



Graduate School of Biomedical Sciences

CATALOG 2021-2022

Programs Of Study, Courses, And Requirements For All Graduate Programs



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This Catalog must be used in conjunction with the individual Program Guides, which provide detailed information about all phases of the graduate career.

Note that these program progressions are specifically for students entering in Summer or Fall 2021. The selection and timing of electives are flexible, based on course offerings and students' interest. Students should confer with their faculty mentors and the Program Advisor about available options before making final course selections.

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Every effort is made to ensure that the degree requirements and course information, applicable policies, and other materials contained in this catalog are accurate and current. The Graduate School of Biomedical Sciences (GSBS) 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 GSBS web site is the governing document, and contains the current policies and information about the graduation requirements for students entering in that academic year.

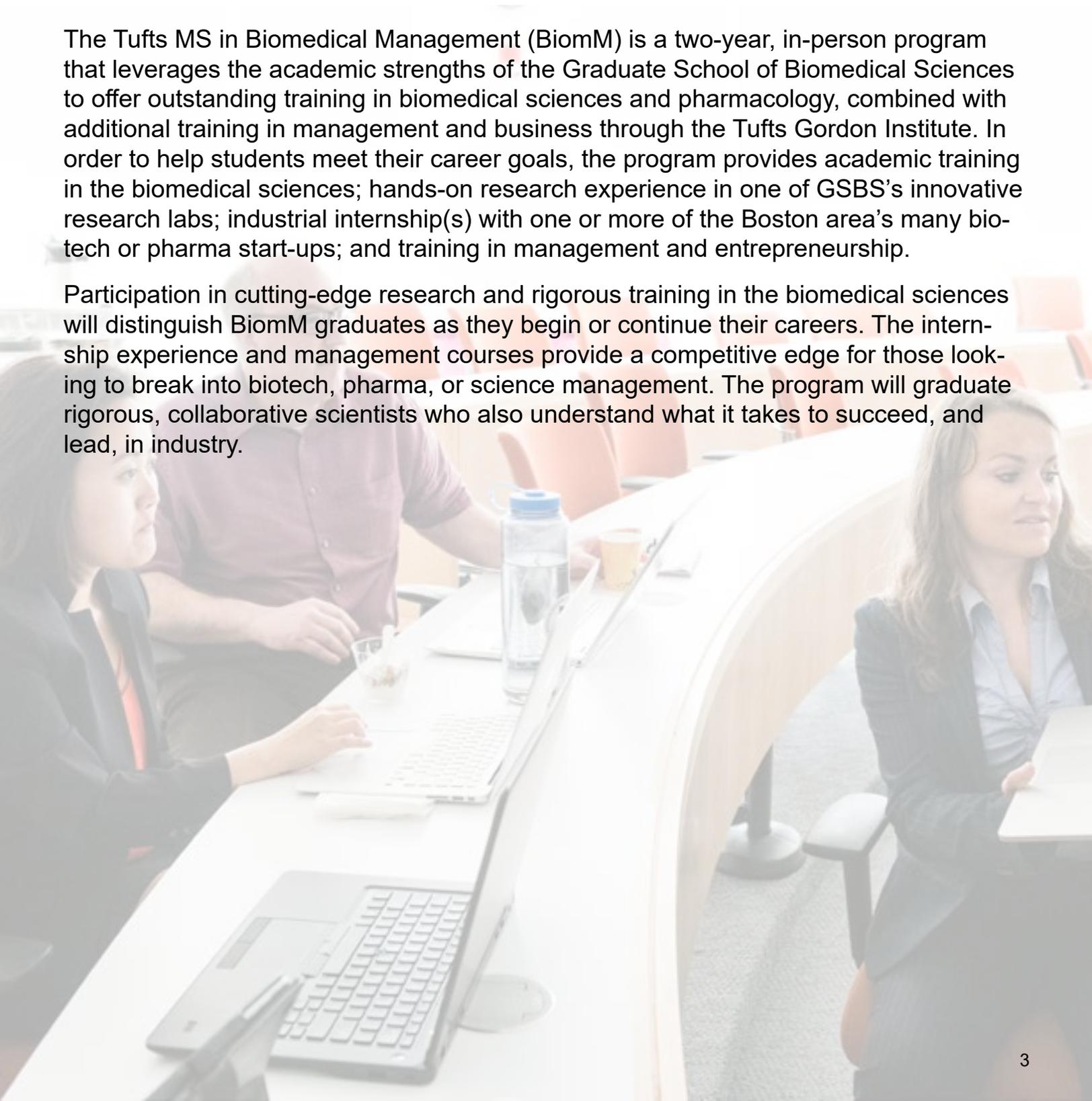
NOTE: Due to COVID-19 restrictions, some timelines, deadlines and requirements may be modified.

Tufts University is an equal opportunity educator and employer.

BIOMEDICAL MANAGEMENT

The Tufts MS in Biomedical Management (BiomM) is a two-year, in-person program that leverages the academic strengths of the Graduate School of Biomedical Sciences to offer outstanding training in biomedical sciences and pharmacology, combined with additional training in management and business through the Tufts Gordon Institute. In order to help students meet their career goals, the program provides academic training in the biomedical sciences; hands-on research experience in one of GSBS's innovative research labs; industrial internship(s) with one or more of the Boston area's many biotech or pharma start-ups; and training in management and entrepreneurship.

Participation in cutting-edge research and rigorous training in the biomedical sciences will distinguish BiomM graduates as they begin or continue their careers. The internship experience and management courses provide a competitive edge for those looking to break into biotech, pharma, or science management. The program will graduate rigorous, collaborative scientists who also understand what it takes to succeed, and lead, in industry.



BIOMEDICAL MANAGEMENT

MASTER'S COURSE REQUIREMENTS AND PROGRESSION

All students are required to complete 11 courses over the two years of the program. In the first year, these include **BIOM 0180, 0205, 0212; CMDB 0220; GSBS 0275**, as well as an **introductory course** offered by one of the GSBS Basic Science programs. Second-year required courses include **EM 0208**.

Students complete at least four elective courses and conduct lab research during both program years. They also complete two three-month blocks of experiential learning during the summer terms.

RESEARCH AND THESIS

A three-semester research experience in an academic biomedical lab is designed to introduce students to the processes of laboratory research and management. For students with significant prior research experience, a non-lab, literature-based research thesis is an option. The literature-based thesis, completed with the guidance of a faculty advisor, will typically be an analysis or case study of the biomedical basis of a drug or diagnostic.

EXPERIENTIAL LEARNING

BiomM students will complete two three-month blocks of experiential learning. This will consist either of two summer industry internships aligned with the student's lab project; or, for those who are already working in industry, a worksite project at their company. During the two three-month blocks of experiential learning, students will participate in a fortnightly seminar.

CAPSTONE EXPERIENCE

The capstone experience is designed to integrate the different aspects of BiomM training and evaluate the student's grasp of the core program competencies. Students will present their research, demonstrating an understanding of their scientific premise and the aim of their study. Students are expected to present a rigorous analysis of their results, a discussion of how these results inform the

WEB LINKS

- Biomedical Management [Program Faculty](#)
- Biomedical Management [Website](#)

SAMPLE MASTER'S CURRICULUM

First Year

Fall	BIOM 0180	Communities of Practice and Management
	BIOM 0212	Intro to Biomedical Research
	GSBS 0275	Applied Ethics for Scientists
	<i>Program Intro Course*</i>	
	<i>Elective**</i>	
Spring	BIOM 0135	Lab Experience/Thesis
	BIOM 0205	Intro to Drug Discovery
	CMDB 0220	Essentials in Biomedical Statistics and Computational Biology
	<i>Elective**</i>	
Summer	BIOM 0336	Internship/Worksite Project

Second Year

Fall	BIOM 134	Lab Experience/Thesis
	EM 0208	Program and Project Management***
	<i>Elective**</i>	
Spring	BIOM 0135	Lab Experience/Thesis
	BIOM 0400	Capstone
	<i>Elective**</i>	
Summer	BIOM 0336	Internship/Worksite Project

*Based on student interest; chosen from existing courses, in consultation with BiomM Program Administration

**Timing of elective courses is based on course offerings and student interest

***Enrollment in this course will be via cross-registration into the Tufts School of Engineering's Gordon Institute

premise, and what future studies could be done to achieve or extend the aim.

CELL, MOLECULAR, AND DEVELOPMENTAL BIOLOGY

The Graduate Program in [Cell, Molecular, and Developmental Biology \(CMDB\)](#) offers strong interdisciplinary training across the full spectrum of biomedically-related basic and translational research. This training program has its roots in a highly successful integrated first year curriculum that provides a strong foundation in biomedical research. Students entering CMDB select one of three concentration areas: Cancer Biology; Cell & Developmental Biology; and Structural & Chemical Biology. Each concentration is designed to give trainees in depth knowledge while preserving a breadth of exposure to contemporary research approaches in biomedical science. The CMDB program fosters the development of student-driven discoveries that will inform understanding of the cellular pathways, molecular signaling networks, and systems-based mechanisms that govern human development and disease and lead to the generation of innovative new therapies.

CELL, MOLECULAR, AND DEVELOPMENTAL BIOLOGY

PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the CMDB program complete coursework designed to provide a strong knowledge base for their research. Required courses include **BCHM 0223, 0230; CMDB 0220; ISP 209A, 209B, 210A, 210B;** and **GSBS 0275.**

All CMDB students must also complete the requirements for one of the three Specialization groups: Cancer Biology; Cell & Developmental Biology; or Structural & Chemical Biology. Each requires two credits of didactic coursework and two credits of elective coursework.

All students participate in 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 begin research after completing four lab rotations. When the aims of the research project have been achieved, students write and defend their theses.

Note that the specialization courses are usually offered every other year. Other courses can serve as the specialization course with the permission of the Program Director. These courses are typically taken in the second or third year.

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

PHD CURRICULUM

First Year

Fall	BCHM 0223	Graduate Biochemistry
	CMDB 0291	Graduate Seminar
	GSBS 0275	Applied Ethics for Scientists
	ISP 209A	Membranes & Trafficking
	ISP 0234	Laboratory Rotations
	ISP 0295	Journal Club
Spring	BCHM 0230	Gene Exp. & Signal Transduction
	CMDB 0220	Biomedical Stats & Comp Bio
	CMDB 0292	Graduate Seminar
	ISP 209B	Cell Behavior
	ISP 210B	Mol. Cell Biology of Development
	ISP 0235	Laboratory Rotations
	ISP 0296	Journal Club
Summer	CMDB 0299	Graduate Research

Second Year

Fall	<i>Specialization Signature Course</i> §	
	CMDB 0291	Graduate Seminar
	CMDB 0295	Journal Club
	CMDB 0297	Graduate Research
	ISP 210A	Mol. Cell & Molecular Genetics
	<i>Elective</i>	
Spring	<i>Specialization Signature Course</i> §	
	CMDB 0000	Qualifying Exam
	CMDB 0292	Graduate Seminar
	CMDB 0296	Journal Club
	CMDB 0298	Graduate Research
	<i>Elective</i>	
Summer	CMDB 0299	Graduate Research

Third Year and Beyond

Fall	CMDB 0291	Graduate Seminar
	CMDB 0295	Journal Club
	CMDB 0297	Graduate Research
Spring	CMDB 0292	Graduate Seminar
	CMDB 0296	Journal Club
	CMDB 0298	Graduate Research
Summer	CMDB 0299	Graduate Research

§ Specialization Signature Courses are as follows:

Cancer Biology: GENE 0203 Cancer Genetics
 Cell & Developmental Biology: CMDB 0235 Advanced Developmental Biology
 Structural & Chemical Biology: BCHM 231A Molecular Recognition & BCHM 231B Drug Design

CELL, MOLECULAR, AND DEVELOPMENTAL BIOLOGY

MD/PHD COURSE REQUIREMENTS AND PROGRESSION

Students entering the CMDB program as part of the combined MD/PhD degree program complete two laboratory rotations in the summers before and during the first two years of medical school, and choose their thesis lab prior to their first year of coursework at GSBS. MD/PhD students complete an individualized didactic program of no less than 5 credit hours, which includes at least one of the Specialization Signature Courses. Students also enroll in **Clinical Implications of Basic Research seminar (GBMD 0209/0210)**, which is taken every semester until completion of the PhD, beginning in the first year of medical school. Students who take longer than four years to complete their PhD will also be required to complete an ethics refresher course.

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

GENERAL REQUIREMENTS

QUALIFYING EXAMINATION

Students must pass a qualifying examination. 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 & THESIS

Students enter their thesis lab and begin thesis research after completing the final laboratory rotation. Each student meets with their thesis advisory 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. When the thesis committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION

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

WEB LINKS

- Cell, Molecular, and Developmental Biology [Program Faculty](#)
- Cell, Molecular, and Developmental Biology [Web Site, with Program Guide](#)

MD/PHD CURRICULUM

First Year

Summer	CMDB 0299	Graduate Research
Fall	CMDB 0291	Graduate Seminar
	CMDB 0295	Journal Club
	CMDB 0297	Graduate Research
	GBMD 0209	Clin Imp of Basic Research
	GSBS 0275	Applied Ethics for Scientists
<i>Required Coursework</i>		

Spring	CMDB 0000	Qualifying Examination
	CMDB 0292	Graduate Seminar
	CMDB 0296	Journal Club
	CMDB 0298	Graduate Research
	GBMD 0210	Clin Impl of Basic Research
<i>Required Coursework</i>		

Summer	CMDB 0299	Graduate Research
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Second Year and Beyond

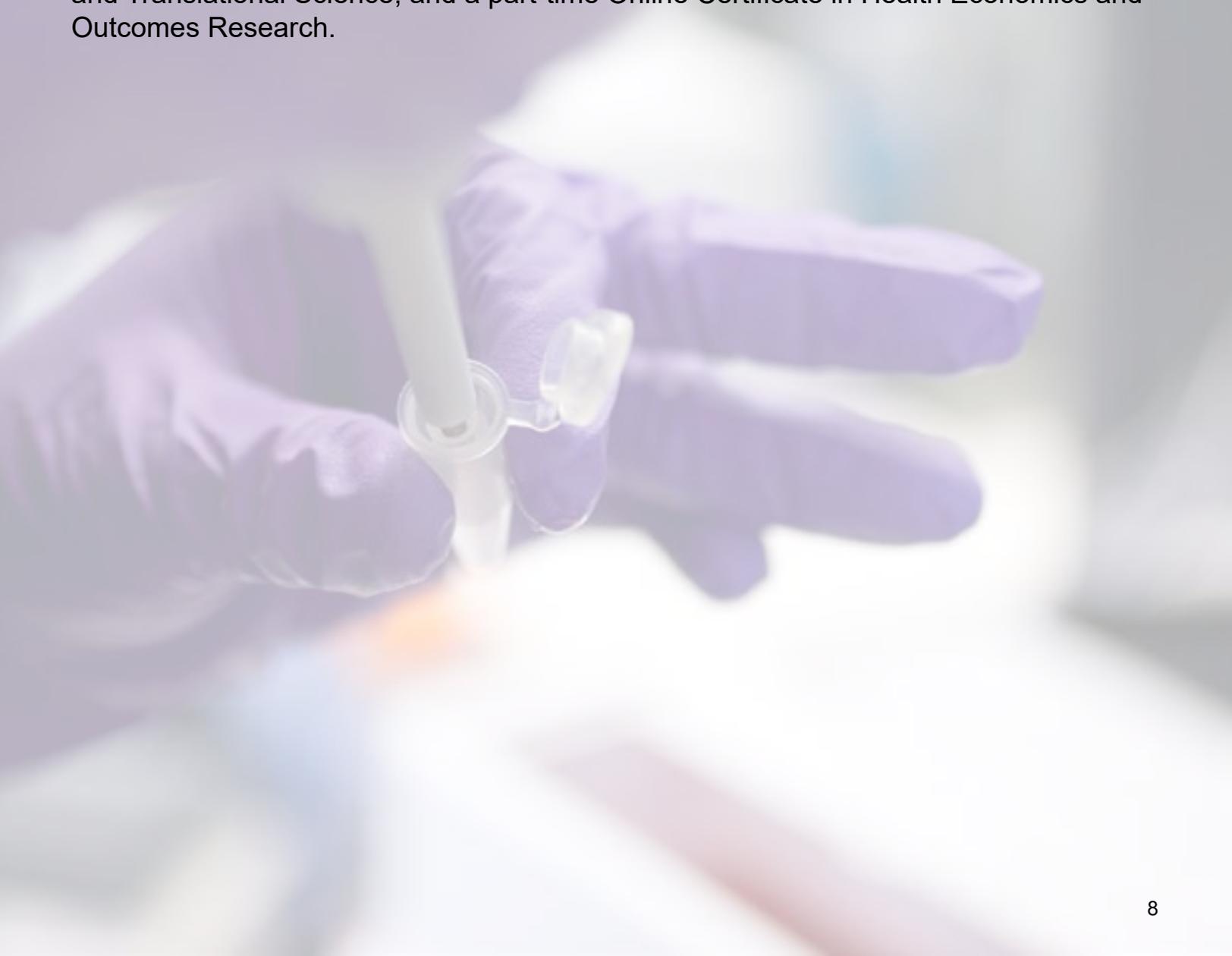
Fall	CMDB 0291	Graduate Seminar
	CMDB 0295	Journal Club
	CMDB 0297	Graduate Research
	GBMD 0209	Clinical Impl of Basic Research

Spring	CMDB 0292	Graduate Seminar
	CMDB 0296	Journal Club
	CMDB 0298	Graduate Research
	GBMD 0210	Clin Impl of Basic Research

Summer	CMDB 0299	Graduate Research
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CLINICAL AND TRANSLATIONAL SCIENCE

The Graduate Programs in [Clinical and Translational Science \(CTS\)](#) train physicians and other clinicians who will 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 CTS program offers full-time study leading to MS and PhD degrees as well as a part-time Certificate in Clinical and Translational Science, and a part-time Online Certificate in Health Economics and Outcomes Research.



CLINICAL AND TRANSLATIONAL SCIENCE

MASTER'S COURSE REQUIREMENTS AND PROGRESSION

The CTS Master's program curriculum provides a strong foundation of core methods and skills, including research methods, statistics, research conduct, ethics, and manuscript and grant writing. Students are required to complete **CTS 0500, 0523, 0525, 0537, 0538, 0540**; two courses from **CTS 0561, 0566, and 0581**; and two biostatistics courses, typically **CTS 0527** and **0575** (for students entering the MS program from the Certificate program, only one additional biostatistics course is required). Students must also complete 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.

PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the CTS PhD program develop the necessary competencies for a career in academic medicine that involves significant translational research. In addition to completing the Master's curriculum, PhD candidates complete the Qualifying Exam and subsequently register for **CTS 0500, 0517, and 0539** each Fall and Spring term, and **0517** in the Summer, until they have completed their thesis research. In addition, five elective courses are required. The PhD program is typically completed in approximately four and a half years.

MD/PHD COURSE REQUIREMENTS AND PROGRESSION

Students entering the CTS program as part of the combined MD/PhD degree program complete two laboratory rotations in the summers before and during the first two years of medical school, and choose their thesis lab prior to their first year of coursework at GSBS. MD/PhD students also have adjusted didactic requirements including the

MASTER'S CURRICULUM

First Year

Summer	CTS 0525	Intro to Clinical Care Research
Fall	CTS 0500	Study Design Seminar
	CTS 0515	Mentored Research Project/Thesis
	CTS 0523	Intro Clinical to Epidemiology
	CTS 0527	Biostatistics I
	CTS 0537	Scientific Manuscript Writing
	<i>CTS 0561</i>	<i>Intro to Clinical Trials*</i>
Spring	CTS 0500	Study Design Seminar
	CTS 0515	Mentored Research Project/Thesis
	CTS 0537	Scientific Manuscript Writing
	CTS 0540	Ethics of Clinical Investigation
	<i>CTS 0566</i>	<i>Intro to Health Services Research*</i>
	CTS 0575	Advanced Epi & Regression
	<i>CTS 0581</i>	<i>Intro to Evidence-Based Medicine*</i>

*Choose two of these three courses

Second Year

Fall	CTS 0500	Study Design Seminar
	CTS 0516	Mentored Research Project/Thesis
	CTS 0538	Scientific Grant Writing
	<i>Elective</i>	
Spring	CTS 0500	Study Design Seminar
	CTS 0516	Mentored Research Project/Thesis
	CTS 0538	Scientific Grant Writing
	<i>Elective</i>	

GBMD 0209/0210 Clinical Implications of Basic Research seminar (every fall and spring). Required didactic courses include **CTS 0523, 0525, 0527, 0540, and 0575**, plus **CTS 0500, 0517, and 0539** each Fall and Spring term, and **0517** every Summer. Five elective courses are also required. Additional didactic requirements are determined by the CTS program, in coordination with the GSBS Dean's Office.

CLINICAL AND TRANSLATIONAL SCIENCE

GENERAL MASTER'S AND PHD REQUIREMENTS

QUALIFYING EXAMINATION

The exam is designed to measure originality and independence and requires that the student suggest a feasible research project, 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 & THESIS

MS and PhD thesis committees are formed during the first term of study. Thesis work must be original and rigorous, and approved by the student's thesis committee and the CTS Program Advisory Committee. The thesis must be presented in the official University format, which is different from the format of an article or paper.

After the Program Advisory Committee has approved the thesis topic, each student meets with the thesis 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.

CLINICAL AND TRANSLATIONAL SCIENCE

CERTIFICATE COURSE REQUIREMENTS AND PROGRESSION

CERTIFICATE IN CLINICAL AND TRANSLATIONAL SCIENCE

The CTS 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.

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

ONLINE CERTIFICATE IN HEALTH ECONOMICS AND OUTCOMES RESEARCH

The HEOR program offers an introduction to core topics in health economics and outcomes, including measurements of health benefits across disease domains, cost benefits across time and over multiple societal sectors, use of real world evidence to inform healthcare decision making, and the use of health technology assessment to project health benefits and costs.

The program consists of three online courses, one taken in the first term and two taken in the second term. Students will also participate in an in-person (or live via videoconference) workshop during the second term.

These courses may not be transferred back into any other GSBS school degree or certificate, and students in the HEOR program are not eligible to take courses on campus.

WEB LINKS

- Clinical and Translational Science [Program Faculty](#)
- Clinical and Translational Science [Web Site, with Program Guide](#)

CERTIFICATE IN CLINICAL AND TRANSLATIONAL SCIENCE CURRICULUM

First Year

Summer	CTS 0506	Intro to Biostatistics I*
	CTS 0525	Intro to Clinical Care Research
Fall	CTS 0500	Study Design Seminar
	CTS 0507	Intro to Biostatistics II*
	CTS 0523	Intro to Clinical Epidemiology
	CTS 0561	Intro to Clinical Trials
Spring	CTS 0500	Study Design Seminar
	CTS 0514	Clinical Research Project
	CTS 0540	Ethics of Clinical Investigation
	CTS 0566	Intro to Health Services Research
	CTS 0581	Intro to Evidence-Based Medicine

*CTS 0527 Biostatistics I can be taken instead of CTS 0506/0507

ONLINE CERTIFICATE IN HEALTH ECONOMICS AND OUTCOMES RESEARCH CURRICULUM

First Year

Fall	CTS 0157	Introduction to Health Economics and Outcomes Research
Spring	CTS 0150	Real World Evidence
	CTS 0152	Introduction to Health Technology Assessment

GENETICS

The [Graduate Program in Genetics \(GENE\)](#) is designed to train scientists in the basic principles and applications of classical and molecular genetics for careers in research, teaching, and biotechnology. The goal of the program is to train talented individuals to think critically, identify important issues in genetics, and design and competitively conduct original research in prokaryotic, eukaryotic, mammalian, and human genetics. Strong emphasis is placed on the laboratory experience and hands-on research training.

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

GENETICS

PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the Genetics program complete coursework designed to provide a strong knowledge base for their research. All students participate in 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 during the first year. When the aims of the research project have been achieved, students write and defend their theses.

Students in the traditional Genetics track are required to take **BCHM 0223, 0230A; GENE 0205, 0212;** and **GSBS 0275**. Students must pass the qualifying examination by the end of their second year of coursework and must also complete two elective courses.

TRADITIONAL PHD CURRICULUM

First Year

Fall	BCHM 0223 9GI	Graduate Biochemistry
	GENE 0212	Introduction to Genetics
	GENE 0235 001	Laboratory Rotations
	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GSBS 0275	Applied Ethics for Scientists
Spring	BCHM 230A	Gene Expression
	GENE 0205	Mammalian Genetics
	GENE 0235 001	Laboratory Rotations
	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
Summer	GENE 0299 001	Graduate Research

Second Year

Fall	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GENE 0297 001	Graduate Research
	<i>Elective</i>	
Spring	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
	GENE 0298 001	Graduate Research
	<i>Elective</i>	
Summer	GENE 0000	Qualifying Examination
	GENE 0299 001	Graduate Research

Third Year and Beyond

Fall	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GENE 0297 001	Graduate Research
Spring	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
	GENE 0298 001	Graduate Research
Summer	GENE 0299 001	Graduate Research

GENETICS

MAMMALIAN GENETICS COURSE REQUIREMENTS AND PROGRESSION

Students in the Mammalian Genetics Track study at the Jackson Laboratory (JAX) in Bar Harbor, ME. JAX-based students are required to take **BCHM 0223, 0230A; GENE 0205, 0208, 0212;** and **GSBS 0275**. Students must pass the qualifying examination by the end of the second year of coursework and must also complete one elective course.

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.

MAMMALIAN GENETICS PHD CURRICULUM

First Year

Fall	BCHM 0223 9GI	Graduate Biochemistry
	GENE 0212	Introduction to Genetics
	GENE 0234 002	Laboratory Rotations
	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GSBS 0275	Applied Ethics for Scientists
Spring	BCHM 230A	Gene Expression
	GENE 0205	Mammalian Genetics
	GENE 0235 002	Laboratory Rotations
	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
Summer	GENE 0208	Mammalian & Exp. Genetics
	GENE 0299 002	Graduate Research

Second Year

Fall	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GENE 0297 002	Graduate Research
	<i>Elective</i>	
Spring	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
	GENE 0298 002	Graduate Research
Summer	GENE 0000	Qualifying Examination
	GENE 0299 002	Graduate Research

Third Year and Beyond

Fall	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GENE 0297 002	Graduate Research
Spring	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
	GENE 0298 002	Graduate Research
Summer	GENE 0299 002	Graduate Research

GENETICS

MD/PHD COURSE REQUIREMENTS AND PROGRESSION

Students entering the traditional Genetics program as part of the combined MD/PhD degree program complete two laboratory rotations in the summers before and during the first two years of medical school and choose their thesis lab prior to their first year of coursework at GSBS. MD/PhD students also have adjusted didactic requirements including **Clinical Implications of Basic Research seminar (GBMD 0209/0210)**, which is taken every semester until completion of the PhD, beginning in the first year of medical school. Required didactic courses include **BCHM 230A; GENE 0205, 0212; and GSBS 0275**. Students who take longer than four years to complete their PhD will also be required to complete an ethics refresher course. Genetics MD/PhD students are not usually required to take electives.

After the first year, MD/PhD students 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 thesis research.

MD/PHD CURRICULUM

First Year

Summer	GENE 0299 001	Graduate Research
Fall	GBMD 0209	Clin Imp of Basic Research
	GENE 0212	Introduction to Genetics
	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GENE 0297 001	Graduate Research
	GSBS 0275	Applied Ethics for Scientists
Spring	GBMD 0210	Clin Imp of Basic Research
	GENE 0205	Mammalian Genetics
	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
	GENE 0298 001	Graduate Research
	Summer	GENE 0000
	GENE 0299 001	Graduate Research

Second Year and Beyond

Fall	GBMD 0209	Clin Imp of Basic Research
	GENE 0289	Research Presentations
	GENE 0291	Graduate Seminar
	GENE 0295	Journal Club
	GENE 0297 001	Graduate Research
Spring	GBMD 0210	Clin Imp of Basic Research
	GENE 0290	Research Presentations
	GENE 0292	Graduate Seminar
	GENE 0296	Journal Club
	GENE 0298 001	Graduate Research
Summer	GENE 0299 001	Graduate Research

GENETICS

GENERAL REQUIREMENTS

QUALIFYING EXAMINATION

Students must pass a qualifying examination. 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 & THESIS

Students enter their thesis lab and begin thesis research after completing the final laboratory rotation. Each student

meets with their thesis advisory 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. When the thesis committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION

Students are required to publish at least one 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.

WEB LINKS

- Genetics [Program Faculty](#)
- Genetics [Web Site, with Program Guide](#)

IMMUNOLOGY

The Graduate Program in [Immunology \(IMM\)](#) offers training on immunologic aspects of disease, focusing on basic inflammation and the immunology of chronic diseases, as well as pathogenesis, diagnosis, prevention and treatment of inflammatory diseases. 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. 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 our understanding of important questions in inflammation. When they finish the program, our graduates will be ready for rigorous postdoctoral research training that will place them in positions of leadership in academic medical centers, universities, or in the biotechnology and pharmaceutical industry.

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.

IMMUNOLOGY

PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the Immunology program complete coursework designed to provide a strong knowledge base for their research. Required courses include **BCHM 0223**; **IMM 0212, 0223, 0230, 0245, 0250, 0252**; and **GSBS 0275**.

All students must 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 fall of the second year. In addition, fifth year students are required to complete an ethics refresher course. Students typically begin thesis research after completing four lab rotations. Students in the second year are expected to conduct thesis research while preparing for their qualifying examination. When the aims of the research project have been achieved, students write and defend their theses.

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

PHD CURRICULUM

First Year

Summer	IMM 0223	Intro to Infect and Inflamm Dis
Fall	BCHM 0223 9GI	Graduate Biochemistry
	GSBS 0275	Applied Ethics for Scientists
	IMM 0212	Introduction to Immunology
	IMM 0217	First Year Journal Club
	IMM 0234	Laboratory Rotations
	IMM 0245	Advanced Cell Immunology
	IMM 0289	Research Presentations
	IMM 0291	Graduate Seminar
Spring	IMM 0235	Laboratory Rotations
	IMM 0252	System Approaches to Imm
	IMM 0290	Research Presentations
	IMM 0292	Graduate Seminar
Summer	IMM 0299	Graduate Research

Second Year

Fall	IMM 0000	Qualifying Examination
	IMM 0230	Inflamm & Chronic Inflamm Disease
	IMM 0289	Research Presentations
	IMM 0291	Graduate Research
	IMM 0295	Journal Club
	IMM 0297	Graduate Research
Spring	IMM 0250	Immunochem – Signal & Dynamics
	IMM 0290	Research Presentations
	IMM 0292	Graduate Seminar
	IMM 0296	Journal Club
	IMM 0298	Graduate Research
Summer	IMM 0299	Graduate Research

Third Year and Beyond

Fall	IMM 0289	Research Presentations
	IMM 0291	Graduate Seminar
	IMM 0295	Journal Club
	IMM 0297	Graduate Research
Spring	IMM 0290	Research Presentations
	IMM 0292	Graduate Seminar
	IMM 0296	Journal Club
	IMM 0298	Graduate Research
Summer	IMM 0299	Graduate Research

IMMUNOLOGY

MD/PHD COURSE REQUIREMENTS AND PROGRESSION

Students entering the Immunology program as part of the combined MD/PhD degree complete two laboratory rotations in the summers before and during the first two years of medical school, and choose their thesis lab prior to their first year of coursework at GSBS. MD/PhD students also have adjusted didactic requirements including the **Clinical Implications of Basic Research seminar (GBMD 0209/0210)**, which is taken every semester. Required didactic courses include **IMM 0212, 0245, 0250, 0252**; and **GSBS 0275**. Students who take longer than four years to complete their PhD will also be required to complete an ethics refresher course. Immunology MD/PhD students are not usually required to take electives.

After the second year, MD/PhD students continue to enroll in **Journal Club (0295/0296)** for one more year and continue **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 thesis research.

MD/PHD CURRICULUM

First Year

Summer	IMM 0299	Graduate Research
Fall	GBMD 0209	Clinical Implications of Basic Research
	GSBS 0275	Applied Ethics for Scientists
	IMM 0000	Qualifying Examination
	IMM 0212	Introduction to Immunology
	IMM 0217	First Year Journal Club
	IMM 0245	Advanced Cellular Immunology
	IMM 0289	Research Presentations
	IMM 0291	Graduate Seminar
IMM 0297	Graduate Research	
Spring	GBMD 0210	Clinical Implications of Basic Research
	IMM 0252	System Approaches to Immunology
	IMM 0290	Research Presentations
	IMM 0292	Graduate Seminar
	IMM 0298	Graduate Research
Summer	IMM 0299	Graduate Research

Second Year

Fall	GBMD 0209	Clinical Implications of Basic Research
	IMM 0289	Research Presentations
	IMM 0291	Graduate Seminar
	IMM 0295	Journal Club
	IMM 0297	Graduate Research
Spring	GBMD 0210	Clinical Implications of Basic Research
	IMM 0250	Immunochem – Signaling and Dynam
	IMM 0290	Research Presentations
	IMM 0292	Graduate Seminar
	IMM 0296	Journal Club
	IMM 0298	Graduate Research
Summer	IMM 0299	Graduate Research

Third Year and Beyond

Fall	GBMD 0209	Clinical Implications of Basic Research
	IMM 0289	Research Presentations
	IMM 0291	Graduate Seminar
	IMM 0295	Journal Club
	IMM 0297	Graduate Research
Spring	GBMD 0210	Clinical Implications of Basic Research
	IMM 0290	Research Presentations
	IMM 0292	Graduate Seminar
	IMM 0296	Journal Club
	IMM 0298	Graduate Research
Summer	IMM 0299	Graduate Research

IMMUNOLOGY

GENERAL REQUIREMENTS

QUALIFYING EXAMINATION

Students must pass a qualifying examination. 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 & THESIS

Students enter their thesis lab and begin thesis research after completing the final laboratory rotation. Each student meets with their thesis advisory 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. When the thesis committee determines that the aims of the project have been met, the thesis is prepared and defended. The committee, together with an additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION

Students are required to have a first author paper based on their thesis work accepted for publication 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.

WEB LINKS

- Immunology [Program Faculty](#)
- Immunology [Web Site, with Program Guide](#)

MOLECULAR MICROBIOLOGY

The Graduate Program in [Molecular Microbiology \(MMB\)](#) offers rigorous theoretical and experimental training in the biology of microorganisms – bacteria, viruses, fungi, and parasites – and their interactions with their hosts, accomplished through a broad range of graduate courses and laboratories for academic study and scientific development. The program of study includes courses and seminars in genetics, pathogenesis, virology, biochemistry, immunology, and other topics.

In addition to the traditional PhD program, Molecular Microbiology students may also pursue one of two additional tracks with the program, the [MERGE-ID \(Medically-oriented Research in Graduate Education – Infectious Disease\)](#) track, and the Molecular Genetics track. The MERGE-ID track is specifically designed to provide strong training in the basic microbiology and immunology of pathogenic organisms and host interactions as well as allowing students to gain appreciation for the clinical implications of their work, with the potential for moving their discoveries to the bedside. Seminars and enrichment activities that focus on interaction with clinical ID fellows and physicians supplement the training, including the potential for participating in clinical rounds during Graduate Years 2, 3, and 4. The [Molecular Genetics](#) track is specifically designed to provide rigorous training in molecular genetics. The curriculum emphasizes strong grounding in fundamentals such as biochemistry and molecular biology as well as fundamental aspects of genetics. Students can join this track once they join their thesis lab and choose their thesis project.

MOLECULAR MICROBIOLOGY

PHD COURSE REQUIREMENTS AND PROGRESSION

Students in all MMB program tracks complete coursework designed to provide a strong knowledge base for their research. Students also participate in weekly journal clubs, seminars, and research presentations and must pass a qualifying examination. Students are required to complete an Ethics course during their first year and those who take longer than four years to complete their PhD will also be required to complete an ethics refresher course. Students typically begin thesis research after completing four lab rotations and successfully passing the qualifying examination. When the aims of the research project have been achieved, students write and defend their theses.

Students in the traditional Molecular Microbiology track are required to take **BCHM 0223**; **MMB 0210/0211**, **0214**, **0241**; and **GSBS 0275**. Students are also required to take one of the Advanced Topics courses (either **MMB 026E** or **026O**, depending on which is offered).

SPECIAL TRACKS

In their first two years, students in the MERGE-ID track are required to take **BCHM 0223**; **IMM 0212**; **MMB 0210/0211**, **0214**, **0223** and **0241**; and **GSBS 0275**. Students are also required to take one of the Advanced Topics courses (either **MMB 026E** or **026O**, depending on which is offered).

Students in the Molecular Genetics track opt into the program after their first year. They are required to take **BCHM 0223**; **GENE 0205** or **0208**, **MMB 0241** and **0214**; and **GSBS 0275**. Students are also required to take one of the Advanced Topics courses (either **MMB 026E** or **026O**, depending on which is offered), and a genetics-related elective. **MMB 0210/0211** or **BCHM 0230** would fulfill this requirement. There may be courses offered by other Tufts schools or offered by consortium schools that would fulfill this requirement, with program approval.

After the second year, students in all tracks 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.

TRADITIONAL PHD CURRICULUM

First Year

Fall	BCHM 0223	Graduate Biochemistry
	GSBS 0275	Applied Ethics for Scientists
	MMB 0234	Laboratory Rotations
	MMB 0241	Microbial Gene and Micro
	MMB 0291	Graduate Seminar
Spring	MMB 0295	Journal Club
	MMB 0214	Animal Virology*
	MMB 0235	Laboratory Rotations
	MMB 026E	Advanced Topics in Micro E**
	MMB 0292	Graduate Seminar
Summer	MMB 0296	Journal Club
	MMB 0000	Qualifying Examination
	MMB 0299	Graduate Research

Second Year

Fall	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	MMB 0210/0211	Host-Pathogen Interface/Bacterial-Host Cell Interaction*
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	MMB 0299	Graduate Research

*MMB 0210/0211 and MMB 0214 are offered in alternating years.

**MMB 026E and 026O are offered in alternating Spring terms. Students enroll in whichever is offered first. There is no need to enroll in the other.

Third Year and Beyond

Fall	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	MMB 0299	Graduate Research

MOLECULAR MICROBIOLOGY

MERGE-ID PHD CURRICULUM

First Year

Summer	MMB 0223	Intro to Infectious Diseases
Fall	BCHM 0223	Graduate Biochemistry
	GSBS 0275	Applied Ethics for Scientists
	MMB 0234	Laboratory Rotations
	MMB 0241	Microbial Gene and Micro
	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
Spring	MMB 0214	Animal Virology*
	MMB 0235	Laboratory Rotations
	MMB 026E	Advanced Top in Micro E**
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
Summer	MMB 0000	Qualifying Examination
	MMB 0299	Graduate Research

Second Year

Fall	IMM 0212	Introduction to Immunology
	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	MMB 0210/0211	Host-Pathogen Interface/ Bacterial-Host Cell Inter.*
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	MMB 0299	Graduate Research

*MMB 0210/0211 and MMB 0214 are offered in alternating years.

**MMB 026E and 026O are offered in alternating Spring terms. Students enroll in whichever is offered first. There is no need to enroll in the other.

Third Year and Beyond

Fall	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	MMB 0299	Graduate Research

MOLECULAR GENETICS PHD CURRICULUM

First Year

Fall	BCHM 0223	Graduate Biochemistry
	GSBS 0275	Applied Ethics for Scientists
	MMB 0234	Laboratory Rotations
	MMB 0241	Microbial Gene & Micro
	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
Spring	MMB 0214	Animal Virology
	MMB 0235	Laboratory Rotations
	MMB 026E	Advanced Topics in Micro E*
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	<i>Elective**</i>	
Summer	MMB 0000	Qualifying Examination
	MMB 0299	Graduate Research

Second Year

Fall	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	GENE 0205	Mammalian Genetics**
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	GENE 0208	Mammal. & Experim. Gene***
	MMB 0299	Graduate Research

*MMB 026E and 026O are offered in alternating Spring terms. Students enroll in whichever is offered first. There is no need to enroll in the other.

**The elective should generally be taken during the first two years but need not be taken during a specific term.

***Choose one of these two courses.

Third Year and Beyond

Fall	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	MMB 0299	Graduate Research

MOLECULAR MICROBIOLOGY

MD/PHD COURSE REQUIREMENTS AND PROGRESSION

Students entering the Molecular Microbiology program as part of the combined MD/PhD degree complete two laboratory rotations in the summers before and during the first two years of medical school and choose their thesis lab prior to their first year of coursework at GSBS. MD/PhD students also have adjusted didactic requirements including the **Clinical Implications of Basic Research seminar (GBMD 0209/0210)**, which is taken every semester. Required didactic courses include **BCHM 231A**; **GSBS 0275**; and either **MMB 0260** or **026E**. Students who take longer than four years to complete their PhD will also be required to complete an ethics refresher course.

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.

GENERAL REQUIREMENTS

QUALIFYING EXAMINATION

Students must pass a qualifying examination. 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 & THESIS

Students enter their thesis lab and begin thesis research after completing the final laboratory rotation. Each student meets with their thesis advisory 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. 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

WEB LINKS

- Molecular Microbiology [Program Faculty](#)
- Molecular Microbiology [Web Site, with Program Guide](#)

MD/PHD CURRICULUM

First Year

Summer	MMB 0299	Graduate Research
Fall	GBMD 0209	Clin Imp of Basic Research
	GSBS 0275	Applied Ethics for Scientists
	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
Spring	MMB 0297	Graduate Research
	BCHM 231A	Molecular Recognition in Biology*
	GBMD 0210	Clin Imp of Basic Research
	MMB 026E	Advanced Topics in Micro E**
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
Summer	MMB 0298	Graduate Research
	MMB 0000	Qualifying Examination
	MMB 0299	Graduate Research

*BCHM 231A is offered every other year. It should be taken at the first opportunity.

**MMB 026E and 026O are offered in alternating Spring terms. Students enroll in whichever is offered first. There is no need to enroll in the other.

Second Year and Beyond

Fall	GBMD 0209	Clin Imp of Basic Research
	MMB 0291	Graduate Seminar
	MMB 0295	Journal Club
	MMB 0297	Graduate Research
Spring	GBMD 0210	Clin Imp of Basic Research
	MMB 0292	Graduate Seminar
	MMB 0296	Journal Club
	MMB 0298	Graduate Research
Summer	MMB 0299	Graduate Research

additional invited non-Tufts scientist, sits as the examination committee.

PUBLICATION

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

NEUROSCIENCE

The Graduate Program in [Neuroscience \(NRSC\)](#) 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.

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

NEUROSCIENCE

PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the Neuroscience program complete coursework designed to provide a strong knowledge base for their research. Required courses include **CMDB 0220**; **ISP 209A**; **NRSC 0200**, **0233**, **0251**, **0311**; and **GSBS 0275**. Students must complete one elective course.

Students also participate in weekly journal clubs, student research presentations, and seminars, and must pass a qualifying examination. Students typically begin thesis research after completing three lab rotations. In addition, fifth year 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.

TRADITIONAL PHD CURRICULUM

First Year

Fall	GSBS 0275	Applied Ethics for Scientists
	ISP 209A	Membranes and Trafficking
	NRSC 0200	Cell & Mol Tutorials in Neuro
	NRSC 0233	Neuro Research Techniques
	NRSC 0234 001	Laboratory Rotations
	NRSC 0251	Biochem Foundations in Neuro
	NRSC 0289	Research Presentations
Spring	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	CMDB 0220	Biomedical Statistics and Computational Biology
	NRSC 0235 001	Laboratory Rotations
	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
Summer	NRSC 0296	Journal Club
	NRSC 0311	Neural Systems and Disease Mechanisms
	NRSC 0299 001	Graduate Research

Second Year

Fall	NRSC 0289	Research Presentations
	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	NRSC 0297 001	Graduate Research
	<i>Elective</i>	
Spring	NRSC 0000	Qualifying Examination
	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
	NRSC 0298 001	Graduate Research
	<i>Elective</i>	
Summer	NRSC 0299 001	Graduate Research

Third Year and Beyond

Fall	NRSC 0289	Research Presentations
	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	NRSC 0297 001	Graduate Research
Spring	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
	NRSC 0298 001	Graduate Research
Summer	NRSC 0299 001	Graduate Research

NEUROSCIENCE

NEURO AT JAX PHD COURSE REQUIREMENTS AND PROGRESSION

Students in the Neuro at JAX track study at the Jackson Laboratory in Bar Harbor, ME.

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

NEURO AT JAX PHD CURRICULUM

First Year

Fall	GSBS 0275	Applied Ethics for Scientists
	ISP 209A	Membranes and Trafficking
	NRSC 0200	Cell & Mol Tutorials in Neuro
	NRSC 0233	Neuro Research Techniques
	NRSC 0234 002	Laboratory Rotations
	NRSC 0251	Biochem Foundations in Neuro
	NRSC 0289	Research Presentations
Spring	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	CMDB 0220	Biomedical Statistics and Computational Biology
	NRSC 0235 002	Laboratory Rotations
	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
Summer	NRSC 0296	Journal Club
	NRSC 0311	Neural Systems and Disease Mechanisms
NRSC 0299 002	Graduate Research	

Second Year

Fall	NRSC 0289	Research Presentations
	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	NRSC 0297 002	Graduate Research
	<i>Elective</i>	
Spring	NRSC 0000	Qualifying Examination
	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
	NRSC 0298 002	Graduate Research
<i>Elective</i>		
Summer	NRSC 0299 002	Graduate Research

Third Year and Beyond

Fall	NRSC 0289	Research Presentations
	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	NRSC 0297 002	Graduate Research
Spring	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
	NRSC 0298 002	Graduate Research
Summer	NRSC 0299 002	Graduate Research

NEUROSCIENCE

MD/PHD COURSE REQUIREMENTS AND PROGRESSION

Students entering the Neuroscience program as part of the combined MD/PhD degree program complete two laboratory rotations in the summers before and during the first two years of medical school, and choose their thesis lab prior to their first year of coursework at GSBS. MD/PhD students also have adjusted didactic requirements including the **Clinical Implications of Basic Research seminar (GBMD 0209/0210)**, which is taken every semester. Required didactic courses include **NRSC 0200, 251B, 0311**; and **GSBS 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 course.

GENERAL REQUIREMENTS

QUALIFYING EXAMINATION

Students must pass a qualifying examination. 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 & THESIS

Students enter their thesis lab and begin thesis research after completing the final laboratory rotation. Each student meets with their thesis advisory 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. 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.

WEB LINKS

- Neuroscience [Program Faculty](#)
- Neuroscience [Web Site, with Program Guide](#)

MD/PHD CURRICULUM

First Year

Summer	NRSC 0299	Graduate Research
Fall	GBMD 0209	Clin Imp of Basic Research
	GSBS 0275	Applied Ethics for Scientists
	NRSC 0200	Cell & Mol Tutorials in Neuro
	NRSC 251B	BFN Receptor/Channel Mech
	NRSC 0289	Research Presentations
	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
Spring	NRSC 0297 001	Graduate Research
	GBMD 0210	Clin Imp of Basic Research
	NRSC 0000	Qualifying Examination
	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
	NRSC 0298 001	Graduate Research
Summer	NRSC 0311	Neural Systems and Disease Mechanisms
	NRSC 0299 001	Graduate Research

Second Year and Beyond

Fall	GBMD 0209	Clin Imp of Basic Research
	NRSC 0289	Research Presentations
	NRSC 0291	Graduate Seminar
	NRSC 0295	Journal Club
	NRSC 0297 001	Graduate Research
Spring	GBMD 0210	Clin Imp of Basic Research
	NRSC 0290	Research Presentations
	NRSC 0292	Graduate Seminar
	NRSC 0296	Journal Club
	NRSC 0298 001	Graduate Research
Summer	NRSC 0299 001	Graduate Research

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.

PHARMACOLOGY & DRUG DEVELOPMENT

The Master's Program in [Pharmacology & Drug Development \(PDD\)](#) is designed for candidates who hold a baccalaureate degree and wish to obtain additional training in pharmacology that will enhance their professional and career options. Current areas of interest of program members include inflammatory diseases, obesity, behavioral disorders, drug-induced hepatotoxicity, pharmacogenomics, neuropharmacology, cardiovascular pharmacology, cancer pharmacology, pharmacokinetics, drug metabolism, and drug interactions. Students who complete the program are equipped for opportunities in industry as well as to continue in academic research.

PHARMACOLOGY AND DRUG DEVELOPMENT

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, 0232**; and **GSBS 0275**. Students must also complete three elective courses and participate in weekly journal clubs and program seminars. During both years, emphasis is placed on original laboratory research through two semester-long rotations and thesis work, which leads to a publishable Master's thesis.

RESEARCH AND THESIS

Students enter their thesis lab and begin thesis research in the spring of their second year and are expected to complete their research and their thesis within their second year. The Master's thesis is reviewed by the student's faculty mentor and one additional faculty reader.

MASTER'S CURRICULUM

First Year

Fall	GSBS 0275	Applied Ethics for Scientists
	PPET 0135	Laboratory Research Experience
	PPET 0211	Translational Pharmacology I
	PPET 0291	Graduate Seminar
	PPET 0295	Journal Club
	<i>Elective</i>	
Spring	PPET 0135	Laboratory Research Experience
	PPET 0232	Translational Pharmacology II
	PPET 0292	Graduate Seminar
	PPET 0296	Journal Club
	<i>Elective</i>	
Summer	PPET 0299	Graduate Research

Second Year

Fall	PPET 0291	Graduate Seminar
	PPET 0295	Journal Club
	PPET 0297	Graduate Research
	<i>Elective</i>	
Spring	PPET 0292	Graduate Seminar
	PPET 0296	Journal Club
	PPET 0298	Graduate Research

WEB LINKS

- Pharmacology [Program Faculty](#)
- Pharmacology [Web Site, with Program Guide](#)

COURSE OFFERINGS

Any course that is not offered on a regular annual or biennial basis has a “last offered” date within the description. The Course Director, who is listed in italics, is based on information available as of June 2021. The Required and Elective Courses listing is followed by a listing of Common Courses such as Journal Club, Seminar, Qualifying Exams, and other similar courses which are parallel across multiple programs.

REQUIRED AND ELECTIVE COURSES

BCHM 0223 Graduate Biochemistry

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. 4 cr. A-F. Fall. *Bohm*

BCHM 0230 Biochemistry of Gene Expression & Signal Transduction

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. 4 cr. A-F. Spring. *Yee*

BCHM 230A Biochemistry of Gene Expression

The fundamental mechanisms underlying transcription, RNA processing, translation, and DNA replication are highlighted in this course. Current literature is emphasized. This course represents the first part of Biochemistry 230 and may be taken as a separate course. 2 cr. A-F. Spring. *Yee*

BCHM 230B Biochemistry of Signal Transduction

The integration of fundamental mechanisms into molecular and cellular regulation of proliferation and signal transduction is discussed. Current literature is emphasized. This course represents the second part of Biochemistry 230 and may be taken as a separate course. 2 cr. A-F. Spring. *Yee*

BCHM 231A Molecular Recognition in Biology

This course builds on graduate biochemistry, providing detailed instruction on how to design and interpret binding experiments, how to visualize and analyze macromolecular structures, and how to apply these techniques in laboratory research. 1 cr. A-F. Spring, even years. Last offered 2020. *Bohm*

BCHM 231B Drug Design

Survey and critical analysis of selected case histories of drug design, discovery, and development, including issues related to commercialization such as market size, patents, and licenses. 1 cr. A-F. Spring, even years. Last offered 2020. *Bachovchin*

BIOM 0180 Communities of Practice and Management in Academia and Industry

This course will introduce concepts of management skills and provide talks by alumni in differing careers who will discuss what the community of practice is for their workplace. As academic and industry workplaces have different unwritten rules of conduct we will have talks on academic (research intensive and primarily undergraduate), industrial (start-up, biotech and big pharma) and non-bench science careers (venture, IP, policy). Students will present based on their analysis of one specific workplace with regard to its community of practice. 1.5 cr. S/U. Fall. *Jay/Gross*

BIOM 0212 Introduction to Biomedical Research

This course will introduce students to biomedical research from fundamental discovery to therapeutic target identification/translation to clinical development and approval of a new drug. Students will gain familiarity with biomedical laboratory procedures and principles through attendance at

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Graduate Biochemistry lectures. Subsequently, the process of drug discovery and development will be illustrated through presentation of specific examples beginning with historical work in basic biomedical research labs through development in biotech/pharma. The course will end with students identifying a drug candidate in clinical trials (any stage), researching the target/lead/candidate history, and presenting their findings. 2 cr. A-F. Fall. *Hinds*

CMDB 0202 Structural Biology

This course covers the basic theory and practice of Macromolecular Crystallography and NMR 1 cr. A-F. Summer. Last offered 2018. *Bohm/Baleja*

CMDB 0220 Essentials in Biomedical Statistics and Computational Biology

An introduction to biostatistics with application to the biomedical sciences and genetics, and introduction to computational biology. Introduction to the use of R and RStudio for biostatistical computations. 2 cr. A-F. Spring. *Nielsen*

CMDB 0235 Developmental Biology

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. 2 cr. A-F. Fall, even years. Last offered 2020. *Hatini*

CMDB 0247 Biology of Aging

This course is an in-depth examination of current topics in aging research, with a focus on human aging. Topics to be discussed include theories of aging; physiological, cellular, and epigenetic changes that occur with aging; biochemical and energetic processes that affect healthspan and lifespan; and interventions that may affect the aging process. The themes for this course vary each time it is offered. This year there will be an emphasis on protein quality control pathways and their roles in homeostasis, aging, and age-related diseases, along with drugs to exploit those capacities. Students will help direct the course by presenting and critiquing papers selected from a curated list of current aging research literature. 3 cr. A-F. Spring. *McVey/Taylor*

CMP 0230 Pathobiology

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. 2 cr. A-F. Spring. Last offered 2018.

CTS 0150 Real World Evidence

This course serves as an introduction to topics in the use of real world evidence (RWE) to inform healthcare decision making. This course will introduce the foundational study designs and analytic approaches that are integral to the valid and efficient analysis of RWE, including those relevant to “big data.” RWE frameworks and approaches to be discussed will include limiting bias in observational big data, harnessing RWE for predictive analytics, identification of heterogeneity of treatment effects, pragmatic trial designs and the role of RWE for various stakeholders, including regulators. The potential role of RWE for the regulatory approval of novel therapies will also be discussed. Topics will be illustrated through the use of contemporary case studies representing both the promise and limitations of using RWE to inform healthcare decision making. 1 cr. A-F. Spring. *Kent*

CTS 0152 Introduction to Health Technology Assessment

This course describes the practice of health technology assessment, as conducted by major agencies and other organizations in the United States and elsewhere, and introduces the technical tools used to project health benefits and costs. For the United States, the course reviews guidelines promulgated by the Second Panel on Cost Effectiveness Analysis in Health, and value assessment frameworks developed in the United States, with a focus on the Institute for Clinical and Economic Review (ICER). The review of HTA in other countries focuses on the National Institute for Health and Care Excellence (NICE) and also reviews approaches used by agencies in other countries. Finally, the course introduces the use of computer simulation to estimate value when empirical data alone will not suffice. 2 cr. A-F. Spring. *Ollendorf/Cohen*

CTS 0157 Introduction to Health Economics and Outcomes Research

This course introduces the fundamentals of Health Economics and Outcomes Research (HEOR). We begin with an overview of the issues addressed by HEOR – including the measurement of health benefits in terms that can be compared across disease domains, and the inclusion of cost impacts across time and over multiple societal sectors that extend beyond health care itself. The first part of the course examines key economic concepts and their relation to health care, including the demand for health care, the structure and consequences of health insurance, and markets for pharmaceutical products. The second part of the course focuses on understanding health economic analysis based on recommendations issued by the Second Panel on Cost Effectiveness in Medicine and Health for the US. The lectures include measuring preferences for health outcomes, estimating costs, simulation modeling, and eth

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ical issues in cost-effectiveness analysis. Finally, through a series of case studies, the course introduces students to important sources of data for the HEOR field. 2 cr. A-F. Fall. *Chambers/Kim*

CTS 0231 Applying Quality Improvement Methods in Healthcare and Public Health

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, clinical research and public health. The course focuses on application, and includes didactic instruction, group discussions, and a small group QI project. The semester long QI project involves collaboration with hospital staff or public health practitioners. 2.5 cr. A-F. Spring. *Daudelin*

CTS 0500 Study Design Seminar

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. 1 cr. A-F. Fall/Spring. *Huggins/Kent*

CTS 0506/0507 Introduction to Biostatistical Methods I

This course is the first half of a two-part course which presents the practical application of biostatistical methods for exploring and analyzing health data. Methods for working with data and exploring basic associations are presented through case examples and clinical research projects. CTS 0506 and 0507 are considered equivalent to 0527. 1 cr. A-F. Summer. *Pagni*

CTS 0510 Predictive Models

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. 2 cr. A-F. Fall. *Kent*

CTS 0514 Clinical Research Project-Certificate Candidates

Students develop mentored research plans with mentors (or mentoring teams) that permits them to demonstrate these skills through the development of a protocol, a report, or research manuscript. The mentoring teams are required to have at least one member who is on the faculty of the GSBS CTS program. The project design is led by students, so they learn the role of principal investigator. This course is required for the Certificate Program, and is not available to non-certificate students. 2 cr. S/U. Spring.

CTS 0515 Clinical Research Project/Thesis Research-First Year

First year master's students begin to learn how to complete comprehensive independent clinical research project, which includes framing a research question and specific project aims, identifying useful data sources, developing appropriate methods, identifying and defending against sources of bias, implementing/managing a project, and writing up a thesis in the form of a publishable article or monograph. 2 cr. S/U. Fall/Spring.

CTS 0516 Clinical Research Project/Thesis Research-Second Year

Second year master's students continue and complete their independent clinical research projects. Students gain additional skills in framing a research question and specific project aims, identifying useful data sources, developing appropriate methods, identifying and defending against sources of bias, implementing/managing the project, and writing up the thesis in the form of a publishable article or monograph. 5 cr. S/U. Fall/Spring.

CTS 0517 Clinical Research Project/Thesis Research-PhD Candidates

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 up the thesis in the form of a publishable article and PhD thesis. 9 cr. S/U. Fall/Spring/Summer.

CTS 0518 Advanced Thesis Research

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. 2-8 cr. S/U. Fall/Spring/Summer.

CTS 0519 Concentration Practicum

This course is an independent mentored experience for students interested in advanced study and skill development in a particular area. This course requires written approval of the Program Director in order to register. 1-4 cr. S/U. Fall/Spring/Summer.

CTS 0523 Introduction to Clinical Epidemiology

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,

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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. 2 cr. A-F. Fall. *Rodday*

CTS 0525 Introduction to Clinical Care Research

This course, meeting three hours daily over a four-week summer session, teaches students how to formulate a clinical research hypothesis and to develop it into a clinical research project. Students acquire an understanding of basic and advanced principles of study design and issues in conducting biomedical research involving human subjects. 4 cr. A-F. Summer. *Kent*

CTS 0527 Biostatistics I

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. 2.5 cr. A-F. Fall. *Rodday*

CTS 0533 Advanced Topics in Biostatistics

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. 1 cr. A-F. Fall. *Rodday/Noubary*

CTS 0537 Scientific Manuscript Writing

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. 1 cr. A-F. Fall/Spring. *Kent*

CTS 0538 Scientific Grant Writing

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. 1 cr. A-F. Fall/Spring. *Kent*

CTS 0539 Scientific Writing, Peer Review & Presentations

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. 1 cr. A-F. Fall/Spring. *Kent*

CTS 0540 Ethics of Clinical Investigation

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 inter-relationships between ethics, law and professional practice standards and explores the role and workings of Institutional Review Boards. 1 cr. A-F. Spring. *Sege*

CTS 0549 Health Care Activism, Community Health, and Patient-Centered Research

This introductory course focuses on principles and methods that can be used to support the involvement of stakeholders in research. The course will examine three approaches to stakeholder and community engagement that have addressed theory, principles, challenges, and potential benefits.

The three approaches include patient-centered research in which researchers collaborate with the public to make research more useful, community-based health research in which researchers and communities work together to co-create research, and health care activism in which individuals come together to influence stewards of publicly-funded research. 1 cr. S/U. Spring. *Concannon*

CTS 0557 Health Economics

This course aims to introduce health care professionals and clinical researchers to key economic concepts and their relation to health care. The course is designed for students with no or rudimentary understanding of economics. In addition to providing students with a foundation in economics, the course will provide students with an understanding of the structure and performance of the US health care system, and an introduction to methods for the economic evaluation of medical technology. The course will also include lectures on the regulation of medical technology, health care innovation, and emerging health policy trends. Coursework will include a workshop in which students will gain hands-on experience manipulating economic evaluations for medical technology. 1 cr. A-F. Spring. Last offered 2020. *Chambers*

CTS 0561 Introduction To Clinical Trials

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. 1 cr. A-F. Fall. *Pittas*

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CTS 0566 Introduction to Health Services Research

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. 1 cr. A-F. Spring. *LeClair*

CTS 0575 Advanced Epidemiology & Regression Methods: An Integrated Approach

This course serves as an introduction to more advanced topics in epidemiologic study design and biostatistical modeling with a focus on multivariate regression methods. It begins with the randomized clinical trial as a paradigm, and proceed to examine observational designs in depth, including prospective and retrospective cohorts, and those sampling from an underlying cohort (i.e. case-control). Design, sampling and analysis strategies and the biases that are specific to each study design will be discussed. 4 cr. A-F. Spring. *Rodday*

CTS 0581 Introduction to Evidence Based-Medicine

This course covers the principles of systematic review processes, evaluation of studies and bodies of evidence as used in the conduct of systematic reviews, meta-analyses and the development of evidence-based clinical practice guidelines. The course focuses on studies of treatment efficacy. 1 cr. A-F. Spring. *Bannuru/Chambers*

CTS 0584 Introduction to Decision Analysis

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. 1 cr. A-F. Spring. *Wong*

GBMD 0209/0210 Clinical Implications of Basic Research

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) and discuss the work. The primary goal of this required course, 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. 0 cr. S/U. Fall/Spring. *Chin*

GBMD 0299 Laboratory Rotations

6-8 week laboratory rotations are designed to provide experience with experimental design and theoretical

aspects of the diverse research problems under investigation in various laboratories. 4 cr. A-F. Summer.

GENE 0203 Cancer Genetics

The course reviews widely-held ideas and current research on the genetic aspects of carcinogenesis. An introduction to cancer concepts is followed by a focus on specific mechanisms and models illustrating the ways in which normal cellular processes are disrupted in particular types of cancers. The course emphasizes problem solving and readings from the current literature. 2 cr. A-F. Every other year. Last offered Spring 2021. *Cochran/Munger*

GENE 0205 Mammalian Genetics

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, and the methodologies that are currently used to perform genetic analysis of mammals. 2 cr. A-F. Spring. *Baker/Dumont*

GENE 0208 Medical & Experimental Mammalian Genetics

The course is an intensive, two-week immersion into mammalian genetics with presenters providing background and current research in important areas of mammalian genetics and its impact on health and disease. This course is offered at The Jackson Laboratory, Bar Harbor, ME. Students in the Mammalian Genetics Track have priority for this course; a limited number of slots are available for other GSBS students with permission from the Genetics program and the Dean's Office. 4 cr. A-F. Summer. *Tewhey/Trowbridge*

GENE 0212 Introduction to Genetics

The goal of the first part of the course is to provide a common foundation for all students in the major principles of molecular genetics upon which they can base more advanced studies. By the end of this course students are expected to understand the major principles of molecular genetics and the underlying processes by which cells and organisms replicate, repair, read, and translate their genetic codes. Students should achieve an advanced understanding of these topics that will allow them to read the primary research literature, understand the biological processes examined, and interpret the results in the larger context of molecular genetics. The goal of the second part is to build upon the first to provide a solid knowledge and understanding of the basic principles of Genetic model organisms, ranging from research in eukaryotes, and how they have developed as the field has matured. The goal of this course is to teach students modern methods of genetic analysis of model organisms, ranging from simple eukaryotic yeast to humans. Students will learn how to use molecular genetics to answer biological questions and read current literature in

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genetics. Experience with reading current primary literature in the field, and with the basics of microarray analysis and next generation sequencing (NGS). 2 cr. A-F. Fall. *Cox/Hinds/Yelick*

GENE 0320 Introduction to Bioinformatics using RNA Sequencing

RNA-seq is a commonly used method for analyzing gene expression. This course will provide 1) hands-on experience processing and analyzing high-throughput sequencing data and 2) exposure to NGS and RNA-Seq processes, applications and terminology. 2 cr. A-F. Spring. *Howell*

GENE 0450 Experimental Models of Human Cancer

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, Bar Harbor, ME. Students in the Mammalian Genetics Track have priority for this course; a limited number of slots are available for other GSBS students with permission from the Genetics program and the Dean's Office. 3 cr. A-F. Summer. *Howell*

GSBS 0101/0102 Basic Skills for Scientists I

This three-module course is designed to give trainees basic skills in oral and written presentation, in approaches to the reading of the scientific literature, and designing experiments and interpreting quantitative data. 1.5 cr. S/U. Fall/Spring. *Wortis/Alcaide*

GSBS 0205 Mentored Undergrad Teaching

This course offers an opportunity for GSBS students to obtain mentored teaching experience. Each GSBS student collaborates with a TUSM and a Friedman student to develop a syllabus and three lectures on one of five disease topics (osteoporosis, breast cancer, asthma, metabolic syndrome, heart disease). Lectures are delivered to undergraduate Biology majors at Pine Manor College, Chestnut Hill, MA. Prerequisites: Year 3 or above. 1 cr. S/U. Fall/Spring/Summer.

GSBS 0275 Applied Ethics for Scientists

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. 1 cr. S/U. Fall. *Maguire*

GSBS 0299 Biomedical Techniques & Research

This course includes research with selected advisor. Visiting Students Only. 0 cr. S/U. Fall/Spring/Summer.

GSBS 0375 Advanced Scientific Ethics

This is an NIH-mandated refresher course for responsible conduct of research (RCR) for 5th year students. It builds on SK 0275, Scientific Ethics; 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. The class provides opportunities for team building, writing, ethical analysis and teaching; grading will be based on the quality of case study and analysis, teaching, effort and participation. 1 cr. S/U. Fall. *Maguire*

IMM 0212 Introduction to Immunology

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. 2.5 cr. A-F. Fall. *Wortis*

IMM 0217 1st Year Journal Club

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. 0 cr. A-F. Fall. *Wortis*

IMM 0223 Introduction to Infectious and Inflammatory Diseases

This course is comprised of three integrated components; 1) a Medical Microbiology and Inflammation/Immunology Tutorial designed to introduce students to pathogens and pathophysiology of infectious and inflammatory diseases, 2) Infectious and Inflammatory Diseases Problem-Based Learning designed to introduce students to clinical cases, and 3) Teaching Clinics designed to expose students to real clinical cases and treatment options. 2 cr. S/U. Summer. *Stadecker/Plaut*

IMM 0230 Inflammation and Chronic Inflammatory Diseases

The course focuses on reading primary literature about the role of inflammation in several chronic diseases. The emphasis is on understanding the role of the immune response during the initiation and progression of chronic inflammatory diseases. The course will explore human diseases and delve into available animal models for such conditions, discuss the beneficial vs pathological aspects of inflammation in various diseases, and ongoing therapies and clinical trials for such conditions. 2 cr. A-F. Fall, even years. *Alcaide*

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IMM 0245 Advanced Cellular Immunology

This course is designed to give students a solid background in contemporary Cellular Immunology. The course will be based on a lecture series supplemented by extensive readings from the current literature. Thirty minutes of each course is dedicated to discuss the assigned reading material, which is two papers per lecture. Prerequisite: IMM 0212 or equivalent. 2 cr. A-F. Fall. *Iacomini*

IMM 0250 Immunochemistry- Signaling and Dynamics

The course covers the genetic basis for lymphocyte differentiation, receptor gene rearrangement, T and B cell antigen-receptor diversity and selection, tolerance, autoimmunity and gene expression. 1.5 cr. A-F. Spring, odd years. *Bunnell*

IMM 0252 System Approaches to Immunology

The course introduces mouse as the main model for studies of human biology. It starts with the 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. At the end, two lectures and hands-on workshops familiarize students with the basics of microarray analysis and next generation sequencing. 1 cr. A-F. Spring, even years. *Poltorak*

ISP 209A Membranes & Trafficking

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. 3 cr. A-F. Fall. *Juo*

ISP 209B Cell Behavior

This course covers major topics in cell biology, including cell motility and mitosis; cell-cell and cell-matrix interactions; and receptor-mediated endocytosis. 1 cr. A-F. Spring. *Hatini*

ISP 210A Cell & Molecular Genetics

This course covers molecular genetics and basic concepts in developmental biology. 1 cr. A-F. Fall. *Cochran*

ISP 210B Molecular Cell Biology of Development

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. 1 cr. A-F. Spring. *Hatini*

MMB 0210 Host Pathogen Interface

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. 1 cr. A-F. Spring, odd years. *Mecsas*

MMB 0211 Bacterial-Host Cell Interaction

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. 1 cr. A-F. Spring, odd years. *Isberg*

MMB 0214 Animal Virology

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. 2 cr. A-F. Spring, even years. *Coffin/Gaglia*

MMB 0223 Introduction to Infectious Diseases

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. 2 cr. S/U. Summer. *Isberg/Hu*

MMB 0241 Microbial Genetics & Microbiology

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. 1.5 cr. A-F. Fall. *Camilli*

MMB 026E/026O Advanced Topics in Microbiology E

This collection of lectures of four trending topics in Microbiology is offered in even years. 3 cr. A-F. Spring, 026E offered in even years; 026O offered in odd years.

MMB 0275 Applied Ethics for Scientists

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

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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. 1 cr. S/U. Spring, odd years. *Tan*

NRSC 0200 Cellular and Molecular Tutorials in Neuroscience

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. 1 cr. S/U. Fall. *Dulla*

NRSC 0213 Synapse Neurobiology

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. 2 cr. A-F. Fall, even years. *Jacob/Reijmers*

NRSC 0220 Scientific Communication and Writing Principles

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. 1 cr. A-F. Fall. *Davies*

NRSC 0233 Neuroscience Laboratory Techniques

The series of workshops exposes student to fundamental laboratory techniques, including tissue culture, genotyping, microscopy, immunohistochemistry, rodent handling, protein quantification, and experimental design. Restricted to first-year Neuroscience students. 1.5 cr. S/U. Fall. *Maguire*

NRSC 0248 Glia-Neuron Interactions in Development and Disease

This course will introduce and discuss development of different glial cell types in several model systems and how they distinctly interact with neurons and the physiological and pathological significance of their interactions will be discussed. In addition, unique experimental approaches to study glia will also be included. 2 cr. A-F. Spring, even years. *Yang*

NRSC 0251 Biochemical Foundations in Neuroscience

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. 4 cr. A-F. Fall. *Jackson*

NRSC 251B Biochemical Foundations in Neuroscience Receptor/Channel Mechanisms

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. 1 cr. A-F. Fall. *Jackson*

NRSC 0277 CNS Drug Discovery

This course covers the process of bringing a new pharmaceutical treatment against disorders of the central nervous system (CNS) to the market, starting at the conception of a novel idea. Compared to other disease areas, CNS drug discovery faces – literally – several additional barriers. Most importantly, therapeutics need to cross the blood-brain-barrier in order to reach their site of action. This provides unique challenges throughout the discovery and development stages, especially for large m 1 cr. A-F. Last offered 2018.

NRSC 0311 Neural Systems and Disease Mechanisms

The goals of this course are two-fold: (i) to provide an overview of nervous system structure and function and (ii) to expose students to some of the clinical consequences of associated with neural dysfunction.

NRSC 0311 is a series of small group discussions with faculty experts. 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. Students will emerge with an enhanced mechanistic understanding of the most common neurological diseases and the experimental approaches that are informing clinical treatments. 1.5 cr. A-F. Spring. *Rios/Tesco*

PPET 0134/0135 Laboratory Research Experience

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. 4 cr. A-F. Fall/Spring.

PPET 0205 Translational Medicine - Drug Discovery to Clinical Development

This comprehensive course covers key processes from drug discovery to development, including the progression and translation of scientific information through different development stages and the transition to clinical studies, to increase the probability of creating a successful therapeutic product. The goal is to impart sufficient background to provide an overall understanding of Translational Medicine that is integral to scientific rationale in Drug Research and Development. 1 cr. A-F. Spring. *Natarajan/Pothos*

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PPET 0211/0232 Translational Pharmacology I & II

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. 4 cr. A-F. Fall and spring.

Fiaturi

PPET 0213 Addiction Medicine

This course is offered in conjunction with the Medical School. 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. 2 cr. A-F. Summer. *Pothos*

PPET 0218 Principles of Immunopharmacology

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. 2 cr. A-F. Fall. *Theoharides*

PPET 0221 Pharmacokinetics in Biological Systems

This course focuses on the uptake and clearance of drugs, using problem-solving exercises and computer modeling to analyze data from original experiments 2 cr. S/U. Fall.

Greenblatt

PPET 0233 Scientific Writing and Presentation Skills

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. 1 cr. S/U. Fall. *Pothos*

PPET 0261 Design and Execution of Clinical Trials

This course will provide graduate students with an understanding of the basic principles and methodology by which a putative therapeutic agent that has been proven safe and effective in preclinical animal models can be developed into one that is suitable for marketing for clinical use in human patients. 0.5 cr. A-F. Spring. *Pothos*

PPET 0281 Design and Analysis of Bioequivalence Studies

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. 1 cr. S/U. Spring, even years. *Pothos*

COURSE OFFERINGS

COMMON COURSES

In addition to the courses listed above, there are a number of academic experiences that are similar across the Graduate School of Biomedical Sciences, but are organized and administered by individual programs. GSBS makes an effort to coordinate numbering of these courses to highlight the similarity in course structure, timing, and objectives.

0000 Qualifying Exam

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. S/U. Fall/Spring/Summer.

0234/0235/0236 Laboratory Rotations

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. S/U. Fall/Spring/Summer.

0289/0290 Research Presentations

Students in Neuroscience, Immunology, and Genetics present progress reports on their research for questions and constructive criticism as well as gain experience in presenting data and leading discussion. S/U. Fall/Spring.

0291/0292 Graduate Seminar

Visiting speakers from the Boston community and beyond present their scientific research to all members of the pro-

gram, including faculty, students, and post-doctoral fellows. S/U. Fall/Spring.

0293/0294/0593/0594 Special Topics

In-depth information is provided on selected topics. Students may also pursue guided individual study of an approved topic. S/U. Fall/Spring.

0295/0296 Journal Club

Students select articles from the current literature, analyze their significance, and present them for discussion in a seminar group. S/U. Fall/Spring.

0297/0298/0299 Graduate Research

These courses provide guided research on a topic suitable for a doctoral thesis. A-F. Fall/Spring/Summer.

0403/0404/0405 PhD Degree Only

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 S/U. Fall/Spring/Summer.