299: BIOMEDICAL TECHNIQUES & RESEARCH (0 CR)

This course includes research with selected adviser. Visiting Students Only. Fall, Spring and Summer. S/U. *Program faculty*

#### SKMD 0209, 0210: 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 required 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. S/U. *Schwob*

SKMD 0236: LABORATORY ROTATION (1.0 CR)

Four 8-10 week laboratory rotations for first-year students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring, Summer. S/U.

*Program faculty*

SKMD 0299: GRADUATE RESEARCH (2 CR)

This course provides guided research on a topic suitable for a doctoral thesis. Summer. S/U. *Program faculty*