

Sackler School of Graduate Biomedical Sciences

CATALOG

2014 – 2015

Programs of Study, Courses and Requirements for all Graduate Programs

Graduate Programs

[BIOCHEMISTRY](#)

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

[CELLULAR AND MOLECULAR PHYSIOLOGY](#)

[CLINICAL AND TRANSLATIONAL SCIENCE](#)

[GENETICS](#)

[IMMUNOLOGY](#)

[INTEGRATED STUDIES](#)

[MOLECULAR MICROBIOLOGY](#)

[NEUROSCIENCE](#)

[PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS](#)

[SACKLER INTER-PROGRAM COURSES](#)

Every effort is made to ensure that the degree requirement and course information, applicable policies, and other materials contained in this catalog are accurate and current. The Sackler School of Graduate Biomedical Sciences reserves the right to correct errors of fact, and to make changes at any time without prior notice. The Catalog as it exists online at the Sackler School web site is the governing document, and contains the current policies and information about the graduation requirements for students entering in that academic year.

Tufts University is an equal opportunity educator and employer.

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 school and government labs, biotechnology industry research, and management. View a list of [Biochemistry Program Faculty](#).

Students who matriculate in the Integrated Studies Program (ISP) Fall, 2014 will be the last class to have the option of completing their graduate degree in the Biochemistry Program. Starting Fall, 2015, students who wish to pursue research in biochemistry may do as part of the newly-restructured Cell, Molecular, and Developmental Biology Program, which offers students the opportunity to select one of four specializations: Cancer Biology, Cell and Developmental Biology, Molecular and Cellular Medicine, and Structural and Chemical Biology.

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, 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 advisor at the end of May in the first year of graduate school. During the second and subsequent years, students complete two additional required didactic courses (BCHM 231A and 231B) and two elective credits. Students must pass a qualifying examination, and participate in Biochemistry journal clubs and seminars until they are granted Permission to Defend. In addition, fifth year students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with the Program Student Advisor 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 231A Molecular Recognition in Biology

BCHM 231B 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 as part of 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, 231A, 231B, and SK 0275. Biochemistry MD/PhD students are not usually required to take any electives. Students who take longer than four years to complete their PhDs will also be required to complete an Ethics refresher course.

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 231A Molecular Recognition in Biology

BCHM 231B 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 Implications 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 their thesis laboratory and the Biochemistry Program. The student and mentor, in consultation with the student advisor 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, Biochemistry graduate students assist in tutorial group teaching of medical students.

PUBLICATION

Students are expected to publish their research in scientific journals appropriate to their topic. Typically, students publish one or more papers before they graduate.

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 0202: MACROMOLECULAR STRUCTURAL ANALYSIS (1 CR)

This is an intensive workshop covering the basic theory and practice of modern protein crystallography and NMR. The course alternates between lectures, hands-on demos, and computer exercises. Summer, alternate years; last offered 2013. A-F. *Bohm*

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. *Bohm*

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 BCHM 0223, 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 are allowed to transfer to this course after the first BCHM 0223 examination if they meet the performance requirements set by the Course Director. Fall. A-F. *Bohm*

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 0230 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 0230 and may be taken as a separate course. Spring. A-F. *Yee, Program faculty*

BCHM 0231A: MOLECULAR RECOGNITION IN BIOLOGY (0.5 CR)

This course covers the association of biological molecules. Complexes of proteins with other proteins, with lipids, and with nucleic acids are emphasized. Spring. A-F. *Bohm, Program faculty*

BCHM 0231B: DRUG DESIGN (0.5 CR)

This course includes discussion of drug screening and optimization techniques as they have been applied in a number of detailed, real-world cases. Spring. A-F. *Program faculty*

BCHM 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

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

Students enroll in this course when they receive permission to write and defend their theses from their thesis committees. This course represents the effort in the final preparation of the doctoral thesis. A grade of "S" is automatically awarded upon successful completion of the thesis. Fall, Spring, 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](#).

Note that in 2015-2016, the Cell, Molecular, and Developmental Biology Program will be expanded, and will offer specializations in Cancer Biology, Molecular and Cellular Medicine, Cell & Developmental Biology, and Structural and Chemical Biology.

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, 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 advisor 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 (CMDB 0235) and one elective credit. Students also participate in Cell, Molecular and Developmental Biology journal clubs and seminars and must pass a qualifying examination. In addition, fifth year students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with the Program Student Advisor 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

CMDB 0299 Graduate Research

SECOND YEAR PhD

Fall

CMDB 0235 Developmental Biology

CMDB 0291 Graduate Seminar

CMDB 0295 Journal Club

CMDB 0297 Graduate Research

Elective

Spring

CMDB 0000 Qualifying Examination

CMDB 0292 Graduate Seminar

CMDB 0296 Journal Club

CMDB 0298 Graduate Research

Summer

CMDB 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 as part of the combined MD/PhD degree 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, CMDB 0235, and SK 0275. CMDB MD/PhD students are not usually required to take electives. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course.

FIRST YEAR MD/PhD

Fall

CMDB 0291 Graduate Seminar

CMDB 0295 Journal Club

CMDB 0297 Graduate Research

SK 0275 Applied Ethics for Scientists

SKMD 0209 Clinical Implications of Basic Research

Spring

CMDB 0000 Qualifying Examination

CMDB 0292 Graduate Seminar

CMDB 0296 Journal Club

CMDB 0298 Graduate Research

ISP 209B Cell Behavior

ISP 210B Molecular Cell Biology of Development

SKMD 0210 Clinical Implications of Basic Research

CMDB 0235 is taken at the first opportunity. The course is offered at least every other year, and was last offered 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 Implications of Basic Research (0209/0210) until they are granted Permission to Defend.

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 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.

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 their thesis laboratory and the Cell, Molecular and Developmental Biology Program. The student and mentor, in consultation with the student advisor 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 advisor) to participate in mentored teaching of a one-semester course. All course assignments are determined by a consensus of the student, his/her advisor, 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 before they graduate.

COURSES

CMDB 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*

CMDB 0203: MEDICAL HISTOLOGY (2 CR)

This Tufts University School of Medicine course introduces students 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 a practical background in both cell and tissue biology. Fall. A-F. *Castellot*

CMDB 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; last offered 2013. A-F. *Program faculty*

CMDB 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

CMDB 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, Spring, Summer. A-F. *Program faculty*

CMDB 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, Spring. *S/U. Program faculty*

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

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

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

Students enroll in this course when they receive permission to defend their theses from their thesis committees. This course represents the effort in the final preparation of the doctoral thesis. A grade of "S" is automatically awarded upon successful completion of the thesis. Fall, Spring, 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](#).

Students who matriculate in the Integrated Studies Program (ISP) Fall, 2014 will be the last class to have the option of completing their graduate degree in the Cellular and Molecular Physiology Program. Starting Fall, 2015, students who wish to pursue research in cellular and molecular physiology may do as part of the newly-restructured Cell, Molecular, and Developmental Biology Program, which offers students the opportunity to select one of four specializations: Cancer Biology, Cell and Developmental Biology, Molecular and Cellular Medicine, and Structural and Chemical Biology.

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, 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 advisor 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. In addition, fifth year students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor 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

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 0000 Qualifying Exam
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 one more year, and 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 as part of 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, and three credits chosen from ISP 209A, 209B, 210A, and 210B; BCHM 0224; and BCHM 0230. CMP MD/PhD students are also required to take one additional credit of elective coursework. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course.

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

After the first year, students continue to enroll in Journal Club (0295/0296) for one more year, and 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 take a qualifying exam during the spring of their first year in the Cellular and Molecular Physiology Program. The exam requires the preparation and defense of an original research proposal that is relevant, but not identical 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.

Admission to candidacy is based on achievements in didactic courses and lab rotations, participation in seminars, and satisfactory performance on the qualifying exam. Students who successfully complete their qualifying examinations are subsequently considered candidates for the doctoral degree.

RESEARCH AND THESIS

Students begin preliminary research when they enter their thesis lab and the Cellular and Molecular Physiology Program. The student and mentor, in consultation with the student advisor and program director, select a thesis advisory committee composed of at least two Cellular and Molecular Physiology Program faculty members, in addition to their mentor. 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

CMP has no specific teaching requirements. However, students who are interested in obtaining teaching experience may contact their program director for information on potential opportunities.

PUBLICATION

Students are expected to publish their research in scientific journals appropriate to their topic. Typically, students publish one or more papers before they graduate.

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, pending minimum enrollment. A-F. *Herman*

CMP 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

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

Students enroll in this course when they receive permission to write and defend their theses from their thesis committees. This course represents the effort in the final preparation of the doctoral thesis. A grade of "S" is automatically awarded upon successful completion of the thesis. Fall, Spring, 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. Program 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 offers full-time study leading to MS and PhD degrees and also offers a part-time 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, including research methods, statistics, research conduct, research ethics, and manuscript and grant writing. For students matriculating in Summer, 2014, required didactic coursework includes CTS 0500, 0523, 0525, 0537, 0538, 0540; two courses from CTS 0561, 0566, and 0581; and two biostatistics courses, typically 0527 and 0575 (for students entering the MS program from the certificate program, only one additional biostatistics course is required). Students must also complete 2.5 elective credits. In addition, students participate in seminars, hands-on computer labs, workshops, and mentored research projects. Because the ability to self-initiate and execute independent research is key to success as a researcher, a central degree requirement is the completion of an independent research project that leads to a Master's thesis. The Master's Degree typically takes two years to complete.

FIRST YEAR MASTER'S

Summer

CTS 0525 Intro to Clinical Care Research

Fall

CTS 0500 Study Design Seminar

CTS 0515 Mentored Research Project/Thesis

CTS 0523 Intro Clinical Epidemiology

CTS 0527 Biostatistics I

CTS 0537 Scientific Manuscript Writing

*CTS 0561 Intro to Clinical Trials**

Spring

CTS 0500 Study Design Seminar

CTS 0515 Mentored Research Project/Thesis

CTS 0537 Scientific Manuscript Writing

CTS 0540 Ethics of Clinical Investigation

*CTS 0566 Intro to Health Services Research**

CTS 0575 Advanced Epidemiology & Regression Methods

*CTS 0581 Intro to Evidence-based Medicine*Elective*

*choose two of three

SECOND YEAR MASTER'S

Fall

CTS 0500 Study Design Seminar

CTS 0516 Mentored Research Project/Thesis

CTS 0538 Scientific Grant Writing

Elective

Spring

CTS 0500 Study Design Seminar

CTS 0516 Mentored Research Project/Thesis

CTS 0538 Scientific Grant Writing

Elective

PHD QUALIFYING EXAMINATION

After approval by the Advisory Committee, students interested in pursuing PhD degrees in Clinical and Translational Science sit for their qualifying exams during the summer after their first year in the MS program. Once PhD candidates satisfactorily complete the qualifying exam, they finish the second year of the Master's curriculum. Subsequently, PhD students register for CTS 0500, 0539, and 0517 each Fall and Spring term, and just 0517 in the Summer.

RESEARCH AND THESIS

MS or PhD thesis committees are formed during the first term of study, and must include a Project Mentor, a Program Mentor, and a Statistical Mentor. PhD students are also required to have an External Advisor. Thesis 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 for the student to graduate. The thesis must be presented in the official University format, which is different from the format of an article or paper.

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 their research 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.

PUBLICATION

Students are expected to publish their research in scientific journals appropriate to their topic. Master's students submit at least one paper, and PhD students submit three or more before they graduate.

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. Required didactic courses include CTS 0500, 0523, 0525, 0540, 0561, 0566, 0581, and biostatistics (either 0506 and 0507, or 0527), as well as seminars, workshops, and a one-credit research project. Research efforts should result in a publishable manuscript, research proposal, or protocol.

CERTIFICATE PROGRAM

Summer

CTS 0506 Introduction to Biostatistics I
CTS 0525 Introduction to Clinical Care Research

Fall

CTS 0500 Study Design Seminar
CTS 0507 Introduction to Biostatistics II
CTS 0523 Introduction Clinical Epidemiology
CTS 0561 Introduction to Clinical Trials

Spring

CTS 0500 Study Design Seminar
CTS 0514 Clinical Research Project
CTS 0540 Ethics of Clinical Investigation
CTS 0566 Introduction to Health Services Research
CTS 0581 Introduction to Evidence-based Medicine

For students who wish to continue in the Master's degree program, all required didactic credits transfer to the Master's program; additional elective credits do not. Students who do not complete the Certificate program requirements may transfer a maximum of two courses into the CTS Master's program.

COURSES

CTS 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*

CTS 0231: APPLYING QUALITY IMPROVEMENT METHODS IN HEALTHCARE AND PUBLIC HEALTH (1 CR)

This course aims to provide a broad overview of current trends, core concepts, and methods in quality improvement (QI) and demonstrate their application to healthcare and public health. The course focuses on application, and includes didactic instruction, group discussions, and individual and group projects. Spring. A-F. *Leslie*

CTS 0500: STUDY DESIGN SEMINAR (0.5 CR)

These seminars 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, Spring. A-F. *Kent, Freund*

CTS 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. Last offered 2009. A-F. *Program faculty*.

CTS 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. Last offered 2009. A-F. *Huggins*

CTS 0506: INTRODUCTION TO BIOSTATISTICAL METHODS I (0.5 CR)

This course is the first half of a two-part course that 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. CTS 0506 and 0507 are considered equivalent to 0527. Summer. A-F. *Finkelman*

CTS 0507: INTRODUCTION TO BIOSTATISTICAL METHODS II (0.5 CR)

This course is the second half of a two-part course that 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. CTS 0506 and 0507 are considered equivalent to 0527. Fall. A-F. *Finkelman*

CTS 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*

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

This course introduces the 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. Last offered 2011. S/U. *Program faculty*

CTS 0512: COMPARATIVE EFFECTIVENESS RESEARCH SURVEY (1 CR)

The course describes the current state of comparative effectiveness research (CER) and evidence-based medicine (EBM). Various tools and forms of CER from clinical trials, registry and observational research, technology assessments, and evidence reports are explored. Methodologies used are explained, for example: effectiveness trials, decision analysis, cost-effectiveness analysis, systematic review, and meta-analysis. Last offered 2011. S/U. *Program faculty*

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

Students develop research plans with mentors (or mentoring teams) that permit them to practice research skills through the development of a protocol, a report, or research manuscript. 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*

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

First year Master's students begin to learn how to complete a comprehensive independent clinical research project, which includes framing a research question and specific project aims, identifying useful data sources, developing appropriate methods, identifying and defending against sources of bias, implementing/managing a project, and writing a thesis proposal. Fall and Spring. S/U. *Program faculty*

CTS 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 the thesis and a publishable article. Fall, Spring. S/U. *Program faculty*

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

PhD students 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 the thesis and publishable articles. Fall, Spring, Summer. S/U. *Program faculty*

CTS 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, Summer. S/U. *Program faculty*

CTS 0519: CONCENTRATION PRACTICUM (0.5-2 CR)

This course is an independent mentored experience for students interested in advanced study and skill development in a particular area. This course requires completion of an Independent Study proposal in order to register. Fall, Spring, Summer. S/U. *Program faculty*

CTS 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*

CTS 0525: INTRODUCTION TO CLINICAL CARE RESEARCH (2 CR)

This course, meeting three hours daily over four weeks in the Summer, 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*

CTS 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. *Noubary*

CTS 0533 ADVANCED BIOSTATISTICS (0.5 CR)

This course provides background in advanced applied statistical methods in clinical research. Topics in the course include Poisson, multinomial, and ordinal regression, competing risk survival models, longitudinal data analysis, and hierarchical mixed models. The course provides students with the statistical foundations of these methods and their applications in clinical research. The seminar allows participants to explore advanced statistical topics and provides clinical and translational scientists with exposure to methods that may be applicable in their own research. Fall, A-F. *Terrin*

CTS 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, Spring. A-F. *Paulus*

CTS 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, Spring. A-F. *Program faculty*

CTS 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, Spring. A-F. *Program faculty*

CTS 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*

CTS 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. *Program faculty*

CTS 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 course covers methods and uses of pharmacoeconomic analyses and other economic evaluations of medical technologies in health care. Spring. A-F. *Neumann*

CTS 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*

CTS 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. Last offered 2010. S/U. *Snydman*

CTS 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. *Soeteman*

CTS 0575 ADVANCED EPIDEMIOLOGY AND REGRESSION METHODS: AN INTEGRATED APPROACH (2 CR)

This course serves as an introduction to more advanced topics in epidemiologic study design and biostatistical modeling with a focus on multivariate regression methods. Design, sampling, and analysis strategies and the biases that are specific to each study design will be discussed. Epidemiologic topics in analysis and interpretation will be covered including confounding, information bias and effect modification, as well as tools available to limit bias such as matching, propensity scores, and directed acyclic graphs (DAGs). The corresponding biostatistical topics will emphasize developing an understanding of the assumptions, limitations, and interpretation of regression results for clinic and public health data arising from continuous, binary, and time-to-event data. Prerequisites: 0523, 0527. Spring. A-F. *Paulus, Noubary*

CTS 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. Studies of treatment efficacy are the primary focus. Spring. A-F. *Terrin, Balk*

CTS 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. *Wong*

CTS 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, Spring, Summer. 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. The goal of the program is to train talented individuals to think critically, identify important issues in genetics, and design and conduct original 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 (JAX) 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 for students in the traditional Genetics track include BCHM 0223 and 0230A; GENE 0201, 205A, 205B; and SK 0275. Students must also complete two elective courses.

Students in the Mammalian Genetics Track matriculate in early July and complete an additional required course, GENE 0208, and one laboratory rotation in Bar Harbor during their first summer. JAX students are only required to take one elective course.

All students participate in weekly journal clubs, seminars and research presentations and must pass a qualifying examination. In addition, fifth year students are required to complete an Ethics refresher course. Students typically begin thesis research after completing four lab rotations and successfully passing the qualifying examination. From the second year, 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor 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 001 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 002 Laboratory Rotations
GENE 0290 Research Presentations
GENE 0292 Graduate Seminar
GENE 0296 Journal Club
GENE 0298 Graduate Research

SECOND YEAR PhD - Mammalian Genetics Track

Summer

GENE 0000 Qualifying Examination
GENE 0299 Graduate Research

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

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 as part of 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, GENE 0201, 205A, 205B, and SK 0275. 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

Summer

GENE 0000 Qualifying Examination
GENE 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 Implications of Basic Research (0209/0210) until they have completed their research. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course.

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 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 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.

TEACHING

The Genetics program has no specific teaching requirements. However, students who are interested in obtaining teaching experience may contact their program director for information on potential opportunities.

PUBLICATION

Students are expected to publish their research in scientific journals appropriate to their topic. Typically, students publish one or more papers before they graduate.

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 faculty*

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 in late July. 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 (JAX), Bar Harbor, ME. Permission of the Genetics Program Director and registration through JAX in addition to Tufts is required. Summer. A-F. *Handel*

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

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, Kumar-Singh

GENE 0289, 0290: RESEARCH PRESENTATIONS (0.5 CR)

Students present progress reports on their research for questions and constructive criticism while gaining experience in presenting data and leading discussion. Fall, Spring. S/U. *Program faculty*

GENE 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

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

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

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

Students enroll in this course when they receive permission to write and defend their theses from their thesis committees. This course represents the effort in the final preparation of the doctoral thesis. A grade of "S" is automatically awarded upon successful completion of the thesis. Fall, Spring, 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. Individuals seeking to gain a deeper understanding of statistical and computational methods as well as 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 (JAX), Bar Harbor, ME. Permission of the Genetics Program Director and registration through JAX in addition to Tufts is required. Fall. A-F. *The Jackson Labs faculty*

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

This ten-day graduate-level genetics course is designed for individuals 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 (JAX), Bar Harbor, ME. Permission of the Genetics Program Director and registration through JAX in addition to Tufts is required. Summer A-F.
Mills, The Jackson Lab faculty

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 experts in the laboratory techniques required to achieve these goals. Students are expected to design critical experiments, be creative but self-critical, and to make original scientific contributions that will enhance understanding of important questions in immunologically-related research. When they finish the program, 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, prevention, 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 for students in the traditional Immunology track include BCHM 0223, IMM 0212, 0215/0216, 0245, 0250, 0252 and SK 0275.

Students in the MERGE-ID track begin their program in July with MMB 0223. They are also required to take BCHM 0223; IMM 0212, 0215/0216, 0245, 0250; MMB 0241/0242; ISP 0220 and SK 0275.

All students must complete one elective course, and participate in Journal Club through their fourth year in the program. Students also participate in seminars and research presentations and must pass a qualifying examination. In addition, fifth year students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor about options available before making final course selections.

FIRST YEAR PhD

Fall

BCHM 0223 Graduate Biochemistry
IMM 0212 Introduction to Immunology
IMM 0217 First Year Journal Club
IMM 0234 Laboratory Rotations
IMM 0245 Advanced Cellular Immunology
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 0235 Laboratory Rotations
IMM 0250 Immunochemistry- Signaling and Dynamics
IMM 0252 System Approaches to Immunology
IMM 0290 Research Presentations
IMM 0292 Graduate Seminar

Summer

IMM 0299 Graduate Research

SECOND YEAR PhD

Fall

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

Elective

Spring

IMM 0216 Immunological Mechanisms in 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

MMB 0223 Introduction to Infectious Diseases

Fall

BCHM 0223 Graduate Biochemistry
IMM 0212 Introduction to Immunology
IMM 0217 First Year Journal Club
IMM 0234 Laboratory Rotations
IMM 0245 Advanced Cellular Immunology
IMM 0289 Research Presentations
IMM 0291 Graduate Seminar
MMB 0241 Microbial Genetics & Microbiology I
SK 0275 Applied Ethics for Scientists

Spring

IMM 0000 Qualifying Examination
IMM 0218 First Year Journal Club
IMM 0235 Laboratory Rotations
IMM 0250 Immunochemistry- Signaling and Dynamics
IMM 0290 Research Presentations
IMM 0292 Graduate Seminar
MMB 0242 Microbial Genetics & Microbiology II

SECOND YEAR PhD – Immunology MERGE-ID Track

Summer

IMM 0299 Graduate Research

Fall

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

Elective

Spring

IMM 0216 Immunological Mechanisms in 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 as part of the combined MD/PhD degree 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 0245, 0250, 0252, and SK 0275. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course. 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 0245 Advanced Cellular Immunology
IMM 0289 Research Presentations
IMM 0291 Graduate Seminar
IMM 0297 Graduate Research
SK 0275 Applied Ethics for Scientists
SKMD 0209 Clinical Implications of Basic Research

Spring

IMM 0000 Qualifying Exam
IMM 0218 First Year Journal Club
IMM 0250 Immunochemistry-Signaling and Dynamics
IMM 0252 System Approaches to Immunology
IMM 0290 Research Presentations
IMM 0292 Graduate Seminar
IMM 0298 Graduate Research
SKMD 0210 Clinical Implications of Basic 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 Implications 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 qualifying examination. 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. *Iacomini*

IMM 0215, 0216: IMMUNOLOGICAL MECHANISMS IN DISEASE I AND II (1 CR)

These courses 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. Last offered 2013-2014. 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, Spring. S/U. *Selsing*

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. Last offered 2011. S/U. *Hu*

IMM 0234, 0235, 0236: LABORATORY ROTATIONS (0.5-1 CR)

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*

IMM 0245 ADVANCED CELLULAR IMMUNOLOGY (1.0 CR)

This course is designed to give students a background in contemporary cellular immunology. The course is based on a lecture series supplemented by extensive readings from the current literature. Part of each class is dedicated to discussing the assigned reading material, which is two papers per lecture. Prerequisite: IMM 0212 or equivalent. Fall. A-F. *Huber*

IMM 0250 IMMUNOCHEMISTRY- SIGNALING AND DYNAMICS (1.0 CR)

This 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. Spring. A-F. *Bunnell*

IMM 0252: SYSTEM APPROACHES TO IMMUNOLOGY (1.0 CR)

This course introduces the mouse as the main model for studies of human biology. It starts with mouse genetics, continues with classical genetic analysis in the mouse, and moves to genetic basis of immunological phenomena such as receptor editing, B-cell tolerance, and autoimmunity. Lectures and hands-on workshops familiarize students with the basics of microarray analysis and next generation sequencing. Spring. A-F. *Poltorak*

IMM 0289, 0290: RESEARCH PRESENTATIONS (0.5 CR)

Students present progress reports on their research for questions and constructive criticism while gaining experience in presenting data and leading discussion. Fall, Spring. S/U. *Wortis, Program faculty*

IMM 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

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

Students enroll in this course when they receive permission to write and defend their theses from their thesis committees. This course represents the effort in the final preparation of the doctoral thesis. A grade of "S" is automatically awarded upon successful completion of the thesis. Fall, Spring, 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 (CMDDB); and Cellular and Molecular Physiology (CMP). 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.

Students who matriculate in the Integrated Studies Program (ISP) Fall, 2014 will be the last class to have the option of completing their graduate degrees in Biochemistry or Cellular and Molecular Physiology. Starting Fall, 2015, students who wish to pursue research in these fields may do as part of the newly-restructured Cell, Molecular, and Developmental Biology Program, which offers students the opportunity to select one of four specializations: Cancer Biology, Cell and Developmental Biology, Molecular and Cellular Medicine, and Structural and Chemical Biology.

CURRICULUM OVERVIEW

All students interested in the Biochemistry; Cell, Molecular and Developmental Biology; or 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 0220; and SK 0275). 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 advisor 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 three 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 (0.5-1 CR)

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 present their scientific research to all members of the program, including faculty, students, and post-doctoral fellows. Fall, 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, Spring, Summer. 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, 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, prevention, 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 and 231A; IMM 0212; MMB 0206, 0207B, 0241/0242; and SK 0275. In addition, students must choose two of the following three elective courses: BCHM 230A, MMB 0210/0211, and MMB 0214.

Students in the MERGE-ID track begin their program in July with MMB 0223. In their first two years, they are required to take BCHM 0223, IMM 0212, ISP 0220, MMB 0241/0242 and 0214, and SK 0275. In addition they must complete two elective courses: either IMM 0215/0216 or MMB 0210/0211; and either MMB 0206 or MMB 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. In addition, upper-division students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor about options available before making final course selections.

FIRST YEAR PhD

Fall

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

Spring

BCHM 231A Molecular Recognition in Biology
MMB 0206 Molecular Biology of Episomes and Plasmids
MMB 0235 Laboratory Rotations
MMB 0242 Microbial Genetics & Microbiology II
MMB 0292 Graduate Seminar
MMB 0296 Journal Club

Elective

Summer

MMB 0299 Graduate Research

SECOND YEAR PhD

Fall

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

Elective

Spring

MMB 207B Microbial Physiology & Differentiation
MMB 0292 Graduate Seminar
MMB 0296 Journal Club
MMB 0298 Graduate Research

Elective

Summer

MMB 0000 Qualifying Examination*
MMB 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
MMB 0234 Laboratory Rotations
MMB 0241 Microbial Genetics & Microbiology I
MMB 0291 Graduate Seminar
MMB 0295 Journal Club
SK 0275 Applied Ethics for Scientists

Spring

MMB 0235 Laboratory Rotations
MMB 0242 Microbial Genetics & Microbiology II
MMB 0292 Graduate Seminar
MMB 0296 Journal Club

Summer

MMB 0299 Graduate Research

SECOND YEAR PhD - Microbiology MERGE-ID Track

Fall

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

Elective

Spring

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

Elective

Summer

MMB 0000 Qualifying Examination*
MMB 0299 Graduate Research

*may also be completed in the Spring.

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 as part of 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 and 231A, MMB 0241/0242, and SK 0275. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course. Molecular Microbiology MD/PhD students are required to take two elective courses; note that MMB 0210/0211 counts as one elective.

FIRST YEAR MD/PhD

Fall

BCHM 0224 Advanced Graduate Biochemistry
MMB 0241 Microbial Genetics & Microbiology I
MMB 0291 Graduate Seminar
MMB 0295 Journal Club
MMB 0297 Graduate Research
SK 0275 Applied Ethics for Scientists
SKMD 0209 Clinical Implications of Basic Research

Spring

BCHM 231A Molecular Recognition in Biology
MMB 0242 Microbial Genetics & Microbiology II
MMB 0296 Journal Club
MMB 0292 Graduate Seminar
MMB 0298 Graduate Research
SKMD 0210 Clinical Implications of Basic Research

Summer

MMB 0000 Qualifying Exam*
MMB 0299 Graduate Research

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

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 is a requirement for taking 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.

After achieving candidacy, students must pass a qualifying examination by the end of 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.

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 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.

PUBLICATIONS

Students are expected to publish their research in scientific journals appropriate to their topic. Typically, students publish one or more papers.

COURSES

MMB 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*

MMB 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. Last offered 2013. A-F. *Malamy*

MMB 207B: MICROBIAL PHYSIOLOGY AND DIFFERENTIATION (1 CR)

This course covers cellular controls of biosynthesis of DNA, RNA, and proteins; kinetics of cell division in bacteria; regulation of metabolism; and bacterial differentiation as a model system for development in higher organisms. Global regulatory mechanisms responsible for the control of gene expression are emphasized. Spring-alternate years. Last offered 2014. A-F. *Ng, A. Sonenshein*

MMB 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. Last offered 2013. A-F. *Mecsas*

MMB 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. Last offered 2013. A-F. *Isberg*

MMB 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. Last offered 2014. *Coffin, Heldwein*

MMB 0223: INTRODUCTION TO INFECTIOUS DISEASES (1 CR) Restricted to incoming MERGE-ID students

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, L. Hu*

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

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*

MMB 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*

MMB 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 readings, 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*

MMB 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. Last offered 2014. S/U. *Isberg*

MMB 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

MMB 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, Spring, Summer. A-F. *Program faculty*

MMB 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, Spring. S/U. *Coffin*

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

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

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

Students enroll in this course when they receive permission to write and defend their theses from their thesis committees. This course represents the effort in the final preparation of the doctoral thesis. A grade of "S" is automatically awarded upon successful completion of the thesis. Fall, Spring, 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 cutting edge 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

Students in the Neuroscience Program complete a series of required and elective didactic courses designed to provide a strong knowledge base for their research. Required didactic courses include NRSC 0200, 0233, 0251, 0310, 0312; ISP 209A, 209B, 0220; and SK 0275. Students must complete one elective credit. They also participate in weekly journal clubs, student research presentations, 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 three lab rotations and successfully passing the qualifying examination. In addition, fifth year students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives is flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor 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
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 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
Elective

Summer

NRSC 0299 Graduate Research

After the second year, all students continue to enroll in Journal Club (0295/0296) for two more years, and 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 Neuroscience Program as part of 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, 0312, and SK 0275. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course. 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

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 Journal Club (0295/0296) for two more years, and Research Presentations (0289/0290), 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 take 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 which is directly related to the thesis topic. 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.

Students who successfully complete their qualifying examinations are subsequently considered candidates for the doctoral degree.

RESEARCH AND THESIS

Students begin preliminary thesis research when they enter their thesis laboratory. The student and mentor, in consultation with the student advisor 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.

TEACHING

The Neuroscience program has no specific teaching requirements. However, students who are interested in obtaining teaching experience may contact their program director for information on potential opportunities.

PUBLICATION

Students are expected to publish their research in scientific journals appropriate to their topic. Typically, students publish one or more papers before they graduate.

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, interactive group 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. Last offered 2012. 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. *Reijmers, Jacob*

NRSC 0220: SCIENTIFIC WRITING PRINCIPLES (0.5 CR)

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

NRSC 0233: NEUROSCIENCE LABORATORY TECHNIQUES (0.5 CR)

This series of workshops exposes students 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 CR)

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 (2 CR)

This course 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. *Biederer, Bohm*

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

This course is the middle section of the Biochemical Foundations in Neuroscience course, focusing predominantly on mechanisms of enzyme, receptor, and channel function in the nervous system. Fall. A-F. *Biederer*

NRSC 0263: NEUROGENETICS (1 CR)

The course reviews principles of forward and reverse genetics, presents several animal model systems that are employed in neurogenetics research, and provides 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 while gaining experience in presenting data and leading discussion. Fall, Spring. S/U. *Jacob*

NRSC 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

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, Spring, Summer. 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, 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, Summer. S/U. *Program faculty*

NRSC 0310: SYSTEMS NEUROSCIENCE (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. S/U. *Rios, Tesco*

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

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

PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

The [Graduate Program in Pharmacology and Experimental Therapeutics](#) (PPET) 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 biomedical sciences, medicine, veterinary medicine, dentistry, pharmacy, or medicinal chemistry 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 offers two degrees: a Master's in Pharmacology and Drug Development, and a PhD in Pharmacology & Experimental Therapeutics. View a list of [Pharmacology Program Faculty](#).

MASTER'S COURSE REQUIREMENTS AND PROGRESSION

The Master's degree curriculum in Pharmacology and Drug Development is a series of required and elective courses focusing on basic and clinical pharmacology as it relates to drug development. Required didactic courses include PPET 0211 and 0232, and SK 0275. Students must also complete three elective courses and participate in weekly journal clubs and program seminars. Students typically select their research mentor at the end of May of the first year and begin thesis research after completing two lab rotations. During the second year, emphasis is placed on thesis research, which leads to a publishable Master's thesis.

Note that these program progressions are specifically for students entering in Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor about options available before making final course selections.

FIRST YEAR MS

Fall

PPET 0134 Laboratory Research Experience

PPET 0211 Translational Pharmacology I

PPET 0291 Graduate Seminar

PPET 0295 Journal Club

SK 0275 Applied Ethics for Scientists

Elective

Spring

PPET 0135 Laboratory Research Experience

PPET 0232 Translational Pharmacology II

PPET 0292 Graduate Seminar

PPET 0296 Journal Club

Elective

Summer

PPET 0299 Graduate Research

SECOND YEAR MS

Fall

PPET 0291 Graduate Seminar

PPET 0295 Journal Club

PPET 0297 Graduate Research

Elective

Spring

PPET 0292 Graduate Seminar

PPET 0296 Journal Club

PPET 0298 Graduate Research

Master's students who wish to apply for a PhD in the PPET Program should confer with the Program Admissions Chair and the Sackler Admissions Director about their specific circumstances. Applicants must meet the admissions requirements for the Sackler PhD degree programs, which are different from the MS program, before they will be reviewed by the PPET admissions committee along with all other PhD applicants.

PHD COURSE REQUIREMENTS AND PROGRESSION

The Pharmacology and Experimental Therapeutics PhD curriculum is a series of required and elective didactic courses designed to provide a strong knowledge base for their research. Required didactic courses include BCHM 0223; PPET 0211, 0232, and 0233; and SK 0275. Students must complete two elective courses. They also participate in weekly journal clubs and seminars and must pass a qualifying examination. In addition, fifth year students are required to complete an Ethics refresher course. 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 Fall, 2014. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their mentors and the Program Student Advisor about options available before making final course selections.

FIRST YEAR PhD

Fall

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

Spring

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

Summer

PPET 0000 Qualifying Examination
PPET 0299 Graduate Research

SECOND YEAR PhD

Fall

PPET 0291 Graduate Seminar
PPET 0295 Journal Club
PPET 0297 Graduate Research
Elective

Spring

PPET 0292 Graduate Seminar
PPET 0296 Journal Club
PPET 0298 Graduate Research
Elective

Summer

PPET 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) as part of 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 PPET 0211, 0232, 0233, and SK 0275. Students who take longer than four years to complete their PhD will also be required to complete an Ethics refresher course. PPET MD/PhD students are also required to take one elective course.

FIRST YEAR MD/PhD

Fall

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

Spring

PPET 0232 Translational Pharmacology II
PPET 0292 Graduate Seminar
PPET 0296 Journal Club
PPET 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 Implications 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. Students must complete their Qualifying Exam before the beginning of their second Fall term in the 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 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 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

PPET 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*

PPET 0134, 0135: LABORATORY RESEARCH EXPERIENCE (1 CR)

16-20 week laboratory rotations for Master's students are designed to provide experience with experimental design and theoretical aspects of the diverse research problems under investigation in various laboratories. Fall, Spring A-F. *Program faculty*

PPET 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, Beinborn, Program faculty*

PPET 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 lectures, readings and clinical case-oriented problem-solving is used. Extensive independent study and reading is required. A-F. *Greenblatt, Program faculty*

PPET 0213: ADDICTION MEDICINE (1 CR)

This course is offered through Tufts University School of Medicine. It 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*

PPET 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. Last offered 2013. A-F. *Theoharides, Program faculty*

PPET 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. Last offered 2011. S/U. *Greenblatt, Program faculty*

PPET 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. Last offered 2010. A-F. *Shuster, Program faculty*

PPET 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. Last offered 2012. A-F. *Greenblatt*

PPET 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, Beinborn, Program faculty*

PPET 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. *Program faculty*

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

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*

PPET 0281 DESIGN AND ANALYSIS OF BIOEQUIVALENCE STUDIES (0.5 CR)

A generic drug is bioequivalent to a brand name drug when their bioavailabilities (assessed by the respective plasma concentration time curves) after administration in the same molar dose are essentially the same. The comparison of the bioavailabilities is examined by conducting a bioequivalence study. The course will train the students in the design and data analysis of bioequivalence studies. Spring, alternate years. S/U. Prerequisite: PPET 0211. *Pothos*

PPET 0291, 0292: GRADUATE SEMINAR (0.5 CR)

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

PPET 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, Spring, Summer. A-F. *Program faculty*

PPET 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, Spring. S/U. *Program faculty*

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

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

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

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

SACKLER INTER-PROGRAM COURSE OFFERINGS

Several courses contain content that spans two or more program areas. These courses are taught by a team of inter-program faculty, required by some programs, and open to all Sackler graduate students unless otherwise noted. 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 0202: STRUCTURAL BIOLOGY (0.5 CR)

This course covers the basic theory and practice of Macromolecular Crystallography and NMR. Summer-alternate years. Last offered 2013. A-F. *Bohm, Baleja*

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. Last offered 2008. 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, or heart disease). Lectures are delivered to undergraduate Biology majors at Pine Manor College in 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. Topics include: academic integrity issues/fraud and misconduct/plagiarism/data handling/notebooks, mentoring and conflict resolution and ethical use of animals and human subjects. There are two lectures in the fall, followed by the third lecture and case study small groups in the second week of January. Fall. S/U. *Jay*

SK 3275: ADVANCED SCIENTIFIC ETHICS (0.5 CR)

This course, for Sackler students in the fifth year, is a refresher course for responsible conduct of research (RCR). It builds on SK 0275, Scientific Ethics and is mandated by NIH. Students will work in teams to develop a new case study addressing an RCR issue, provide a written in depth analysis and teach the case study to a small group of students enrolled in SK 0275 under the supervision of the course director. Grading will be based on the quality of case study and analysis, teaching, effort, and participation. Fall. S/U. *Jay*

SK 0299: BIOMEDICAL TECHNIQUES & RESEARCH (0 CR)

Research with selected advisor for students enrolled at other universities. Visiting Students Only. Fall, Spring, 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, Spring. S/U. *Schwob*

SKMD 0236: LABORATORY ROTATION (1.0 CR)

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*