

Mayo Clinic Graduate School of Biomedical Sciences

Ph.D., Master's and Certificate Programs

2023-2024

Course and Program Catalog

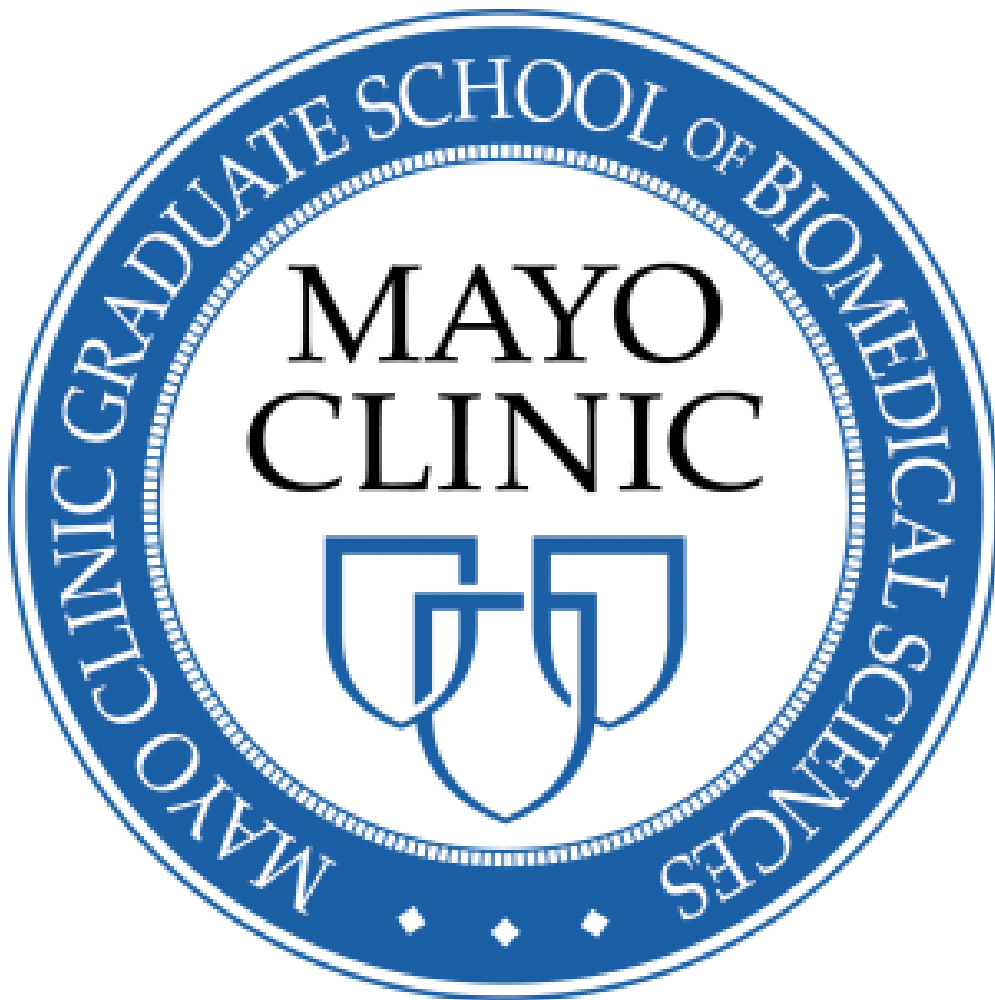


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Mayo Clinic College of Medicine and Science – Arizona	
Mayo Clinic Graduate School of Biomedical Sciences - Arizona 13400 East Shea Blvd Scottsdale, AZ 85259 https://college.mayo.edu	Nhan L. Tran, Ph.D. <i>Associate Dean, Mayo Clinic Graduate School of Biomedical Sciences</i>
Mayo Clinic College of Medicine and Science – Florida	
Mayo Clinic Graduate School of Biomedical Sciences - Florida 4500 San Pablo Rd S Jacksonville, FL 32224 https://college.mayo.edu	Evette S. Radisky, Ph.D. <i>Associate Dean, Mayo Clinic Graduate School of Biomedical Sciences</i>
Mayo Clinic College of Medicine and Science – Rochester	
Mayo Clinic Graduate School of Biomedical Sciences - Rochester 200 First Street SW Rochester, MN 55905 Phone: 507-284-1339 Fax: 507-293-0838 https://college.mayo.edu	Stephen C. Ekker, Ph.D. <i>Dean, Mayo Clinic Graduate School of Biomedical Sciences</i>

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Mayo Clinic Mission

To inspire hope and contribute to health and well-being by providing the best care to every patient through integrated clinical practice, education, and research.

Mayo Clinic Primary Value

The needs of the patient come first.

Mayo Clinic Value Statements

These values, which guide Mayo Clinic's mission to this day, are an expression of the vision and intent of our founders, the original Mayo physicians, and the Sisters of Saint Francis.

Respect

Treat everyone in our diverse community including patients, their families, and colleagues with dignity.

Integrity

Adhere to the highest standards of professionalism, ethics, and personal responsibility, worthy of the trust our patients place in us.

Compassion

Provide the best care, treating patients and family members with sensitivity and empathy.

Healing

Inspire hope and nurture the well-being of the whole person, respecting physical, emotional, and spiritual needs.

Teamwork

Value the contributions of all, blending the skills of individual staff members in unsurpassed collaboration.

Innovation

Infuse and energize the organization, enhancing the lives of those we serve, through the creative ideas and unique talents of each employee.

Excellence

Deliver the best outcomes and highest quality service through the dedicated effort of every team member.

Stewardship

Sustain and re-invest in our mission and extended communities by wisely managing our human, natural and material resources.

Mayo Clinic Graduate School of Biomedical Sciences Mission

The overriding mission of the Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) is to train future leaders in biomedical research and education. In order to pursue this goal, we will:

- Enroll outstanding students
- Utilize the unique education, research and clinical practice resources of Mayo Clinic to foster the individual academic strengths of each student;
- Engage students in interactive learning and research experiences that enhance their critical thinking, problem solving, and biomedical knowledge.

A fundamental goal of MCGSBS is to promote an academic environment that supports trainee and faculty development and facilitates biomedical innovation.

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John D. Poe

Chair, Department of Education Administration

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Associate Dean, Faculty Affairs

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Assistant Dean, Mayo Clinic in Arizona

Evette Radisky, Ph.D.

Associate Dean, Mayo Clinic in Florida

Wilfried O. Rossoll, Ph.D.

Assistant Dean, Mayo Clinic Florida

Marina R. Walther-Antonio, Ph.D.

Assistant Dean, Diversity and Inclusion

Christopher K. Pierret, Ph.D.

Assistant Dean, Academic Affairs

Karen S. Nation, MBA/HCM

Administrator

Rachel L. Halsrud, M.B.A.

Operations Manager

Hayden T. Nielsen, M.H.S.

Operations Manager, Mayo Clinic in Arizona

Caitlyn J. Foerst

Operations Manager, Mayo Clinic in Florida

2023-2024 Academic Calendar

Summer Quarter (Term 202410)

Registration for summer quarter courses opens – June 1, 2023
Registration for summer quarter courses due – June 16, 2023
Summer quarter begins – July 3, 2023
Independence Day Holiday (observed) – July 4, 2023
Last date to register or withdraw – Before one-half of the course is completed
Labor Day Holiday – September 4, 2023
Last day of quarter – September 22, 2023

Fall Quarter (Term 202420)

Registration for fall quarter courses opens – September 1, 2023
Registration for fall quarter courses due – September 15, 2023
Fall quarter begins – September 25, 2023
Last date to register or withdraw – Before one-half of the course is completed
Thanksgiving Holiday – Thursday, November 23, 2023
Last day of quarter – December 15, 2023

Winter Quarter (Term 202430)

Registration for winter quarter courses opens – December 1, 2023
Registration for winter quarter courses due – December 15, 2023
Winter quarter begins – January 2, 2024
Last date to register or withdraw – Before one-half of the course is completed
Last day of quarter – March 22, 2024

Spring Quarter (Term 202440)

Registration for spring quarter courses opens – March 1, 2024
Registration for spring quarter courses due – March 15, 2024
Spring quarter begins – April 1, 2024
Last date to register or withdraw – Before one-half of the course is completed
Memorial Day Holiday – May 27, 2024
Last day of quarter – June 21, 2024

2024-2025 Academic Calendar

Summer Quarter (Term 202510)

Registration for summer quarter courses opens – June 3, 2024
Registration for summer quarter courses due – June 21, 2024
Summer quarter begins – July 1, 2024
Independence Day Holiday (observed) – July 4, 2024
Last date to register or withdraw – Before one-half of the course is completed
Labor Day Holiday – September 2, 2024
Last day of quarter – September 20, 2024

Fall Quarter (Term 202520)

Registration for fall quarter courses opens – September 2, 2024
Registration for fall quarter courses due – September 20, 2024
Fall quarter begins – September 30, 2024
Last date to register or withdraw – Before one-half of the course is completed
Thanksgiving Holiday – Thursday, November 21, 2024
Last day of quarter – December 20, 2024

Winter Quarter (Term 202530)

Registration for winter quarter courses opens – December 2, 2024
Registration for winter quarter courses due – December 20, 2024
Winter quarter begins – January 6, 2025
Last date to register or withdraw – Before one-half of the course is completed
Last day of quarter – March 28, 2025

Spring Quarter (Term 202540)

Registration for spring quarter courses opens – March 3, 2025
Registration for spring quarter courses due – March 21, 2025
Spring quarter begins – April 7, 2025
Last date to register or withdraw – Before one-half of the course is completed
Memorial Day Holiday – May 26, 2025
Last day of quarter – June 27, 2025

Introduction

Mayo Clinic Graduate School of Biomedical Sciences

History

The Mayo Clinic developed gradually from the family medical practice of Dr. William Worrall Mayo and his sons, Dr. William James Mayo, and Dr. Charles Horace Mayo. The elder Dr. Mayo came to Rochester in 1863 to practice medicine. His sons assisted him during their boyhood years and later joined him in the practice of medicine. As the demand for their services increased, the Mayos invited other physicians to work with them.

This pioneering venture in the private group practice of medicine became known in the early 1900s as Mayo Clinic. This name today describes an organization of over 3,300 scientists and medical and surgical specialists working together as a team for the advancement of medical and biomedical education, research in medicine and related sciences, and medical care.

Mayo awarded its first Ph.D. degree in 1917 in affiliation with the University of Minnesota. Since 1984, Mayo has been an independent, degree granting institution. In January 1989, MCGSBS became a separate unit that administers Ph.D. and Master's degree programs in the biomedical sciences. Enrollment currently includes approximately 300 Ph.D. and M.D.-Ph.D. candidates, and 100 Master's candidates in biomedical science.

Other educational components of Mayo Clinic include:

- Mayo Clinic School of Graduate Medical Education, organized in 1915 to offer programs of graduate medical education. Enrollment currently includes nearly 1,600 residents and fellows in clinical fields.
- Mayo Clinic Alix School of Medicine (MCASOM), an undergraduate medical school offering the M.D. degree, opened in 1972. Current enrollment includes over 200 students on the Rochester, Minnesota campus and 200 on the MCASOM Arizona campus.
- Mayo Clinic School of Health Sciences, organized in 1973 to provide training and certification in the health professions allied to medicine. The school offers 120 programs with an enrollment of more than 1,800.
- Mayo Clinic School of Continuous Professional Development, organized in 1977 to provide continuing education for care providers within Mayo Clinic, nationally and internationally.

Mayo Clinic is accredited by The Higher Learning Commission, <https://www.hlcommission.org/>.

Mayo Clinic College of Medicine and Science is registered with the Minnesota Office of Higher Education pursuant to Minnesota Statutes sections 136A .61 to 136A .71. Registration is not an endorsement of the institution. Credits earned at the institution may not transfer to all other institutions.

Faculty

All staff appointments are made to Mayo Clinic and this staff constitutes the faculty for the educational programs of Mayo Clinic. The 4,000 plus faculty members include full-time investigators in the biomedical sciences, clinician investigators, and clinicians. Each member of the staff is full-time salaried and individual staff members have ample opportunity to teach. Members of the staff have the overall responsibility for undergraduate and graduate education in medicine and the biomedical sciences, for continuing education and research, as well as for the care of patients. Graduate faculty privileges are awarded to qualified faculty members with interest in delivering graduate level courses and in supervising candidates for graduate degrees.

See listing of graduate faculty with full privileges and their research interests [here](#).

Facilities

Educational programs, clinical practice and research are conducted within three key locations; Mayo Clinic campus in Rochester, Minnesota; Jacksonville, Florida; and Phoenix and Scottsdale, Arizona.

Technology

Mayo Clinic in Rochester, Arizona and Florida are linked via a sophisticated telecommunications system, which provides videoconferencing and data transmission. Staff and students in Rochester, Arizona and Florida can have live, interactive courses and seminars via TV monitors. In addition, Mayo has a telephone dialing and pager system that ties all three sites together.

Mayo Clinic also provides delivery of education in a virtual setting to accommodate students who cannot be physically present in a classroom on the Mayo campus. MCGSBS utilizes Blackboard Collaborate, a web conferencing/webinar platform designed for use in online teaching, in addition to Zoom and other virtual delivery tools. The Education Technology Center and Learning Solutions Center have partnered to provide resources for students and instructors for learning in a virtual setting.

Graduate Student Association

The Mayo Graduate Student Association is comprised of Ph.D. students pursuing graduate degrees at MCGSBS. Membership includes a representative (rep) from each track, a first year student rep, an Arizona and Florida rep, a MCGSBS Education Committee member rep, an M.D.- Ph.D. program rep, social media rep, Mayo Clinic Alumni Association rep, International student rep, MRFA rep, IMSD rep, Communications Liaison, Treasurer, Secretary, and prior year president(s) emeritus. Its purpose is to facilitate interaction among graduate students, and among students, faculty, and administration. It provides a means for students to give input concerning coursework and curriculum and other MCGSBS issues.

Career Development Internships

What is a Career Development Internship?

Career Development Internships (CDIs) are MCGSBS-funded opportunities for upper-level PhD students to spend 100 hours (or more) as interns in one of several career environments. CDI internships allow MCGSBS students to explore possible interests, network with professionals, contribute to the mission of the CDI partner organization and gain informed appreciation for career options.

The goal of the CDI program is to provide MCGSBS students with hands-on experience in diverse career environments to assist with making informed career path decisions.

CDI activities are flexible, allowing approximately 100 hours of paid study leave from MCGSBS during one quarter. For off-site CDI opportunities requiring travel, the CDI program may cover travel and housing costs. Internships are individualized. The MCGSBS intern and sponsoring CDI partner work together to design the ideal experience.

We are ready to partner with you to create a CDI experience designed just for you! For questions, please contact Carol (CJ) Prestegard at 6-5277 or email to: prestegard.carol@mayo.edu.

CDI Application Process:

PhD and MD/PhD students currently in MCGSBS are eligible to apply if they have:

1. successfully completed the written and oral qualifying exams,
2. are in good academic standing at MCGSBS (average GPA of 3.0 or higher),
3. have selected a mentor and an area of research, and
4. are making satisfactory PhD thesis research progress.

The CDI application includes the following supporting documents, to be combined into a single pdf and emailed to [Career Development Applications](#). If it is a competitive CDI opportunity, the single pdf will need to be received by the deadline specified in the email announcement.

1. CDI Application
2. Letter of recommendation from thesis mentor / or email with thesis mentor's support
3. CV or resume
4. 1-page single spaced statement of interest
 - a. Specify which of the CDI experiences is requested and an explanation for why you are interested in this particular opportunity. Include information you wish the CDI partner to consider.

The Special CDI Offering is competitive. Applications are collected for an internal deadline, and then reviewed internally and by the external CDI collaborator of interest. CDI awards are based on matching qualifications and interests of the applicant with the proposed CDI partner. **Applicants may indicate only one CDI collaborator in their application.**

CDI Structure and Students Responsibility of Documentation

After a student has been selected for a CDI experience, there is the expectation that the experience will be documented and provide to MCGSBS.

1. Selected applicants will be provided with contact information for the CDI collaborator and will have the responsibility to initiate contact.
 - a. **Record of Initial Meeting** (form)
2. Working with the CDI collaborator, the student will then develop a **CDI Plan** to be summarized in a 1-2 page single-spaced .pdf document
 - a. The CDI Plan will indicate how the 100-hour internship will occur (a single block of time, or multiple contacts), the name and contact information for the CDI collaborator mentor, and a brief description of planned activities. The 1-2 page CDI Plan summary should contain a budget proposal estimating reimbursable costs associated with any ground travel and/or accommodations. Meal costs are the responsibility of the intern. For CDI experiences involving travel off campus, trip and reimbursement arrangements must be made through the MCGSBS office.
3. Prior to or shortly after the internship ending, the student will host a meeting with the CDI collaborator to review the experience.
 - a. **Record of Summary Meeting** (form)
4. Within 14 days of completion of the CDI experience, the intern will submit, to MCGSBS administration, a brief report summarizing their experience.
 - a. The CDI Summary will summarize in a 1- 2 page single-space document the CDI experience.
5. Evaluation of the CDI experience will be captured in similar surveys provided to the student and the CDI partner. The focus of the evaluation will not be on the intern performance, but on the value of the CDI experience.

Graduate Employment Opportunities

See latest employment opportunities in our most recent [This Week at Mayo Clinic Graduate School of Biomedical Sciences Newsletter](#) (TW@MCGSBS).

Stipends

Students accepted into the Ph.D. program receive a fellowship, which includes stipend, tuition, and fees. The stipend, provided by Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS), continues until successful thesis defense or up to five years, whichever comes first, contingent upon satisfactory performance. Students have up to 30 days after successful thesis defense for completion of all requirements. Support for additional years beyond the fifth (fourth for M.D.-Ph.D. students) must be provided by the mentor. Stipends for all graduate students are set at a uniform level (planned for \$35,587 for 2022-2023) and are reviewed at regular intervals.

Students who are accepted into the M.D.-Ph.D. program are provided a fellowship with stipend, tuition, and fees. The stipend is provided by Mayo Clinic Alix School of Medicine (MCASOM) while the student is in the M.D. portion of training. MCGSBS provides up to four years of funding for the Ph.D. portion of the program. Extensions in the Ph.D. program beyond four years must be financially supported by the mentor. MCASOM and MCGSBS tuition and fees are provided by a full fellowship for students accepted into this combined M.D.-Ph.D. program, with satisfactory performance.

Clinical residents and research fellows accepted into the Master's program continue to receive the salary from their primary appointment and do not receive a stipend from MCGSBS.

Employees pursuing Master's degrees on a part-time basis receive their usual employee salary.

Tuition/Program Fees

Annual tuition for graduate students is \$27,000 for Ph.D. students. Tuition is \$700 per quarter credit. Tuition is provided by a full fellowship for students who are enrolled in the Ph.D and M.D.-Ph.D. degree programs of MCGSBS. Extramural sources of funds are used to defray tuition when appropriate and all eligible students are expected to apply for individual extramural awards. Program Fees are charged for many Master's programs to cover administrative costs. More details are available on the MCGSBS Master's Programs intranet site, including options for financial support.

Registration

Mayo courses are primarily intended for individuals appointed to the degree programs of MCGSBS. Others may enroll if they show appropriate prerequisites and secure the course director's approval. Tracks may have differing course enrollment criteria. Enrollment in some courses is very limited; degree candidates are given preference for these courses. Registration information is available on the [MCGSBS intranet site](#). Registration for MCGSBS courses is accomplished through the Registrar's Office and must be made online before the applicable deadline (see Academic Calendar on previous pages).

**An individual must have an active Mayo employment or education role to be eligible for MCGSBS courses.*

Registration for credit

- Unless provided through a fellowship or scholarship, students will be billed for tuition.
- Tuition is refunded if a course is cancelled.

Changes in registration

- The current tuition refund policy is available on the Financial Aid intranet site.
- Retroactive registration after a course is completed is not permitted.
- Students who wish to register for a course after the registration deadline date must have written permission from the course director. Some courses may only allow late registrants up until the first day of class.

Grading System

MCGSBS uses two grading systems:

A	Outstanding	S	Satisfactory
A-	Excellent	N	Not satisfactory
B+	Very Good	P	Pass
B	Acceptable	F	Fail
B-	Marginal/below standards expected		
C+	Below standards		
C	Poor/lowest performance to receive credit		
F	Unsatisfactory		

The Grade Point Average (GPA) is based on:

A	=	4.0	B-	=	2.7
A-	=	3.7	C+	=	2.3
B+	=	3.3	C	=	2.0
B	=	3.0	F	=	0.0

The grading system to be used is determined by the course director at the time the course is established. A grade of "S", "P", or "N" is not considered in determination of GPA. A grade of "F" is considered in determination of the GPA if the course is assigned the standard letter grading scale. The GPA, which is recorded on the official transcript, is calculated by dividing the sum of all grade points earned by the sum of all credits assigned grade points. Students do not receive credits for courses in which they received an "F" grade. In addition to the grades, the transcripts show the following, if applicable (see list below). Students have a maximum of one year to make up any deficiency. If the deficiency is not corrected within the year, the transcript will show an "F" or "N" for the course.

CRX	Credit by examination
I	Incomplete
PD	Proficiency demonstrated and transfer credits awarded
R	Indicates a student registered for a course, did not attend, and did not officially withdraw
W	Withdrawn
WVD	Course waived
T	Transfer course
X	Continuous registration/multi-term. A course that is continued over more than one quarter is given an "X" until the final quarter, when a grade is assigned. Credits are counted in the quarter the grade is entered.
Z	Repeated course

Students may retake a course one time to improve their grade with the permission of their program director and the course director. The higher grade will appear on the transcript and will be used in computation of the GPA.

Definition of Credit Hour

Credit is determined by the number of contact hours per week. A one-hour lecture per week equals one credit per quarter. A quarter is usually 12 weeks. In some courses, credit is also given for laboratory time.

Course Numbering

Graduate courses are designated with a 5— or 6— number. The 5— level courses are introductory graduate courses. The 6— level courses include MCGSBS core courses and the track courses considered to be at the boundary of what is known or done in a particular field. They can be expected to be exceptionally rigorous.

Residence Requirement

Regardless of how many transfer credits are awarded, candidates for graduate degrees from MCGSBS must complete a minimum period in residence after admission to their degree program. For Ph.D. degree candidates, the minimum period of residence will be two years (start date to end date), and for Master's degree candidates the period is one year.

Your Transcript

Current learners and alumni employed by Mayo Clinic may request a transcript online through EdLink, the [student portal](#). To request an official copy of your transcript, click on Student Records from the home menu. Directions on how to print an unofficial academic transcript are found on the MCGSBS Policies and Procedures intranet site.

Student Responsibility

Each graduate student must complete all requirements for a degree established by MCGSBS and the student's track. It is the student's personal responsibility to be aware of and to understand these requirements. A student's mentor may not assume these responsibilities, nor substitute, waive, or exempt the student from any established requirement or academic standard. Such exemptions may, however, be proposed for consideration by MCGSBS. MCGSBS reserves the right to modify requirements at any time.

Extensions

Ph.D. appointments are for up to five years and M.D.-Ph.D. appointments are for up to four years in the Ph.D. program. Extensions beyond the fifth year for Ph.D. students and beyond four years for M.D.-Ph.D. students are permitted with evidence of satisfactory performance and a recommendation signed by at least four of the five members of the student's Thesis Advisory Committee and the program director. Each extension is for a maximum of one year. If a Ph.D. student is extended into a sixth year or an M.D.-Ph.D. student into a fifth year, the student's stipend and benefits must be provided by the mentor.

For more details, see the Extension Request Procedure and Extension Request Form found on the MCGSBS intranet site.

Confidentiality of Student Records

The Family Educational Rights and Privacy Act (FERPA) afford students certain rights with respect to their education records. The FERPA policy is available on the MCGSBS Policies and Procedures intranet site.

Equal Opportunity/Affirmative Action

Mayo Clinic College of Medicine and Science upholds all federal and state laws that preclude discrimination on the basis of race, sex, age, religion, national origin, marital status, sexual orientation, disabilities, or veteran status.

Doctor of Philosophy (Ph.D.) in Biomedical Sciences

Degree Program

- Biochemistry and Molecular Biology Track (BMB)
- Biomedical Engineering and Physiology Track (BMEP)
- Clinical and Translational Science Track (CTS)
- Immunology Track (IMM)
- Molecular Pharmacology and Experimental Therapeutics Track (MPET)
- Neuroscience Track (NSC)
- Regenerative Sciences Track (REGS)
- Virology and Gene Therapy Track (VGT)

Purpose and Philosophy

The Biomedical Sciences Ph.D. Program is intended to train students in the most modern approaches to biomedical research, and to assist with development of analytical, technical, oral, and written communication skills, which allow students to become independent investigators of the most important and challenging problems in biomedical research.

Students are provided with a supportive atmosphere where they can find role models and mentors to emulate in the development of their research skills and begin acculturation into the biomedical research community. Courses introduce students to the body of information most important to their subsequent research endeavors and other educational activities facilitate the development of independent learning skills. Students are assisted with formulation of career goals and pathways which best utilize their individual talents and skills.

Mayo Clinic's Ph.D. program places heavier emphasis on research training than on course work. This philosophy is a natural outgrowth of the institution's long history as a center for investigation in the life sciences. Courses are, nevertheless, an integral part of the Ph.D. program providing the intellectual foundation necessary for a well-rounded scientist. A minimum of 66 credits is required of all Ph.D. students matriculating 2020 and forward; 42 for matriculants prior to 2020. (Difference now granting credit for Predoctoral Research course registration vs. no credit.) Mayo Clinic's graduate level courses in specific disciplines of the basic sciences will be adequate preparation for most students. All Ph.D. candidates must complete at least two years of full-time course registration at Mayo to be eligible for the degree.

Admission

Appointment Requirements

To be considered for admission to the Ph.D. program, applicants must:

1. Hold a bachelor's degree from an accredited college or university with a minimum 3.0 grade point average based on a 4.0 scale and supply the official transcript.
 - a. It is strongly recommended that candidates have completed at least one year of coursework, with demonstrated competence (B average or above), in the following undergraduate courses: biology, calculus, chemistry and physics.
 - b. In addition, foundation courses in biochemistry, molecular biology, cell biology and physiology are highly recommended. Biomedical Engineering and Physiology

- students are encouraged to have courses in quantitative science and engineering (e.g., signal processing, computer science, instrumentation).
2. Foreign applicants must demonstrate proof of English language proficiency to be considered for an appointment. This can be satisfied via the Test of English as a Foreign Language (TOEFL), or via other method as described on the English Language Proficiency Attestation.
 3. Each track may establish additional requirements.
 4. Applications will only be considered for review if they are submitted within the application submission window of September 1 – December 1 each year, for appointment in the following academic year.

Authority to make appointments rests with the Mayo Clinic Graduate School of Biomedical Sciences Education Committee. Falsifying or omitting information on or accompanying the application may disqualify an applicant from admission or subject a student to dismissal. The application and supporting documents become the property of MCGSBS upon receipt. The average number of years to degree is 5.2.

Inquiries regarding admission to the MCGSBS Ph.D. Program should be sent to:
mgsphdadmissions@mayo.edu

Core Courses

The core curriculum has been designed to provide a common fundamental knowledge base and technical language supporting multiple discipline-specific, advanced fields. With advice from a first year mentor and/or the program director, the core credits are chosen from the following courses:

Summer

*CORE 6000	Responsible Conduct of Research	1 cr.
CORE 6150	Genome Biology (begins in late July	3 cr.

Fall

CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6200	Basic Graduate Immunology.....	3 cr.

Winter

*CORE 6000	Responsible Conduct of Research	1 cr.
CORE 6250	Molecular Cell Biology	3 cr.
CORE 6400	Molecular Genetics	3 cr.
CORE 6770	Virology and Gene Therapy	3 cr.

Spring

CORE 6050	Critical Thinking and Scientific Writing.....	2 cr.
CORE 6300	Molecular Biophysics	3 cr.
CORE 6450	Molecular Pharmacology and Receptor Signaling	3 cr.
CTSC 6100	Molecular Mechanisms of Human Disease	3 cr.
**CORE 6001	Responsible Conduct of Research Refresher Course	0 cr.

*Students in Biomedical Engineering and Physiology are not subject to the same core requirements.

* Required of all students.

**The NIH requires Responsible Conduct of Research (RCR) instruction at least once during each career stage, and at a frequency of no less than once every four years. Ph. D. and M.D.–Ph.D. students will be notified by MCGSBS when they are required to take the refresher course and no grade will be assigned.

Area of Specialization/Track

In addition to the core courses, track courses are also required. These courses are chosen with the aid and approval of the student's mentor. Courses required by the different tracks are outlined in the next section. Any remaining credits needed to meet the minimum 66 required credits may be selected from any area that the student and mentor deem appropriate and necessary. The typical program structure is as follows:

- Year I Core, track course work, and laboratory rotations
- Year II Advanced courses and commencement of thesis research
- Year III, IV, & V Primarily thesis research with some additional advanced courses, seminars, and journal clubs.

All students enrolled in the Ph.D. program are full-time students. Full-time enrollment each quarter may include any combination of course work, laboratory rotations or research. This does not preclude students from registering for research before course work is complete. These students retain full-time enrollment status and will be graded on the S-N scale. No credit hours will be assigned, and research is not calculated in the GPA. Students who have completed all course work and are engaged in full-time thesis research must register for research each quarter.

Laboratory Rotations

Each student must complete three laboratory rotations in three different laboratories for a total of six credits. Rotations must be done in the laboratories of faculty with full graduate faculty privileges. These credits count towards the track credits required. Some comparable research experiences already completed may be considered to substitute for a required lab rotation. Eligible experiences for consideration include: Summer Undergraduate Research Fellowship (SURF); Mayo Post-baccalaureate Research Education Program (PREP); Graduate Research Education Program (GREP); and relevant Master's degree or other post-baccalaureate experience. For more details see the Lab Rotations Policy on the MCGSBS Policies and Procedures intranet site.

Mentor

A Ph.D. degree mentor must have full graduate faculty privileges and must be selected after three laboratory rotations have been completed. For more details see the Mentor Selection, Withdrawal and Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Official Degree Planning Tools

The use of a Degree Planning Tool (DPT) is required and allows students to list the course work to fulfill degree requirements, including transfer credits. Fifty percent of the credits counting toward degree must be graded on the A-F grading system.

The DPT must be completed during the first academic year and should be updated as courses are completed throughout the training program. The DPT should be reviewed periodically with the mentor or program director; frequency of review is at the program's discretion. Variation from the original course plan must be approved by the program director. A final completed DPT must be submitted to the school when a tentative defense date has been determined to be cleared to graduate. The DPT is available on the MCGSBS intranet site under [For Students/General Forms/Resources/PhD Forms](#).

Ph.D. students who matriculated prior to 2015 are allowed to submit a Degree Planning Form (DPF) in place of the DPT. All M.D.-Ph.D. students use the DPF in lieu of the DPT.

Minimum Grade Requirements

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Deficiencies and Unsatisfactory Progress Policy and Warning, Probation, Dismissal and Appeal Policy found on the MCGSBS Policies and Procedures intranet site.

Transfer Credits

A total of 21 credits may be transferred into the Ph.D. Program.

For more details, see the Credit Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Qualifying Examinations

The qualifying examinations are intended to test the student's fund of information in the sciences related to the chosen field of study and to evaluate the student's ability to reason critically.

Written Qualifying Examination

The written qualifying examination will test the breadth of biomedical knowledge, and analytic and critical reasoning skills. The content and format of the examination is determined by each track. The written qualifying examination may be taken no more than twice. If it is not passed on the first attempt, the exam must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination once will result in the student being placed on academic probation. Failing the examination twice will result in dismissal. The written qualifying examination must be completed by timeline defined by track, but at latest before September 30 of the third year for Ph.D. students, and before September 30 of the second year for M.D.-Ph.D. students. MCGSBS must be informed of the exam date three weeks in advance so that the Ph.D. Written Qualifying Examination Report form can be sent to the exam chair. For more details, see the Written Qualifying Exam Procedure on the MCGSBS Policies and Procedures intranet site.

Oral Qualifying Examination

Oral qualifying exam committee composition is determined collaboratively between student and student's mentor and requires approval of the program director and the school. Selection timeline varies by track, but at very latest must be before September 30 of the third year for Ph.D. students, and before September 30 of the second year for M.D-Ph.D. students. All members must have graduate faculty privileges.

The oral qualifying exam committee must consist of a minimum of four members and membership must include:

- OQE Chair
- Mentor
- A minimum of three members must have Full Faculty Privileges (FF).
- A minimum of two members must be designated Experienced Examiners, in any track.

Note: Tracks may have more specific requirements

For more details, see the Oral Qualifying Exam Committee Selection and Procedure on the MCGSBS Policies and Procedures intranet site.

When MCGSBS is notified that the written qualifying examination has been passed, the oral qualifying examination may be taken. MCGSBS must be informed of the date of the examination three weeks in advance so that the Ph.D. Oral Qualifying Examination Report form can be sent to the oral qualifying examination committee chair. The oral qualifying examination timeline varies by track, but at latest must be completed before December 31 of the third year for Ph.D. students, and before December 31 of the second year for M.D.-Ph.D. students. All approved committee members must be present at the exam. Any

absent member is considered a dissenting vote. Only one dissenting vote will be allowed for a “Pass” or “Conditional Pass.” In the event of a Conditional Pass, the specific requirements that must be satisfied by the student must be listed on the back of the Ph.D. Oral Qualifying Examination Report form. The oral qualifying examination may be taken no more than twice. If it is not passed on the first attempt, the exam must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination once will result in the student being placed on academic probation. Failing the examination twice will result in dismissal.

Thesis

Thesis Advisory Committee

Ph.D. candidates are expected to submit to the MCGSBS office the composition of their Thesis Advisory Committee (TAC) within 90 days of selecting a mentor.

The TAC composition is determined collaboratively between student and student’s mentor and requires approval of the program director and the school. All members must have graduate faculty privileges.

The TAC must consist of five members and membership must include:

- TAC Chair
- Mentor
- Three faculty members must have Full Faculty Privileges (FF), including the Chair.
- A minimum of two members must be Experienced Examiners, of any track.
- Two faculty members must have mentored a student to Ph.D. degree.
- The committee for M.D.-Ph.D. students must include a member of the M.D.-Ph.D. Executive Committee either as a voting member or ex-officio.
- The student may consider having the mentor and TAC Chair be separate to avoid potential conflict of interest. This is recommended by the graduate school, but not required.

Note: Tracks may have more specific requirements.

For more details, see the Thesis Advisory Committee Meeting Selection and Documentation Procedure on the MCGSBS Policies and Procedures intranet site.

Thesis Proposal

A written thesis proposal, presentation and thesis committee discussion of the proposal must be completed by December 31 of the student’s third year for Ph.D. students, depending on track, and by December 31 of the second year for M.D.-Ph.D. students. This requirement may be accomplished during the oral qualifying examination or at a separate committee meeting for this purpose. The TAC must be approved prior to this committee discussion.

The Mayo Institutional Review Board must review all protocols for research involving the use of human subjects. It is the candidate’s responsibility to secure approval of any such protocols before the research is undertaken.

Preparation of thesis

The thesis is the most important document that the Ph.D. candidate will prepare during the course of graduate study and is a record of the scientific accomplishments that justify the awarding of the degree. The thesis is archival. Consequently, MCGSBS has developed standards for its format and style, which should be closely followed. MCGSBS Thesis Guidelines for Ph.D. thesis are available on the MCGSBS intranet site under For Students/General Forms/Resources. The student’s mentor must sign a form

indicating that he/she has read the thesis and that it is ready for defense prior to distribution to the thesis advisory committee members. The Verification Thesis Ready to Defend form can be accessed on the MCGSBS intranet site under For Students/General Forms/Resources. The thesis must be submitted to the TAC at least three weeks prior to the final oral examination.

Students enrolled in the M.D.-Ph.D. program must submit their final thesis to their TAC and the Verification of Thesis Corrections Form must be signed and submitted to the MCGSBS office before they can resume studies in Mayo Clinic Alix School of Medicine (MCASOM).

Student Progress

Students must have meetings every six months with their TAC. Students are expected to register each quarter and will be contacted if they have not registered. To remain in good standing, compliance with all requirements is expected. Continuation of stipend depends upon remaining in good standing.

Fellowship Award Submission

Students must submit an application for extramural fellowship award or equivalent during their training.

- All Ph.D. students must submit a fellowship application, preferably during their 2nd year of study but by end of 3rd year. (Applies to students who matriculated in 2020 or after.) Alternatives for international students are explained in the Academic Success and Graduation Requirements Policy.
- All M.D.-Ph.D. students must submit an NIH F30 fellowship application (or equivalent) by the end of their 2nd PhD year.
- Students unable to identify an external organization to apply for a fellowship award must submit an F31 grant application template internally to the graduate school to meet this graduation requirement.

For more details, see the Fellowship Application and Award Policy on the MCGSBS Policies and Procedures intranet site.

Publication Requirement

Ph.D. thesis research must make a substantial contribution to the biomedical literature and preparing work for publication is an important part of research training. The expectation is that student thesis research will result in multiple publications, with the requirement for graduation of a minimum of one peer-reviewed first-authored original paper accepted for publication. Students are required to indicate in publications their affiliation with and support from MCGSBS. Exceptions to the publication requirement must be submitted as a recommendation from the TAC with endorsement from the program director, and approval by the MCGSBS Education Committee. For more details, see the Publication Requirement Policy and Publication Exception Request Procedure on the MCGSBS Policies and Procedures intranet site.

Final Oral Examination

The final oral examination will be scheduled after 1) the written qualifying and oral qualifying examinations have been passed, and 2) all course and non-course requirements have been met. , MCGSBS must be informed of the date of the examination three weeks in advance so that the Ph.D. Final Oral Examination Report form can be sent to the TAC Chair. The exam will be open to the Mayo public. Members of the TAC should receive copies of the thesis at least three weeks prior to the final oral examination.

The Chair must be present at the defense as a real time participant. Additional, voting members of the TAC must be present in real time via physical presence or video- or teleconferencing at the final oral examination. Only one dissenting vote will be allowed for a "Pass." Any absent voting member is considered a "Fail" vote. Passage of the final oral examination requires a minimum of four passing votes, otherwise a determination of "Fail" must be made. Thus, no more than one TAC member may be absent

for the final oral examination. The final oral examination may be taken no more than once. Failing the examination will result in dismissal. PhD appointments in MCGSBS will continue no more than 30 days beyond a successful thesis defense date.

For more details, see the Final Oral Examination-Thesis Defense Procedure on the MCGSBS Policies and Procedures intranet site.

Final Thesis Corrections

After the student has passed the final oral examination, the student has no more than 30 days to complete all degree requirements. The chair of the TAC must sign a form indicating he/she is satisfied that the final corrections to the thesis have been made and before the student will be cleared for graduation. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted. This requirement is satisfied by uploading the final thesis into ProQuest for publication with the option of adding a publication hold if needed. If a student does not wish to have their thesis published, they must submit a PDF version of the final thesis to the graduate school by their student end date.

Graduation

Students are granted degrees four times a year (3rd Friday except in May it is the date of commencement): February, May, August, and November. The May date involves a formal ceremony as part of the Mayo Clinic graduation exercises in conjunction with MCASOM. No ceremony is held in February, August, and November, but students who graduate at one of these times are encouraged to participate in the May ceremony.

Students are allowed no more than 30 days to complete Ph.D. degree requirements after a successful thesis defense. Students should also keep in mind that Ph.D. appointments in MCGSBS will continue no more than 30 days beyond a successful thesis defense when scheduling the thesis defense. If a student does not meet the thesis deadline, they will be required to re-defend their thesis.

For degree conferral in:	Defend by:	All Post-Defense Requirements completed by:
February	January 1	February 1
May	April 1	May 1
August	July 1	August 1
November	October 1	November 1

M.D. – Ph.D. Program

The M.D.-Ph.D. program is a highly competitive program for students with exceptional academic records and previous research experience. Both the M.D. and Ph.D. degrees may be earned in an integrated seven-to eight-year program. Students follow the Mayo Clinic Alix School of Medicine (MCASOM) curriculum for two years. Step 1 of the United States Medical Licensing Examination (USMLE) must be taken by the end of the second year and a passing score must be documented before entry into the Ph.D. phase of the dual degree. Students then begin Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) training. The advanced course work in the track and the thesis research are undertaken and usually completed in the next three to four years. During the final two years, students complete the MCASOM curriculum.

The elements of the Ph.D. training for students enrolled in the M.D.-Ph.D. program are generally the same as those for non-M.D.-Ph.D. candidates, except for laboratory rotations. M.D.-Ph.D. students are required to take the following courses:

Core Courses

CORE	6000	Responsible Conduct of Research
CORE	6100	Chemical Principles of Biological Systems (all tracks except BMEP)
CORE	6150	Genome Biology
CORE	6300	Molecular Biophysics (required for BMEP)
MGS	5000	Fundamental Skills (required starting with 2021 G1s)

Intermediate and Advanced Quantitative Biology Courses- 2 courses required (not required for BMEP)

BMB	6100	Macromolecular Structure and Dynamics
BMEP	6350	Advanced Concepts in Molecular Biophysics
CORE	6300	Molecular Biophysics
CORE	6450	Molecular Pharmacology and Receptor Signaling
CTSC	5400	Introduction to Bioinformatics Concepts and Core Technologies for Individualized Medicine Approaches
CTSC	5600	Statistics in Clinical and Translational Research
CTSC	5602	Utilizing Statics in Clinic Research
CTSC	5610	Introductory Statistical Methods II
CTSC	5650	Survival Analysis
CTSC	5740	Systematic Reviews and Meta-Analyses
CTSC	6160	Genomic Analysis & Data Interpretation for Rare & Undiagnosed Diseases
MPET	6450	Applied Data Science and Artificial Intelligence in Pharmacology
MPET	6813	Tutorial in Systems Pharmacology

M.D.-Ph.D. Selectives- both required

MDPH	5150	Grant Writing for MD-PhD Students
MDPH	5200	Critical Reading Skills for MD-PhD Students

Weekly M.D.-Ph.D. Conference – Required to register each year during the Ph.D. phase of the program:

MDPH	5300	Weekly MD-PhD Conference
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Submission of a fellowship application. All M.D.-Ph.D. students will work with their Mentors to prepare and submit an application for an F30 or equivalent fellowship before their 48th month in the program. Submission of a fellowship application is a program requirement.

Clinical Experience Elective Course. For MD-PhD students in the research years to maintain focused clinical training after having taken CLNX 7640 (MD-PhD Clinical Experience) for credit through MCASOM.

MDPH 6100 MD-PhD Clinical Experience

Senior Post Graduate MD-PhD Research Experience. For students who have completed all PhD requirements, completed all required medical school courses and electives and would like to return to the laboratory to work on a new project with a new laboratory mentor or complete a promising project that was started with their original mentor.

MDPH 6200 Senior Post Graduate MD/PhD Research Experience

Track Requirements

M.D.- Ph.D. students must complete all track-required courses, journal clubs and seminars; however, there are exceptions allowed for track electives and MCGSBS laboratory rotations. As a result of these exceptions, M.D.-Ph.D. students are allowed to take less than the standard 66 credits.

- Track electives are fulfilled by preclerkship medical school coursework.
- Laboratory rotations are satisfied by completing 2 or 3 one-month, full-time rotations. It is recommended that one rotation be completed before entering medical school, the second between during the preclerkship curriculum, and the third (optional) between medical school and graduate school (before or after taking USMLE Step 1).

MDPH 5000 Laboratory Rotation for M.D.-Ph.D. Students (4 weeks)

Waived Courses

CORE 6050 Critical Thinking & Scientific Writing – waived for M.D.-Ph.D. students in the Biomedical Engineering and Physiology and Clinical Translational Science, Neuroscience, and Regenerative Sciences tracks.

CORE 6200 Basic Graduate Immunology – waived for M.D.-Ph.D. students in the Immunology and Virology and Gene Therapy Tracks

CTSC 6100 Molecular Mechanisms of Human Disease – waived for M.D.-Ph.D. students in the Clinical and Translational Science Track

BMEP 6700 Physiology from Cells to Organisms – waived for M.D.-Ph.D. students in the Biomedical Engineering and Physiology Track (and students with existing MD if pass WQE)

MPET 5808 Introduction to Molecular Pharmacology – waived for M.D.-Ph.D. students in the Molecular Pharmacology and Experimental Therapeutics track

NSC 6401 Practical Neuroanatomy - waived for M.D.-Ph.D. students in the Neuroscience track

M.D.-Ph.D. candidates are expected to submit to the MCGSBS office the composition of their Thesis Advisory Committee (TAC) within 90 days of selecting a mentor. The thesis advisory committee must include a member of the M.D.-Ph.D. Executive Committee, either as a voting member or an ex-officio member.

Biochemistry and Molecular Biology (BMB) – Ph.D. Degree

John R. Hawse, IV, Ph.D., *Program Director*

Matthew J. Schellenberg, Ph.D., *Associate Program Director*

Biochemistry and Molecular Biology Track:

Biochemistry and Structural Biology (BSB) | Cell Biology and Genetics (CBG) | Cancer Biology (CB)

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have a 42 credit requirement, not counting Research credit.)

CORE Courses (12 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.
MGS 5000	Fundamental Skills (<i>required for 2021 matriculants and forward</i>).....	2 cr.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102	Lab Rotations (8 weeks).....	2 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (8 credits required)

BMB 5200	BMB Works in Progress (1 cr. /yr.)*.....	2 cr.
BMB 6500	BMB Journal Club (1 cr. /yr.)**.....	4 cr.
BMB 6900	BMB Thesis Proposal.....	2 cr.

*Two credits maximum. Students must attend all years enrolled in the program and present annually from Year 2 and on. At least 70% attendance is required.

**Four credits maximum. Students must register for and participate in the BMB JC their first year in the program. In subsequent years, students may continue to participate in the BMB JC or substitute the BMB journal club for any other journal club offered within the graduate school in years 2-5 should a different journal club better align with their research projects. Courses to be selected in consultation with your thesis mentor.

Elective Courses (18 credits required)

Students may select from any courses approved for graduate credit regardless of the track that they fall under. Students are expected to work with their mentor and TAC members to select the most appropriate courses for their training.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Must enroll every quarter once a thesis laboratory is selected for remainder of program.

Directed research projects under the supervision of a faculty mentor.

Lab Selection, Qualifying Exams and Thesis Research

Students are expected to complete their rotations and select the laboratory for their thesis studies within six months of joining the program.

Written Qualifying Exam

Written qualifying exam: Students take the written qualifying exam at the end of the first year. The exam is a one-day exam held at the beginning of July. The exam consists of demonstrating critical evaluation and understanding of two published primary research papers relevant to the broad field of Biochemistry and Molecular Biology as covered in the core courses CORE 6100, CORE 6150 and CORE 6250 as well as the elective courses, CORE 6400 and BMB 5000. Three sets of papers reflecting the three areas of emphasis of the track: BSB, CBG and CB, will be made available to the students three days before the exam. On the day of the exam, students are required to answer a series of specific questions associated with any two of the six papers. The questions will cover foundation of knowledge in addition to synthesis of concepts. The exam is prepared and graded by the faculty and an overall grade of 70% is required for successful completion of the exam.

Oral Qualifying Exam

Students are expected to take the oral qualifying exam by the end of their second year. This exam includes a thesis proposal and it is presumed that preliminary data in support of the project will be in hand. Concerns pertaining to the timing of this exam should be directed to BMB Track leadership. Before taking the exam, the student must prepare a final version of their thesis proposal and circulate it to their thesis committee at least two weeks before the examination. The thesis proposal serves as a springboard for faculty to probe the student's background knowledge, ability to propose and defend hypotheses, and design experiments to test these hypotheses. The oral qualifying exam committee must conform to MCGSBS requirements and be approved by the program director.

Thesis Proposal

The written thesis proposal matches the format of NIH F31 grants and, hence, is limited to 8 pages, including illustrations but not including references. In the student's own words, the proposal should outline the rationale for the proposed project and how it is to be executed. The proposal is subdivided into the following sections.

- 1) Abstract: Summary of your project (30 lines of text limit)
- 2) Specific Aims page: Describe briefly the aims of your project and hypotheses (1 page limit).
- 3) Research Strategy (6 page limit)
 - Significance: Put your project into context with what is known about this area of biology and show the importance of the questions you are asking (1-1.5 pages).
 - Innovation: How is the project you are proposing novel and groundbreaking (0.5-1 page).
 - Approach: Describe what you plan to do and how you plan to do it. Include preliminary data for each aim that sets the scene and supports your hypotheses (3.5-4.5 pages).

Reflecting the importance the track puts on the quality of this document and the role it plays in planning your thesis studies, 2 credits are given for preparing and defending the proposal (Registration in BMB, 6900). All students are expected to submit an F31 or equivalent grant to the NIH or any other funding agency that they are eligible for. Any student unable to identify a mechanism for which they are eligible must submit the grant to the graduate school.

Biomedical Engineering and Physiology (BMEP) – Ph.D. Degree

Kristin D. Zhao Ph.D., *Program Director*

Leigh G. Griffiths, Ph.D., MRCVS, *Associate Program Director*

Biomedical Engineering and Physiology has four major areas of emphasis:

Biomechanics | Biomedical Imaging | Molecular Biophysics | Physiology

Course Work

The curriculum for the Predoctoral degree consists of **72 or 73 credits** (depending on emphasis chosen), which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have 46 or 47 credit requirement, not counting Research credits.)

CORE Courses (8 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
*CORE 6050	Critical Thinking and Scientific Writing	2 cr.
CORE 6300	Molecular Biophysics	3 cr.
MGS 5000	Fundamental Skills (<i>required for 2021 matriculants and forward</i>).....	2 cr.

*M.D.-Ph.D. students may exclude these in accordance with M.D.-Ph.D. requirements.

Track Requirements (24 credits required)

BMEP 5200	Mathematics in Biomedical Engineering and Physiology.....	4 cr.
BMEP 5452	Biomechanics.....	3 cr.
BMEP 5704	Bio-Instrumentation and Signal Processing	3 cr.
BMEP 5800	Introduction to Medical Imaging.....	6 cr.
BMEP 6600	Biomedical Engineering and Physiology Seminars	1 cr.
BMEP 6650	BMEP Journal Club.....	1 cr.
*BMEP 6700	Physiology from Cells to Organism.....	6 cr.

*M.D.-Ph.D. students may exclude these in accordance with M.D.-Ph.D. requirements.

Also waived for students matriculating with an MD degree, contingent upon passing WQE.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102	Lab Rotations (8 weeks)	2 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)
Must enroll every quarter once a thesis laboratory is selected for remainder of program.
Directed research projects under the supervision of a faculty mentor.

Emphasis Requirements (10 or 11 credits required)

Biomechanics Emphasis (10 credits required)

BMEP 5250	Anatomy for Biomedical Engineering & Physiology.....	2 cr.
BMEP 5453	Fundamental Concepts in Biomechanics.....	3 cr.
BMEP 5802	Advanced Principles of Biomechanics	3 cr.
BMEP 6710	Numerical Methods in Biomedical Research	3 cr.
BMEP 6840	Laboratory Methods in Biomechanics	2 cr.
BMEP 6857	Tutorial in Cellular Mechanics.....	2 cr.
BMEP 6861	Tutorial in Skeletal Muscle Physiology.....	2 cr.

Biomedical Imaging Emphasis (minimum of 11 credits required)

BMEP 5100	Radiological Health	2 cr.
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BMEP 5160	Radiation Physics.....	3 cr.
BMEP 5250	Anatomy for Biomedical Engineering & Physiology.....	2 cr.
BMEP 5460	Finite Element Methods.....	3 cr.
BMEP 5550	Image Guided Procedures in Biomedical Applications	4 cr.
BMEP 5740	Magnetic Resonance Imaging Systems.....	3 cr.
BMEP 6100	Medical Health Physics.....	2 cr.
BMEP 6151	Radiation Oncology Physics.....	3 cr.
BMEP 6302	Tutorial in Ultrasonic Imaging.....	2 cr.
BMEP 6304	Tutorial in Physiological Imaging	2 cr.
BMEP 6490	Advanced Topics in Biomedical Image Processing.....	3 cr.
BMEP 6500	Special Topics in Imaging Science	2 cr.
BMEP 6710	Numerical Methods in Biomedical Research.....	3 cr.
BMEP 6720	Deep Learning for medical Resonance Imaging.....	3 cr.
BMEP 6730	Laboratory Methods in Magnetic Resonance Imaging.....	2 cr.
BMEP 6740	Advanced Topics in Magnetic Resonance Imaging	3 cr.
BMEP 6750	Magnetic Resonance Technical Seminar.....	1 cr.
BMEP 6770	Fuzzy Logic Theory and Applications.....	4 cr.
BMEP 6853	Readings in Biomedical Engineering	2 cr.

Molecular Biophysics Emphasis (minimum of 11 credits required)

CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
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Choose at least one:

CORE 6450	Molecular Pharmacology and Receptor Signaling.....	3 cr.
BMEP 6350	Advanced Concepts in Molecular Biophysics	4 cr.

Additional Courses - Choose at least three of the following:

BMB 6100	Macromolecular Structure and Dynamics	2 cr.
BMB 6050	Biological Kinetics	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.
CORE 6400	Molecular Genetics	3 cr.

Physiology Emphasis (10 credits required)

BMEP 6830	Laboratory Methods in Physiology.....	2 cr.
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Additional Courses:

Choose at least three of the following:

BMEP 6000	Tutorial in Exercise Physiology	2 cr.
BMEP 6300	Tutorial in Neurophysiology.....	3 cr.
BMEP 6855	Tutorial in Cardiovascular Physiology	3 cr.
BMEP 6856	Tutorial in Respiratory Physiology	3 cr.
BMEP 6858	Tutorial in Smooth Muscle Physiology.....	2 cr.
BMEP 6859	Tutorial in Renal Physiology.....	2 cr.
BMEP 6860	Tutorial in Endocrine Physiology.....	2 cr.
BMEP 6861	Tutorial in Skeletal Muscle Physiology.....	2 cr.
BMEP 6862	Tutorial in Neuromotor Control Physiology	2 cr.
BMEP 6863	Tutorial in Neural Engineering.....	2 cr.
BMEP 6870	Systems Physiology I.....	3 cr.
BMEP 6871	Systems Physiology II	3 cr.

Qualifying Exams and Thesis Research

During the first two years of the program, each student is expected to select a laboratory and thesis mentor. This occurs largely as a result of lab rotations. By the beginning of the second year all students should select an area of emphasis. Students may combine areas. At the beginning of the second year, all students must take and satisfactorily pass a comprehensive qualifying exam, consisting of both written and oral components. The written qualifying exam focuses on required core curriculum courses taken in the first year and tests the conceptual integration of material in these courses. The oral qualifying exam will include a presentation of proposed research and tests the synthesis of course work and research interests.

During the second year of the program it is expected that all students will have selected thesis mentor and a Thesis Advisory Committee with approval of the Biomedical Engineering & Physiology Education Committee. Students must have their first thesis committee meeting by March of their 3rd year.

Each student is expected to meet with their TAC at least twice a year to discuss progress towards their dissertation research. The TAC will decide when the research has progressed sufficiently so that a dissertation can be written, and the student will then write their dissertation and publicly defend it.

Clinical and Translational Science (CTS) – Ph.D. Degree

Felicity T. Enders, Ph.D., *Program Director (new effective January 2023)*

TBD, *Associate Program Director*

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have 42 credit requirement, not counting Research credit.)

CORE Courses (12 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6050	Critical Thinking and Scientific Writing*.....	2 cr.
CORE 6051	Scientific Writing Part II.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
MGS 5000	Fundamental Skills.....	2 cr.

*Clinical and Translational Science M.D.-Ph.D. students may exclude this in accordance with M.D.-Ph.D. requirements.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

The track education committee will guide students to a minimum of one rotation each in laboratory-based translational research (wet bench); patient-based translational research (human studies, clinical trials, CRU-based); and population-based translational research (epidemiology, statistics, health outcomes, biomedical ethics, community engagement).

MGS 5102	Lab Rotations (8 weeks).....	2 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (17 credits required)

CTSC 5020	Regulatory Issues in Clinical Research.....	1 cr.
CTSC 5070	Introduction to Community Engagement.....	1 cr.
CTSC 5080	Introduction to Health Disparities.....	1 cr.
CTSC 5370	Introduction to Epidemiology.....	2 cr.
CTSC 5600	Introduction to Statistics in Clinical and Translational Research.....	2 cr.
CTSC 5602	Introduction to Utilizing Statistical Software in Clinical and Translational Research.....	1 cr.
CTSC 5720	Clinical Trials: Design and Conduct.....	1 cr.
CTSC 6100	Molecular Mechanisms of Human Disease*.....	3 cr.
CTSC 6110	CTS Works in Progress**.....	1 cr.
CTSC 6120	Case Studies in Translation.....	2 cr.
CTSC 6130	CTS Journal Club**.....	1 cr.
CTSC 5100	Academic Publishing.....	1 cr.

(Students gain credit only for quarters in which they present. Minimum one credit required.)

*Clinical and Translational Science M.D.-Ph.D. students may exclude this in accordance with the M.D.-Ph.D. requirements.

**Students gain credit only for quarters in which they present. Minimum one credit required.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Must enroll every quarter once a thesis laboratory is selected for remainder of program.

Directed research projects under the supervision of a faculty mentor.

Advanced and Elective Courses (9 credits required)

Sixty-six credits are required for graduation. In addition to the core and track requirements, courses should be selected after consultation between the student, their mentor, and the program director/associate program director. Depending on the student's area of concentration (laboratory, patient or population-based translational science) additional advanced courses will be selected from either CTSC track courses or MCGSBS core courses in the basic science disciplines.

Qualifying Exams and Thesis Research**Written Qualifying Examination (WQE)**

The written qualifying examination tests your breadth of biomedical knowledge, as well as your analytical and critical reasoning skills. This examination must be completed before the end of your second year in the program. The CTS predoctoral programs education coordinator will assist you with the examination timeline.

The purpose of the Written Qualifying Examination (WQE) is to evaluate student's PhD thesis project. The examination will be in the format of a project proposal pulling components from the NIH F30 grant for dual degree candidates (MD/PhDs), the F31 grant for doctoral trainees (PhDs), other equivalent grant appropriate upon approval.

In general, the proposal-based examination consists of documents that demonstrate the following:

- The ability to identify a substantive proposal topic
- The ability to formulate valid and testable hypotheses
- The ability to identify the importance of and justification for the proposed research, by preparing a comprehensive review of related research literature and presenting the proposed project in that context
- The ability to prepare a sound research plan that includes both appropriate techniques and approaches suitable for the testing of the hypotheses and alternative strategies and hypotheses
- The ability to articulate an understanding of clinical and translational science and team science as it relates to proposed research

These courses must be completed before you take the exam:

- CORE 6000 Responsible Conduct of Research
- CORE 6050 Critical Thinking and Writing
- CORE 6051 Scientific Writing Part II
- CORE 6100 Chemical Principles of Biological Systems
- CORE 6150 Genome Biology
- CTSC 5020 Regulatory Issues in Clinical Research
- CTSC 5370 Introduction to Epidemiology
- CTSC 5600 Introduction to Statistics in Clinical and Translational
- CTSC 5602 Introduction to Utilizing Statistical Software in Clinical and Translational Research

Oral Qualifying Examination (OQE)

For the oral qualifying examination, students submit a written thesis proposal and defend their thesis research proposal to the Oral Qualifying Exam Committee. The proposal should summarize the goals, methods, and rationale for the research project. The specific guidelines for the form of this proposal are available from the CTS predoctoral education coordinator. This proposal must be submitted to the oral qualifying exam committee at least one week prior to the examination. The oral examination is composed of two or three parts. The first part will be an oral presentation by the student of their proposal; the second part will be a discussion between the student and the committee about this proposal.

If there were any conditional elements or weaknesses identified at the time of the written qualifying exam, the committee may then add a third part to the examination which will include a wide-ranging discussion of either the area of deficiency or course work material covered by the student during the first two years. Students will be notified after their written qualifying examination whether this third component should be expected during the oral qualifying exam.

Pre-Thesis Advisory Committee (Pre-TAC)

CTS students are strongly advised to form a pre-TAC by the end of their first year after their mentor selection to support their experiential training. This will prepare students for the formation of their formal TAC. The pre-TAC will help the student and mentor identify key team members for an official TAC and formulate specific aims that will form the basis of the student's thesis proposal moving forward.

Thesis Advisory Committee

The student, their thesis mentor and the CTS predoctoral program director/associate director will establish a formal TAC to monitor the student's thesis research progress. This should be established no later than the beginning of the student's second year. The student's adviser is chair of the committee. Students are required to meet with their thesis advisory committee at least once every six months. At the meetings, the student will present progress on his, her, or their thesis project. The committee will offer advice, and an evaluation of the student's progress will be discussed with the student at the end of the meeting.

Thesis proposal

Students must complete a written thesis proposal, presentation and thesis committee discussion of their proposal. This requirement may be accomplished during the oral qualifying examination or at a separate committee meeting for this purpose. The student's TAC must be approved prior to this committee discussion.

Publication requirement

Ph.D. thesis research must make a substantial contribution to the biomedical literature, and preparing work for publication is an important part of research training. The expectation is that thesis research will result in multiple publications. To graduate, students need to publish at least one original peer-reviewed paper on which they are first author.

Immunology (IMM) – Ph.D. Degree

Kay L. Medina, Ph.D., *Program Director*

Haidong Dong, M.D., Ph.D., *Associate Program Director, MN*

Henrique Borges da Silva, Ph.D. *Associate Program Director, AZ*

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have 42 credit requirement, not counting Research credit.)

CORE Course (12 credits required)

CORE 6000 Responsible Conduct of Research..... 1 cr.

CORE 6100 Chemical Principles of Biological Systems..... 3 cr.

CORE 6150 Genome Biology..... 3 cr.

**CORE 6200 Basic Graduate Immunology 3 cr.

**CORE electives* 6 cr.

MGS 5000 Fundamental Skills (*required for 2021 matriculants and forward*)..... 2 cr.

* Ph.D. students may take any core courses approved for graduate credit as electives.

** Immunology M.D.-Ph.D. students may exclude these in accordance with M.D.-Ph.D. requirements.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102 Lab Rotations (8 weeks)..... 2 cr.

M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (4 credits required)

During the first two years, students must take a total of four credits as follows: IMM 6863 for one credit each for each of the first and second years. The final two credits can be taken from a combination of any of the following: IMM 6862, IMM 6867 (up to 2 credits), or one credit can be from a journal club in another track.

*Immunology M.D.-Ph.D. students may fulfill this requirement by taking IMM 6863 twice for credit and MDPHD 5300 twice for credit.

IMM 6862 Current Topics in Cell Activation and Signaling..... 1 cr.

IMM 6863 Current Topics in Immunology 1 cr.

IMM 6867 *Current Topics in Barrier Immunology..... 1 cr.

*may be taken twice for credit

Track Tutorials (12 credits required)

Students are required to take the following tutorial courses.

IMM 6878 Tutorial in Innate Immunity and Immunometabolism 2 cr.

IMM 6879 Tutorial in Cellular Activation 2 cr.

IMM 6880 Tutorial in Immunopathology..... 2 cr.

IMM 6882 Tutorial in Mucosal Immunology..... 2 cr.

IMM 6884 Tutorial in Tumor Immunology..... 2 cr.

IMM 6885 Tutorial in the Generation and Function of B Cells..... 2 cr.

Electives/ Other Required CORE & Upper Level Courses (10 credits total required)

Approximately 6 of these credits should be taken from CORE courses, while approximately 4 should be from upper-level courses. MD-PhD students are only required to take 4 elective credits from upper-level courses; these are often MD-PhD program required courses. Any group of courses offered by MCGSBS can be used to fulfill this requirement; however, students are expected to choose courses that complement their thesis work and careers. Also, the plans for elective coursework must be approved by the IMM graduate program director.

In addition, before completion of the program, all students are encouraged to attend the one week long summer course in advanced immunology sponsored by the American Association of Immunologists.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Must enroll every quarter once a thesis laboratory is selected for remainder of program.

Directed research projects under the supervision of a faculty mentor.

Qualifying Exams and Thesis Research

By the end of the first year of the program, each student is expected to select a laboratory and thesis mentor. At the beginning of the second year, all students take a written and oral qualifying exam. The written exam precedes the oral exam and is administered over two consecutive half-day sessions. This exam covers fundamental Immunology, including the material taught in the core Immunology course and the six required Immunology tutorials. The exam is prepared and graded by the faculty responsible for teaching the courses.

All student are strongly encouraged to schedule and take the IMM oral qualifying exam 8 weeks after the written qualifying exam. All students must take and satisfactorily pass the oral qualifying exam no later than October 31 of the third year. Immunology Track students are required to have five faculty members on their exam committee, the composition of which will be determined by the Immunology Program Director with input from the student and the mentor. The student and mentor may choose two examiners, and the Immunology Program Director, drawing from a designated pool of examiners, will choose the remaining three.

A written thesis proposal, presentation, and Thesis Advisory Committee (TAC) discussion of the proposal must be completed by the middle of the student's third year. Immunology Track degree candidates, however, are strongly encouraged to complete this requirement within two months of successfully passing the oral qualifying exam. The student should work with the lab mentor to prepare a 6-7 page written thesis proposal (single-spaced, ½ inch margins on all sides, Arial 11 font; references are required but are not included in the 6-7 page limit) in the format of an F31/F30 NIH fellowship grant. Students who have taken CORE6050 are taught how to write such a document during the course. All students are expected to prepare the thesis proposal by working closely with their lab mentor. The composition of the TAC will be determined by the mentor with input from the student and must be approved by the Immunology Program Director and MCGSBS. The TAC must consist of a minimum of five faculty members; three members must have full privileges.

Molecular Pharmacology and Experimental Therapeutics (MPET) – Ph.D. Degree

Martin E. Fernandez-Zapico, M.D., *Program Director*

TBD, *Associate Program Director*

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have 42 credit requirement, not counting Research credit.)

CORE Courses (15 credits, all required courses)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.
CORE 6450	Molecular Pharmacology and Receptor Signaling.....	3 cr.
MGS 5000	Fundamental Skills (<i>required for 2021 matriculants and forward</i>).....	2 cr.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102	Lab Rotations (8 weeks).....	2 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (12 credits required)

MPET 5100	Pharmacology Seminar Series (required attendance; no credit)	
MPET 5808*	Introduction to Molecular Pharmacology.....	4 cr.
MPET 6800	Research Seminars in Pharmacology (1 cr. /yr.).....	4 cr.
MPET 6805	Drug Metabolism and Pharmacogenomics.....	2 cr.
CTSC 5600	Statistics in Clinical and Translational Research.....	2 cr.

*MPET M.D.-Ph.D. students may exclude in accordance with M.D.-Ph.D. requirements.

Track Tutorials (6 credits required or 3 tutorials required)

MPET 6400	Introduction to Principles of Pharmacokinetics.....	2 cr.
MPET 6450	Applied Data Science and Artificial Intelligence in Pharmacology.....	2 cr.
MPET 6655	Mechanisms of Cell Growth and Death.....	2 cr.
MPET 6811	Tutorial in Cardiovascular Pharmacology.....	2 cr.
MPET 6812	Tutorial in Molecular Pharmacology and Receptor Signaling.....	1 cr.
MPET 6813	Tutorial in Systems Pharmacology.....	2 cr.
MPET 6814	Cellular Pharmacology of Agents that Target Cancer.....	2 cr.
MPET 6815	Neurobehavioral Pharmacology.....	2 cr.
MPET 6820	Regenerative Medicine.....	2 cr.

Electives (5 credits required)

Any courses approved for graduate credit; select in consultation with your thesis mentor.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Must enroll every quarter once a thesis laboratory is selected for remainder of program.

Directed research projects under the supervision of a faculty mentor.

Qualifying Exams and Thesis Research

Written qualifying exam: Ph.D. students can take the written qualifying exam at the end of the first or second year, but no later than September 30 of the third year. M.D.- Ph.D. students must take the written qualifying exam before December 31 of the second year. The written exam covers the fundamentals of pharmacology, including the material covered in all of the required MPET track required courses including, (MPET 6450), Applied Data Science and Artificial Intelligence in Pharmacology or (MPET 6813), Tutorial in Systems Pharmacology. In addition, each student is asked to write an "NIH-style grant" based on data in a recent research article in one of the fields of molecular pharmacology. The exam is prepared and graded by the faculty.

Oral qualifying exam: The oral qualifying exam must be taken by December 31 of the student's third year. In this exam, students orally present a preliminary thesis proposal, which serves as a springboard for faculty to probe the student's background knowledge, ability to propose hypotheses, and design experiments to test hypotheses. The oral qualifying exam committee must conform to the MCGSBS requirements and be approved by the program director.

Thesis proposal: A written thesis proposal in the format of an NIH R01 grant must be presented to your Thesis Advisory Committee within two months of completing the oral qualifying exam.

The proposal should be divided into the following sections:

- **Abstract:** Summary of your project.
- **Specific Aims:** Describe briefly the aims of your project and hypotheses.
- **Significance and Innovation:** Put your project into context with what is known about this area of biology and show the importance of the questions you are asking.
- **Approach:**
 - A. Background and Preliminary Data: Describe the results you (and others) have obtained, in your host laboratory (and in collaboration), that set the scene for your proposal and supports your hypotheses.
 - B. Rationale: Here, you summarize AGAIN your key background and preliminary data, facts and say why they support your hypothesis and approach. Explain why in general you chose your particular specific aims/experiments/approach to test your hypothesis.
 - C. Research Plan: Describe what you plan to do and how you plan to do it. Break this down by specific aims. Include expected outcomes and potential pitfalls for each aim.

Neuroscience (NSC) – Ph.D. Degree

Owen A. Ross, Ph.D., *Program Director, Mayo Clinic in Florida*

Long-Jun Wu, Ph.D., *Associate Program Director, Mayo Clinic in Rochester*

Wolfdieter Springer, Ph.D., *Associate Program Director, Mayo Clinic in Florida*

John D. Fryer, Ph.D., *Associate Program Director, Mayo Clinic in Arizona*

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have 42 credit requirement, not counting Research credit.)

CORE Courses (15 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6050*	Critical Thinking and Scientific Writing	2 cr.
CORE 6051	Scientific Writing Part II.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.
MGS 5000	Fundamental Skills (<i>required for 2021 matriculants and forward</i>).....	2 cr.

*Neuroscience M.D.-Ph.D. students may exclude in accordance with M.D.-Ph.D. requirements.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102	Lab Rotations (8 weeks)	6 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (21 credits required)

NSC 6210	Neurobiology of Disease	3 cr.
NSC 6310	Methods in Neuroscience Research	2 cr.
NSC 6250	Skills for Effective Presentations	2 cr.
NSC 6401*	Practical Neuroanatomy	2 cr.
NSC 6600	Neuroscience Journal Club (1 cr. / yr.)**.....	2 cr.
NSC 6650	Works in Progress (1 cr. / yr.)**.....	2 cr.
NSC 6857	Systems Neuroscience and Behavior	3 cr.
NSC 6862	Molecular and Cellular Neuroscience	3 cr.
NSC 6900	NSC Thesis Proposal.....	2 cr.

*Neuroscience M.D.-Ph.D. students may exclude in accordance with M.D.-Ph.D. requirements.

**Two credits maximum.

Suggested Electives (2 credits required)

NSC 5600	Behavioral Neurology	2 cr.
BMEP 6300	Tutorial in Neurophysiology	3 cr.
MPET 6820	Regenerative Medicine.....	2 cr.
CORE 6200	Basic Graduate Immunology.....	3 cr.
CORE 6400	Molecular Genetics	3 cr.
CORE 6450	Molecular Pharmacology and Receptor Signaling.....	3 cr.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Must enroll every quarter once a thesis laboratory is selected for remainder of program.

Directed research projects under the supervision of a faculty mentor.

Sixty-six credits are required for graduation. In addition to the core and track requirements, additional courses should be selected after consultation between the student and their mentor. Any courses offered by the MCGSBS may be taken for elective credit.

Thesis Mentor

Ideally, you will have identified a thesis mentor by the end of your third rotation. However, additional rotations can be performed if necessary. If you have not identified a thesis mentor after three rotations, you should meet with the program director to discuss any problems/concerns you may have experienced during your rotations and to discuss the identification of another rotation. If you are unable to choose a mentor after 5 rotations you must resign from the program.

Thesis Advisory Committee

You should form your thesis advisory committee within 90 days of selecting your mentor and joining their lab. This committee has a minimum of 5 members who should be identified with the help of your thesis mentor. The committee composition must be approved by the program director. In consultation with your mentor you should select one committee member other than your mentor to serve as the chair of this committee and they must, therefore, have full graduate faculty privileges. Overall, three of the committee members must have full graduate privileges, two of the members must have successfully mentored a student to degree, and two members must be from your degree track. This committee is intended to help you become a successful scientist – as such, and due to the natural evolution of Ph.D. research projects, the committee composition may change over time. Any changes should be discussed thoroughly with your thesis mentor and approved by the program director. Appropriate paperwork for the committee roster must be filed within 90 days of selecting your thesis mentor.

First TAC Meeting: Your first TAC meeting should occur within 90 days of selecting your thesis lab. At this meeting you will introduce your committee to your proposed thesis project area and should include the hypothesis, specific aims, and experimental objectives that you intend to accomplish during your Ph.D. research. Your committee will discuss your intentions and determine whether they represent an appropriate *starting point* for your thesis research. The initial thesis proposal is not a contract between you and the committee – all Ph.D. projects evolve in response to actual experimentation and your final thesis research may differ substantially from your original proposal. Likewise, your committee may modify their expectations and requirements throughout the course of your thesis research. An important aspect of successful Ph.D. training is constant communication with your thesis committee.

Qualifying Exams and Thesis Research

Written Qualifying Exam

Neuroscience students will meet the requirement of the written qualifying exam by preparing a submission-ready pre-doctoral grant application (F31 or equivalent) by the end of fall quarter, year 2. Students will receive ample instruction into the format and expected content of the proposal during CORE6050/6051 the scientific writing courses. All pre-doctoral grants will be reviewed by faculty for quality before a passing grade is conferred. Completion of an acceptable pre-doctoral grant will constitute a passing grade on the written qualifying exam. All students are *required* to submit the application to a funding agency during the following calendar year (January-December/Yr2-3).

Oral Qualifying Exam

The oral qualifying exam is a critical step on the road to acquiring the Ph.D. You are *strongly* encouraged to discuss the oral exam with the program director or educational coordinator well in advance of the end of your 6th quarter.

Timing: The graduate school formally allows students to delay their oral exam until the end of the 2nd year. While this remains an option, Oral qualifying exams should be scheduled no earlier than the 5th quarter, but before the end of your 8th quarter (basically towards the end of your second year). Students will disseminate their Thesis Proposal (F31 or equivalent grant application prepared for the written qualifying exam) to members of their oral exam committee at least 3 weeks before the exam. This document will be used as the basis for your oral exam. Paperwork must be submitted with the graduate school at least three weeks before the scheduled exam.

Committee Composition: The oral exam committee usually mirrors your TAC and includes a minimum of 4 members chosen for their expertise in the general area of research relevant to the student's proposal. The oral exam committee will always include two designated examiners, one of whom should be a member of the NSC Education Committee in order to ensure that all candidates meet a standard level of general background knowledge and to ensure that each candidate is tested fairly on the basis of their readiness for advancement to candidacy, rather than upon the quality of their preliminary data, the nature of their research project, or the influence of their faculty mentor. All members must be approved by the program director and site-specific associate director and should be selected after extensive discussion between the student and their faculty mentor.

Exam Format: The exam will be driven by a well-written, in-depth F31-like proposal focused upon the student's general research area. The oral exam will emphasize general neuroscience knowledge, the ability to generate hypotheses, the ability to "think on your feet", and the ability to diagram and explain scientific concepts (a "chalk talk" format). The exam will also probe the depth of knowledge specific to the proposed area of research. Ultimately, any aspect of scientific thinking and general scientific knowledge is fair game, but the intention of this exam is not to trick or confuse but rather to provide a fair and supportive environment in which each student can prove their readiness for advancement to candidacy.

Fellowships

All eligible students are *required* to apply for pre-doctoral funding via the National Research Service Award (NRSA) mechanism (F31) or equivalent. The written qualifying exam and thesis proposal format is intended to assist in the preparation of a competitive NRSA application. Further information is available at <http://grants.nih.gov/training/nrsa.htm> or the Publication Requirement Policy.

Lab Changes

Changes in thesis mentor are strongly discouraged after the 6th quarter. If changes are requested after this time they will be approved at the discretion of the program director and School.

Regenerative Sciences (REGS) – Ph.D. Degree

Isobel A. Scarisbrick, Ph.D., *Program Director*

Quinn P. Peterson, Ph.D., *Associate Program Director – Rochester Campus*

Clifford D. Folmes, Ph.D., *Associate Program Director – Arizona Campus*

Tsuneya Ikezu, M.D., Ph.D., *Associate Program Director – Florida Campus*

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits.

CORE Courses (14 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.
CORE 6050	Critical Thinking and Scientific Writing*.....	2 cr.
MGS 5000	Fundamental Skills (<i>required for 2021 matriculants and forward</i>).....	2 cr.

*Regenerative Sciences M.D.-Ph.D. students may exclude this in accordance with M.D.-Ph.D. requirements but highly recommended to facilitate preparation of thesis proposal.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102	Lab Rotations (8 weeks).....	2 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (14 credits required)

REGS 5200	Fundamentals of Regenerative Sciences.....	2 cr.
REGS 5300	Stem Cells and Development.....	3 cr.
REGS 5500	Topics in Regenerative Sciences and Medicine**.....	1-3 cr.
REGS 6400	Regenerative Tissue Engineering Principals (<i>future offering</i>).....	4 cr.
REGS 5800	Developmental Biology.....	2 cr.
CTSC 5210	Ethics and Regenerative Medicine.....	2 cr.
MPET 6820	Regenerative Medicine Principles to Practice.....	2 cr.

**Three credits maximum, (1 cr./yr.) starting year 2

Research (maximum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Directed research projects under the supervision of a faculty mentor.

Students must enroll every quarter once a thesis laboratory is selected for the remainder of program, usually beginning in year 3.

Elective Courses (10 credits required)

In addition to the core and track requirements, elective courses should be selected after consultation between the student, their mentor, and the program director/associate program director, based on area of emphasis.

Recommended Elective Courses

CTSC 6100	Molecular Mechanisms of Human Disease.....	2 cr.
IMM 6865	Regenerative T Cell Immunotherapy and Cellular Engineering.....	3 cr.
REGS TBD	Genomic and Epigenomic Data Integration (<i>future offering</i>).....	3 cr.
REGS TBD	Biomaterials and Advanced Tissue Engineering (<i>future offering</i>)	2 cr.
REGS 5210	Advanced Regenerative Medicine and Surgery.....	2 cr.
BMB 6150	Epigenomics Journal Club	2 cr.
CORE 6200	Basic Graduate Immunology.....	2 cr.
CIE 6150	Case Studies in Entrepreneurship.....	2 cr.
CTSC 6120	Case Studies in Translation	3 cr.
CORE 6770	Virology and Gene Therapy	3 cr.
MPET 6813	Tutorial in Systems Pharmacology.....	2 cr.

Potential Pathways to Elective Credits

The following are some recommended pathways to fulfill the elective credits. Students may follow one of these pathways or make their own selections for elective credits.

Advanced Tissue Engineering Emphasis

REGS TBD Biomaterials and Advanced Tissue Engineering (*future offering*)

Regulatory Science in Regenerative Medicine Emphasis

CIE 6150 Case Studies in Entrepreneurship

CTSC 6120 Case Studies in Translation

Data Science in Regeneration Emphasis

MPET 6813 Tutorial in Systems Pharmacology

REGS TBD Genomic and Epigenomic Data Integration (*future offering*)

BMB 6150 Epigenomics Journal Club

Regenerative Genetic Engineering and Immunology Emphasis

CORE 6200 Basic Graduate Immunology

CORE 6770 Virology and Gene Therapy

IMM 6865 Regenerative T Cell Immunotherapy and Cellular Engineering

Regenerative Neuroscience

NSC 6210 Neurobiology of Disease

NSC 6857 Systems Neuroscience and Behavior

NSC 6862 Molecular and Cellular Neuroscience

Qualifying Exams and Thesis Research

Written Qualifying Examination (WQE)

The written qualifying examination tests your breadth of biomedical knowledge, as well as your analytical and critical reasoning skills and is intended to evaluate whether a student has sufficient knowledge and competency in regenerative sciences to continue to PhD candidacy. This examination must be completed before the end of your second year in the program. The REGS Education Coordinator will assist you in ensuring completion of this exam on schedule.

For the WQE, students will develop a research question and prepare a submission-ready pre-doctoral grant application (F31 or equivalent). The pre-doctoral grant will be reviewed by faculty and a passing grade granted for completion of the WQE. The grant proposal will be evaluated to determine the

student's understanding of the field of regenerative sciences, ability to establish a research plan to address the proposed question and ability for independent thought.

The following courses must be completed before you take the exam:

- CORE 6100 Chemical Principles of Biological Systems
- CORE 6150 Genome Biology
- CORE 6250 Molecular Cell Biology
- REGS 5300 Stem Cell and Development
- REGS 6400 Regenerative Tissue Engineering Principles*
- REGS 5800 Developmental Biology
- CTSC 5210 Ethics and Regenerative Medicine
- MPET 6820 Regenerative Medicine Principles to Practice*

*Courses must be completed or students must be concurrently enrolled at the time of the exam.

Oral Qualifying Examination (OQE)

For the oral qualifying examination, students will be evaluated on their theoretical and practical knowledge in the regenerative sciences. Students will defend their thesis research proposal to the Oral Qualifying Exam Committee. The proposal should summarize the goals, methods, and rationale for the research project. This examination must be completed before the end of your second year in the program. The guidelines for this oral presentation are available from the REGS Education Coordinator. The oral examination is composed of two or three parts. The first part will be an oral presentation by the student of their proposal; the second part will be a discussion between the student and the committee about this proposal.

If there were any conditional elements or weaknesses identified at the time of the written qualifying exam, the committee may then add a third part to the oral examination which will include a wide-ranging discussion of either the area of deficiency or course work material covered by the student during the first two years. Students will be notified after their written qualifying examination whether this third component should be expected during the oral qualifying exam.

Formation of Thesis Advisory Committee (TAC)

REGS students are strongly advised to form a TAC by the end of their first year and within 90 days of mentor selection to support their experiential training. TAC formation at this early stage will help the student and mentor chart progress through coursework, qualifying exams, and project development. TAC members may change during PhD studies. Early TAC formation should be viewed as a starting point to aid the student in formulating specific aims that will form the basis of the thesis proposal. Including a TAC member external to Mayo Clinic is encouraged, but not required..

The student, their thesis mentor and the REGS predoctoral program director/associate director will establish a formal TAC to monitor the student's thesis research progress. The TAC must be approved by the REGS Education Committee. This should be established no later than the beginning of the student's second year. The student's adviser is chair of the committee. Additional requirements regarding committee composition may be obtained from the REGS Education Coordinator.

Thesis Advisory Committee Meetings

Students are required to meet with their thesis advisory committee at least once every six months. At the meetings, the student will present progress on his, her, or their thesis project. The committee will offer advice, and an evaluation of the student's progress will be discussed with the student at the end of the meeting.

Thesis Proposal

Students must complete a written thesis proposal, presentation, and thesis committee discussion of their proposal. This requirement may be accomplished during the written and oral qualifying examinations or at the first thesis committee meeting after advancement to candidacy. The student's TAC must be approved prior to this committee discussion.

Virology and Gene Therapy (VGT) – Ph.D. Degree

Michael A. Barry, Ph.D., *Program Director*

Autumn J. Schulze, Ph.D. *Associate Program Director*

Course Work

The curriculum for the Predoctoral degree consists of **68 credits**, which can include a maximum of 24 Research credits. (Matriculants prior to 2020 have 42 credit requirement, not counting Research credit.)

CORE Courses (18 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6200*	Basic Graduate Immunology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.
CORE 6770	Intro to Virology and Gene Therapy.....	3 cr.
MGS 5000	Fundamental Skills (<i>required for 2021 matriculants and forward</i>).....	2 cr.

*Neuroscience M.D.-Ph.D. students may exclude in accordance with M.D.-Ph.D. requirements.

Lab Rotations (6 credits maximum, a minimum of 3 rotations)

MGS 5102	Lab Rotations (8 weeks).....	2 cr.
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M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (6 credits required)

VGT 6740	Viruses and Vectors Journal Club (1 cr. /yr.).....	3 cr.
VGT 6745	Current Topics in VGT (1 cr. /yr.).....	3 cr.

Track Tutorials (8 credits required)

Tutorials will be presented in the areas of Virology and Gene Therapy and in related areas. Students are required to take all three VGT tutorials (VGT 6884, 6886, 6888). They are also required to take one additional tutorial from another track that supports their thesis research.

VGT 6884	Viral Disease Tutorial (odd years).....	2 cr.
VGT 6886	Tutorial in Molecular Virology (odd years).....	2 cr.
VGT 6888	Gene Therapy Tutorial (even years).....	2 cr.

Electives (6 credits required)

Any course approved for graduate credit, including elective core courses.

Research (minimum 24 credits required)

MGS 6890 Predoctoral Research (3 cr./qtr x minimum 8 terms)

Must enroll every quarter once a thesis laboratory is selected for remainder of program.

Directed research projects under the supervision of a faculty mentor.

Postdoctoral Basic Science Master's Degree Program

Descriptions and Track Requirements

- Artificial Intelligence in Health Care Track (AIHC)
- Biochemistry and Molecular Biology Track (BMB)
- Clinical and Translational Science Track (CTS)
- Immunology Track (IMM)
- Molecular Pharmacology and Experimental Therapeutics Track (MPET)
- Regenerative Sciences (REGS)
- Virology and Gene Therapy Track (VGT)

Master of Science – Postdoctoral or Doctoral Candidates

The Postdoctoral Master of Science (M.S.) Program in Biomedical Sciences is designed to advance research training through a combination of course work, a mentored research experience and the development of a manuscript submitted for publication.

Eligibility

Applicants must be an appointed Mayo Clinic physician, scientist, fellow/resident or student with a doctoral degree in a discipline applicable to clinical research. Some tracks are also available for doctoral-seeking students, e.g., medical student, with plans for a research career. Medical students, residents and fellows must have a minimum of 1 year of protected time in their training program to complete course requirements and begin their research project. The research project may take an additional 2-3 years to complete, but must be completed by the end of the training period.

Scholars must have a Mayo Clinic appointment of sufficient length to allow for completion of all requirements of the program. Tracks may have more defined eligibility criteria. More details on eligibility for the CTS track can be found [here](#).

The opportunity to take graduate school courses is a benefit and privilege for qualified learners, but not a guarantee. Permission to take courses may be restricted and/or forfeited at the discretion of the learner's program director if expectations of the learner's primary training role are not being met. Any violation of Mayo Clinic policies may forfeit acceptance into a Master's degree program.

Cost

A Program Fee is due upon admission. More details available on the [MCGSBS Master's Programs web page](#), including options for financial support.

Application

Candidates must complete a formal application. More details are available on the [MCGSBS Master's Programs web page](#). Additional details specific to the CTS Master's Program can be found [here](#). Applicants must be approved by the track program director and admission endorsed by MCGSBS.

Time Requirement

Time to completion can vary by program and Mayo Clinic role from two to five years. Most master's programs are designed to be completed in approximately 2 years. All scholars must be in their program a minimum of 1 year in order to meet the MCGSBS residency requirement. Scholars must complete all program requirements within 5 years. The ability to attend all required courses during the first year is a

critical requirement for successful completion of the degree. All requirements must be satisfied within 30 days of the thesis defense.

Registration Requirement

At least 75% of the coursework for the Master's degree must be completed in MCGSBS. Enrollment in the degree program for a minimum of one year is required.

Minimum Credit Requirements

Students must complete a minimum of 45 credits, which can include a maximum of 16 Research credits. (See individual specialty track descriptions for specific course requirements.) It is expected that a minimum of one year will be devoted to research.

Transfer Credits

A total of 6 didactic credits may be transferred into the program. For more details, see the Credit Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Mentor

A Master's degree mentor must have MCGSBS full or Master's graduate faculty privileges. A list of Faculty with Privileges can be found on the MCGSBS intranet site.

Official Degree Planning Tool

The use of a Degree Planning Tool (DPT) is required and allows students to list the course work to fulfill degree requirements, including transfer credits. Fifty percent of the credits counting toward degree must be graded on the A-F grading system.

The DPT should be completed during the first academic year and should be updated as courses are completed throughout the training program. A final completed DPT must be reviewed with the student's mentor before finalizing a defense date, and submitted to the school when a defense date has been determined (ideally 8 weeks prior to defense). The DPT is available on the MCGSBS intranet site under [For Students/General Forms/Resources/Master's Forms](#).

Minimum Grade Requirements

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Deficiencies and Unsatisfactory Progress Policy and Warning, Probation, Dismissal and Appeal Policy outlined on the MCGSBS Policies and Procedures intranet site.

Examinations

Written Examination

A comprehensive written examination must be taken before completion of the training program. The written examination may be taken no more than twice. Failing the examination twice will result in dismissal. The written examination must be passed before the final oral examination may be scheduled.

Final Oral Examination

Candidates for the Master's degree are expected to pass the final oral examination before completion of the Mayo residency or fellowship training program. The final oral examination may be taken after: 1) the written examination has been passed, 2) all course work has been completed, and 3) the thesis is reviewed and deemed ready to defend.

Voting members of the Thesis Advisory Committee must be present in real time via physical presence or video- or teleconferencing at the final oral examination. Only one dissenting vote will be allowed for a "Pass." Passage of the final oral examination requires a minimum of three passing votes; otherwise a determination of "Fail" must be made. Thus, no more than one Thesis Advisory Committee member may be absent for the final oral examination. The final oral examination may be taken no more than twice. If it is not passed on the first attempt, it must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination twice will result in dismissal.

Thesis

Research Proposal: The research proposal must clearly define the candidate's role in the project and must have sufficient detail to permit review by an advisory committee. Additional details on the research proposal can be found on the [Master's Forms web page](#).

Thesis Advisory Committee: After approval by the track, students submit the Master's [Thesis Advisory Committee E-Form](#) recommending the members of their Thesis Advisory Committee (TAC). All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. The TAC must consist of:

- Four members, including the student's mentor
- Mentor serves as the chair of the TAC
- Any additional members beyond four will be designated as ex-officio and will not vote at the final defense.
- No more than two members may have Teaching/Examining Privileges (TE).

Some tracks may define more specific criteria.

Progress Meetings: The Master's Thesis Advisory Committee must meet at minimum every six months from the date of committee approval. Documentation of student progress using a **progress meeting report form**, must be signed by all members of the Thesis Advisory Committee, and saved within the program. The report form templates can be found on the [Master's Forms web page](#).

Preparation of Thesis: The thesis is the most important document that the Master's candidate will prepare during the course of graduate study and is a record of the scientific accomplishments that justify the awarding of the degree. The thesis is submitted to ProQuest. Consequently, MCGSBS has developed a standard for its format and style, which should be closely followed. Guidelines for Master's thesis are available on the MCGSBS intranet site under For Students/General Forms/Resources.

Final Thesis Corrections: After the student has passed the final oral examination, the chair of the Thesis Advisory Committee must sign a form indicating he/she is satisfied that the final corrections to the thesis have been made. The chair must sign before the student will be cleared for graduation. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted.

Graduation

Students are granted degrees four times a year (3rd Friday except in May it is the date of commencement): February, May, August, and November. Students are allowed no more than 30 days to complete Master's degree requirements after a successful thesis defense. If a student does not meet this deadline, he/she will be required to re-defend their thesis.

Artificial Intelligence in Health Care (AIHC) – Postdoctoral Masters

David R. Holmes, III Ph.D., *Program Director*

Postdoctoral Basic Science Master’s Degree

The Master’s degree track in Artificial Intelligence in Health Care is open only to Mayo Clinic employees who have a doctoral degree in a discipline applicable to clinical research. Doctoral candidates may be considered. Potential candidates for the degree must hold Mayo Clinic appointments of sufficient duration to complete the program requirements.

Pre-Requisite Course Work (more resources to be added)

- 1) Introduction to statistics: Data summarization and statistical testing (like CTSC 5600)
- 2) Linear Algebra: Matrix Math
- 3) Calculus: Single variable (“Calc 1”)
- 4) Introduction to Scientific Programming (Python and/or R preferred)

Course Requirements

The curriculum for the Master’s degree consists of **45 credits**. The student must complete all of the required courses listed below:

Track Requirements (15 credits required)

AIHC	5010	Introduction to Machine Learning.....	3 cr.
AIHC	5020	Introduction to Data.....	3 cr.
AIHC	5030	Introduction to Deployment, Adoption and Maintenance.....	2 cr.
BMEP	5200	Mathematics in Biomedical Engineering & Physiology (1 st qtr only).....	2 cr.
AIHC	5500	Machine Learning Journal.....	1 cr.
CTSC	5300	Fundamentals of Epidemiology.....	1 cr.
CTSC	5350	Ethics Issues in Artificial Intelligence and Information Technologies.....	1 cr.
AIHC	5615	Fundamentals of Statistics for Artificial Intelligence.....	2 cr.

Elective Courses (5 credits required)

Students can choose to focus their elective credits into one of the concentration areas listed below or select their elective credits based on recommendations from their mentor or based on their professional goals.

Concentration Requirements

Signals & Systems (6 credits required)

BMEP	6720	Deep Learning for Medical Imaging.....	3 cr.
BMEP	5704	Bio-instrumentation & Signal Processing.....	3 cr.

Discovery Science (6 credits required)

CTSC	5140	Epigenetic & Epigenomics: Impact on Translational Research.....	2 cr.
CTSC	5410	Molecular Variant Evaluation.....	1 cr.
CTSC	5500	Modern Genetic Epidemiology.....	1 cr.
CTSC	6160	Genomic Analysis & Data Interpretation for Rare & Undiagnosed Diseases.....	2 cr.

Discovery Science – Molecular Genetics (6 credits required)

CORE	6400	Molecular Genetics.....	3 cr.
CTSC	5400	Introduction to Bioinformatics Concepts & Core Technologies.....	1 cr.
MPET	6450	Applied Data Science & Artificial Intelligence in Pharmacology.....	2 cr.

Applied Clinical Informatics (6 credits required)

AIHC	5960	Introduction to Medical Informatics.....	2 cr.
AIHC	5961	Health Information Technology Evaluation: Clinical Informatics Methods.....	1 cr.
AIHC	5962	Clinical Surveillance, Alerting & Data Representation (<i>future offering</i>).....	1 cr.
AIHC	5963	Health Information Security (<i>future offering</i>).....	1 cr.
AIHC	5964	AI&HIT Implementation.....	1 cr.

Translational & Regulatory (6 credits required)

AIHC	5045	FDA & ISO Software Verification & Validation (<i>future offering</i>).....	1 cr.
CTSC	5020	Regulatory Issues in Clinical Research.....	1 cr.
CTSC	5025	Introduction to Regulatory Science.....	1 cr.
CTSC	5035	Case Studies in Regulatory Science.....	1 cr.
CTSC	5400	Introduction to Bioinformatics Concepts & Core Technologies.....	1 cr.
CTSC	5720	Clinical Trials: Design & Conduct.....	1 cr.

Research

It is expected that a minimum of one year will be devoted to research.

MGS Course Requirements (19 credits required)

MGS	6100	Master’s Thesis Proposal.....	3 cr.
MGS	6840	Master’s Research (4 cr/qtr – 4 qtrs required, 16 credits)	16 cr.

Written Qualifying Exam (WQE)

The WQE is designed to demonstrate a student’s ability to integrate and synthesize the core competencies of the program. Students must pass the WQE to complete the degree requirements.

Thesis Defense (Final Oral Examination)

The final oral examination cannot be completed until the following criteria have been met:

- The Written Qualifying Examination has been passed,
- All coursework has been completed with a GPA of 3.0 or higher,
- All program milestones have been met, and
- AIHC Postdoctoral Programs Committee has reviewed and approved the thesis proposal

Publication Requirement

Master’s thesis research must make a substantial contribution to the biomedical literature, and preparing work for publication is an important part of research training. The expectation is that thesis research will result in multiple publications. To graduate, students need to publish at least two original peer-reviewed papers on which they are first author.

Biochemistry and Molecular Biology (BMB) – Postdoctoral Masters

John R. Hawse, IV, Ph.D., *Program Director*

Matthew J. Schellenberg, Ph.D., *Associate Program Director*

Biochemistry and Molecular Biology Track:

Biochemistry and Structural Biology; Cell Biology and Genetics; Cancer Biology Sub-tracks

BMB Postdoctoral Basic Science Master's Degree

This Master's degree track in Biochemistry and Molecular Biology is open only to residents and research fellows in the Mayo School of Graduate Medical Education. It offers a flexible course for Master's study that can be designed to emphasize one of three areas of specialty: Biochemistry and Structural Biology (BSB), Cell Biology and Genetics (CBG) or Cancer Biology (CB).

Course Requirements

The curriculum for the Basic Science Master's degree consists of **45 credits**, which can include a maximum of 16 Research credits.

MGS Course Requirements (19 credits required)

MGS 6100	Master's Thesis Protocol	3 cr.
MGS 6840	Master's Research (4cr/qtr – 4qtrs required, 16 credits).....	16 cr.

Biomedical Science Requirements (10 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems	3 cr.
CORE 6150	Genome Biology	3 cr.
CORE 6250	Molecular Cell Biology	3 cr.

Elective Courses (12 credits required)* Any courses approved for graduate credit.

Journal Clubs (maximum of 4 credits)*

Any graduate school approved Journal Clubs.

*Courses to be selected in consultation with your project mentor.

Research

It is expected that a minimum of one year will be devoted to research.

Written Qualifying Exam

The Master's candidate must pass the BMB Written Qualifying Exam to complete the degree requirements. Students take the written qualifying exam once they have completed the core courses and have considered whether to take the others featured in the exam. The exam is a one-day exam held at the beginning of July and consists of demonstrating critical evaluation and understanding of two published primary research papers relevant to the broad field of Biochemistry and Molecular Biology as covered in the core courses CORE 6100, CORE 6150 and CORE 6250. Three sets of papers reflecting the three areas of emphasis of the track: BSB, CBG and CB, will be made available to the students three days before the exam. On the day of the exam, students are required to answer a series of specific questions associated with any two of the six papers. The questions will cover foundation of knowledge in addition to synthesis of concepts. The exam is prepared and graded by the faculty and an overall grade of 70% is required for successful completion of the exam.

Clinical and Translational Science (CTS) – Postdoctoral Masters

M. Hassan Murad, M.D., *Program Director*

CTS Postdoctoral Basic Science Master’s Degree

The [Master’s degree track in Clinical and Translational Science](#) is open only to Mayo Clinic employees who have a doctoral degree in a discipline applicable to clinical research and are pursuing a clinical and translational research project that will lead to improvements in human health. Potential candidates for the degree must hold Mayo Clinic appointments of sufficient duration to complete the program requirements. Visiting research fellows are eligible to apply. However, visiting clinicians and research trainees are not eligible.

Course Work

The curriculum for the Master’s degree consists of **45 credits**. The student must complete all of the required courses listed below:

MGS Course Requirements (19 credits required)

MGS	6100	Master’s Thesis Proposal.....	3 cr.
MGS	6840	Master’s Research (4 cr/qtr – 4 qtrs required, 16 credits).....	16 cr.

CORE Course Requirements (1 credit required)

CORE	6000	Responsible Conduct of Research.....	1 cr.
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Track Requirements (16 credits required)

CTSC	5010	Clinical Research Proposal Development.....	2 cr.
CTSC	5020	Regulatory Issues in Clinical Research.....	1 cr.
CTSC	5100	Academic Publishing.....	1 cr.
CTSC	5110	Grant Writing in the Sciences.....	1 cr.
CTSC	5370	Introduction to Epidemiology.....	2 cr.
CTSC	5390	Advanced Applied Epidemiologic Methods.....	2 cr.
CTSC	5600	Introduction to Statistics in Clinical and Translational Research	2 cr.
CTSC	5602	Introduction to Utilizing Statistical Software in Clinical and Translational Research.....	1 cr.
CTSC	5610	Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software.....	3 cr.

Choose one of the following:

CTSC	5710	Practical Data Collection.....	1 cr.
CTSC	5810	Qualitative Research Design, Methods and Analysis.....	1 cr.
CTSC	5820	Introduction to Survey Research.....	1 cr.

Elective Courses (9 credits required)

Students can choose to focus their elective credits into one of the concentration areas listed below or select their elective credits based on recommendations from their mentor or based on their professional goals. Students are encouraged to select their elective credits from CTSC courses – CORE courses are also acceptable. However, other courses listed in the MCGSBS catalog may be taken with prior approval from the CCaTS Postdoctoral Executive Committee. Note: CTSC 5300 will only count as an elective if a scholar

transferred into the Master's program from the CCaTS Certificate program and completed the course prior to April 2020.

Concentration Requirements

Biomedical Ethics (BET) (5 credits required)

CTSC 5260	Advanced Methods in Biomedical Ethics Research.....	1 cr.
CTSC 5261	Theoretical and Historical Foundations of Biomedical Ethics.....	2 cr.
CTSC 5262	Case Studies in Health Policy and biomedical Ethics.....	1 cr.
CTSC 5263	Ethical Issues in Population Health Science.....	1 cr.

Clinical Innovation & Entrepreneurship (CIE) (5 credits required)

CIE 6150	Case Studies in Entrepreneurship.....	2 cr.
CIE 6151	Case Studies in Entrepreneurship: Key Resources & Revenue Streams.....	1 cr.
CIE 6152	Case Studies in Entrepreneurship: Risk Assessment, Prototyping, and Commercialization Plan.....	1 cr.
CTSC 6170	The Science of Team Science: Strategies for Success.....	1 cr.

Clinical Trials (CLTR) (5 credits required)

CTSC 5025	Introduction to Regulatory Science.....	1 cr.
CTSC 5650	Advanced Statistics in Clinical and Translational Research: Survival Analysis with Statistical Software	1 cr.
CTSC 5720	Clinical Trials: Design and Conduct.....	1 cr.

Select 2 credits from:

CTSC 5070	Introduction to Community Engagement.....	1 cr.
CTSC 5080	Introduction to Health Disparities.....	1 cr.
CTSC 5640	Logistic Regression	1 cr.
CTSC 5761	Evidence-Based Medicine for Clinical Researchers	1 cr.
CTSC 5770	Diagnostic Testing Strategies.....	1 cr.
CTSC 5820	Introduction to Survey Research (NOTE: excluded if taken as a foundational credit)..	1 cr.

Health Care Delivery (HCD) (5 credits required)

CTSC 5900	Introduction to Health Services Research.....	1 cr.
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Select 4 credits from:

CTSC 5640	Advanced Statistics in Clinical and Translational Research: Logistic Regression with Statistical Software.....	1 cr.
CTSC 5715	Publication Quality Tables and Figures.....	1 cr.
CTSC 5740	Systematic Reviews and Meta-Analysis.....	2 cr.
CTSC 5810	Qualitative Research Design, Methods and Analysis (NOTE: excluded if taken as a foundational credit).....	1 cr.
CTSC 5820	Introduction to Survey Research (NOTE: excluded if taken as a foundational credit)..	1 cr.
CTSC 5910	Economic Evaluation in Health Care	1 cr.
CTSC 5940	Secondary Data Analysis	1 cr.

Individualized Medicine (IDVM) (5 credits required)

CTSC 5340	Ethical Issues in Individualized Medicine.....	1 cr.
CTSC 5400	Introduction to Bioinformatics Concepts and Core Technologies.....	1 cr.
CTSC 5410	Molecular Variant Evaluation.....	1 cr.
CTSC 6160	Genomic Analysis and Data Interpretations for Rare and Undiagnosed Diseases.....	2 cr.

Mixed Methods Research (MIXM) (5 credits required)

CTSC 5810 Qualitative Research Design, Methods, and Analysis (NOTE: excluded if taken as a foundational credit)...	1 cr.
CTSC 5815 Qualitative and Mixed Methods Research for Translational Science.....	2 cr.
CTSC 5820 Introduction to Survey Research (NOTE: excluded if taken as a foundational credit).....	1 cr.
Select 1 credit from:	
CTSC 5263 Ethical Issues in Population Health Science.....	1 cr.
CTSC 5720 Clinical Trials: Design and Conduct...	1 cr.
CTSC 5860 Behavioral Interventions in Clinical Trials.....	1 cr.
CTSC 5900 Introduction to Health Services Research and Policy.....	1 cr.
CTSC 5940 Secondary Data Analysis.....	1 cr.

Quantitative Research Methods (QUAN) (5 credits required)

CTSC 5640 Advanced Statistics in Clinical and Translational Research: Logistic Regression with Statistical Software.....	1 cr.
CTSC 5650 Advanced Statistics in Clinical and Translational Research: Survival Analysis with Statistical Software	1 cr.

Select 3 credits from:

CTSC 5500 Modern Genetic Epidemiology.....	1 cr.
CTSC 5641 Comparative Effectiveness Research: Observational Studies and Pragmatic Trials....	1 cr.
CTSC 5710 Practical Data Collection (NOTE: excluded if taken as a foundational credit).....	1 cr.
CTSC 5715 Publication Quality Tables and Figures	1 cr.
CTSC 5740 Systematic Reviews and Meta-Analysis	2 cr.
CTSC 5815 Qualitative and Mixed Methods Research for Translational Science.....	2 cr.
CTSC 5820 Introduction to Survey Research (NOTE: excluded if taken as a foundational credit)..	1 cr.
CTSC 5940 Secondary Data Analysis.....	1 cr.

Research

It is expected that a minimum of one year will be devoted to research.

Research Proposal

Students develop their research proposals in CTSC 5010: Clinical Research Proposal Development and submit their proposal to the CCaTS Postdoctoral Programs Executive Committee following completion of the course. Proposals are due on February 1 or August 1 following course completion. Members of the CCaTS Scientific Review Group review research proposals, and the CCaTS Masters and Certificate Programs Executive Committee approves them. Details on Research Proposal found [here](#).

Thesis Advisory Committee

When developing your TAC, consider the following:

- Your mentor serves as committee chair.
- Identify three additional faculty members from at least two different clinical research disciplines.
- Identify one member with expertise in statistics, epidemiology or study design.
- It is desirable to have a member with basic science or translational laboratory expertise related to your project.

Additional guidelines specific to CTS scholars are defined [here](#).

Progress Meetings: The CTS scholars must submit their completed [CTSA Master's Thesis Committee Meeting Progress Report Form](#) for approval by the CCaTS Masters and Certificate Executive Committee.

Written Qualifying Exam (WQE)

The WQE is designed to demonstrate a student's ability to integrate and synthesize the core competencies of the program. Students must pass the WQE to complete the degree requirements. The one-day exam is held the third Tuesday of January, April and September. Students can take the WQE once they have their research proposal approved by the CCaTS Masters and Certificate Programs Executive Committee and have earned a minimum GPA of 3.0 in the following courses:

CTSC	5010	Clinical Research Proposal Development
CTSC	5370	Introduction to Epidemiology
CTSC	5390	Advanced Applied Epidemiologic Methods
CTSC	5600	Introduction to Statistics in Clinical and Translational Research
CTSC	5602	Introduction to Utilizing Statistical Software in Clinical and Translational

Research

CTSC	5610	Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software
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Thesis Defense (Final Oral Examination)

The final oral examination cannot be completed until the following criteria have been met:

- The Written Qualifying Examination has been passed,
- All coursework has been completed with a GPA of 3.0 or higher,
- All program milestones have been met, and
- CCaTS Postdoctoral Programs Committee has reviewed and approved the thesis

Publication Requirement

Master's thesis research must make a substantial contribution to the biomedical literature, and preparing work for publication is an important part of research training. The expectation is that thesis research will result in multiple publications. To graduate, students need to have a minimum of two-three original peer-reviewed papers on which they are first author.

Immunology (IMM) – Postdoctoral Masters

Kay L. Medina, Ph.D., *Program Director*

Haidong Dong, M.D., Ph.D., *Associate Program Director*

Henrique Borges da Silva, Ph.D. *Associate Program Director, ARZ*

IMM Postdoctoral Basic Science Master’s Degree

The Master’s degree track in Immunology is open only to residents and research fellows in the Mayo School of Graduate Medical Education.

Course Requirements

The curriculum for the Basic Science Master’s degree consists of **45 credits**, which can include a maximum of 16 Research credits.

MGS Course Requirements (19 credits required)

MGS 6100	Master’s Thesis Protocol	3 cr.
MGS 6840	Master’s Research (4cr/qtr – 4qtrs required, 16 credits).....	16 cr.

Biomedical Science Requirements (12 credits required)

Students are expected to complete 12 credits of course work selected from the Biomedical Sciences core curriculum. CORE 6000 and CORE 6200 must be selected. Students with extensive background in particular areas of the core curriculum will have the opportunity to test out of the core courses.

Track Requirements (4 credits required)

Each student will be expected to take a minimum of four credits offered by the Immunology faculty in areas specific to the student’s research interest. IMM 6863 must be taken at least once. The three remaining credits in Current Topics can be any combination of the following journal clubs:

IMM 6862	Current Topics in Cell Activation and Signaling.....	1 cr.
IMM 6863	Current Topics in Immunology.....	1 cr.
IMM 6867	*Current Topics in Clinical and Translational Immunology	1 cr.

*IMM 6867 may be taken twice for credit

Written Examination

The Master’s candidate must pass the Immunology written qualifying exam to complete the degree requirements.

Track Tutorials (8 credits required)

IMM 6878	Tutorial in Innate Immunity and Immunometabolism.....	2 cr.
IMM 6879	Tutorial in Cellular Activation.....	2 cr.
IMM 6880	Tutorial in Immunopathology.....	2 cr.
IMM 6882	Tutorial in Mucosal Immunology.....	2 cr.
IMM 6884	Tutorial in Tumor Immunology.....	2 cr.
IMM 6885	Tutorial in the Generation and Function of B Cells.....	2 cr.

Students who are not currently enrolled in a degree program must first obtain a signature from the IMM graduate program before enrolling in any IMM tutorial course.

Electives (2 credits required)

Any courses approved for graduate credit; select in consultation with your mentor.

Research: It is expected that a minimum of one year will be devoted to research.

Molecular Pharmacology and Experimental Therapeutics (MPET) – Postdoctoral Masters

Martin E. Fernandez-Zapico, M.D., *Program Director*
TBD, *Associate Program Director*

MPET Postdoctoral Basic Science Master's Degree

The Master's degree track in Molecular Pharmacology and Experimental Therapeutics offers a Master's degree within the Biomedical Sciences Program. This track is only open to residents and research fellows in the Mayo Clinic School of Graduate Medical Education.

Course Requirements

The curriculum for the Basic Science Master's degree consists of 45 credits, which can include a maximum of 16 Research credits.

MGS Course Requirements (19 credits required)

MGS	6100	Master's Thesis Protocol	3 cr.
MGS	6840	Master's Research (4cr/qtr – 4qtrs required, 16 credits).....	16 cr.

Biomedical Science Requirements (12 credits required)

Students are expected to complete 12 credits of introductory Biomedical Sciences courses chosen from the core curriculum. These 12 credits must include CORE 6000, Responsible Conduct of Research.

Track Requirements (9 credits required)

CORE	6450	Molecular Pharmacology and Receptor Signaling.....	3 cr.
MPET	5808	Introduction to Molecular Pharmacology.....	4 cr.
MPET	6805	Drug Metabolism and Pharmacogenomics.....	2 cr.

Track Tutorials (3 credits or 2 courses required from the following)

MPET	6400	Introduction to Principles of Pharmacokinetics.....	2 cr.
MPET	6655	Mechanisms of Cell Growth and Death.....	2 cr.
MPET	6811	Tutorial in Cardiovascular Pharmacology.....	2 cr.
MPET	6812	Tutorial in Molecular Pharmacology and Receptor Signaling.....	1 cr.
MPET	6813	Tutorial in Systems Pharmacology.....	2 cr.
MPET	6814	Cellular Pharmacology of Agents that Target Cancer.....	2 cr.
MPET	6815	Neurobehavioral Pharmacology.....	2 cr.

Electives (2 credits required)

Any courses approved for graduate credit; select in consultation with your mentor.

Research

Students will identify a research mentor on entry into the degree program. It is assumed that the equivalent of 12 months will be spent in full-time academic work, which will consist primarily of research, but will also involve advanced course work.

Regenerative Sciences in Medicine (REGS) – Postdoctoral Masters

Richard Hayden, M.D., *Program Director*

Saranya Wyles, M.D., Ph.D., *Associate Program Director*

Course Work

The curriculum for the Master’s degree consists of **45 credits**. The student must complete all of the required courses listed below:

Prerequisite Courses (4 credits required)

REGS 5200	Fundamentals of Regenerative Sciences.....	2 cr.
REGS 5210	Advanced Regenerative Medicine and Surgery.....	2 cr.

CORE Courses (12 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6050	Critical Thinking and Scientific Writing.....	2 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.

Track Requirements (8 credits required)

REGS 5300	Stem Cells and Development.....	3 cr.
REGS 5500	Topics in Regenerative Sciences and Medicine.....	1 cr.
CTSC 5210	Ethics and Regenerative Medicine.....	2 cr.
MPET 6820	Regenerative Medicine Principles to Practice.....	2 cr.

Elective Courses (2 credits required)

In addition to the core and track requirements, 2 credits of electives are required.

Recommended Elective courses include:

CTSC 6100	Molecular Mechanisms of Human Disease.....	2 cr.
CORE 6200	Basic Graduate Immunology.....	2 cr.
CTSC 6100	Molecular Mechanisms of Human Disease.....	3 cr.
CORE 6770	Virology and Gene Therapy.....	3 cr.
CTSC 6120	Case Studies in Translation.....	3 cr.
CIE 6150	Case Studies in Entrepreneurship.....	2 cr.
IMM 6865	Regenerative T Cell Immunotherapy and Cellular Engineering.....	3 cr.
REGS 5800	Developmental Biology.....	2 cr.
REGS 6400	Regenerative Tissue Engineering Principles.....	4 cr.
REGS 6500	Introduction to Translational BioProduct Development (<i>future offering</i>)	
REGS 6700	Genomic and Epigenomic Data Integration.....	3 cr.

Research Requirements (19 credits required)

MGS 6100	Master’s Thesis Proposal.....	3 cr.
MGS 6840	Master’s Research (4 cr/qtr – 4 qtrs required, 16 credits).....	4 cr.

Qualifying Exams and Thesis Research

Written Qualifying Examination (WQE)

The WQE is designed to demonstrate a student's ability to integrate and synthesize the core competencies of the program. Students must pass the WQE to complete the degree requirements.

For the WQE, students will develop a fundamental research question and write a critical literature review based on this selected topic in regenerative sciences in medicine. The topic should be selected by the student in consultation with their thesis mentor.

Formation of Thesis Advisory Committee (TAC)

Master's students are strongly advised to form a TAC within 60 days of mentor selection to support their experiential training. TAC formation at this early stage will help the student and mentor chart progress through coursework, qualifying exam and project development. TAC members may change over the course of master's studies and this early TAC formation should be viewed as a starting point to aid the student to formulate specific aims that will form the basis of the student's thesis proposal moving forward.

The student, their thesis mentor and the REGS master's program director/associate director will establish a formal TAC to monitor the student's thesis research progress. This should be established no later than 90 days from the beginning of the student's program start. The student's mentor is chair of the committee.

Thesis Advisory Committee Meetings

Students are required to meet with their thesis advisory committee at least once every three months. At the meetings, the student will present progress on his, her, or their thesis project. The committee will offer advice, and an evaluation of the student's progress will be discussed with the student at the end of the meeting.

Thesis Proposal

Students must complete a written thesis proposal, presentation and thesis committee discussion of their proposal. This requirement may be accomplished during the written qualifying examination or at the first thesis committee meeting. The student's TAC must be approved prior to this committee discussion.

Thesis Defense (Final Oral Examination)

The final oral examination cannot be completed until the following criteria have been met:

- The Written Qualifying Examination has been passed,
- All coursework has been completed with a GPA of 3.0 or higher,
- All program milestones have been met, and
- REGS master's program director/associate director have reviewed and approved the thesis proposal

Publication Requirement

Master's thesis research must make a substantial contribution to the biomedical literature and preparing work for publication is an important part of research training. The expectation is that thesis research will result in publication. To graduate, students need to publish one or two original peer-reviewed papers on which they are first author.

Virology and Gene Therapy (VGT) - Postdoctoral Master's Degree

Michael A. Barry, Ph.D., *Program Director*

Autumn J. Schulze, Ph.D., *Associate Program Director*

Postdoctoral Basic Science Master's Degree – 45 credits required over 2 years

The Postdoctoral Master's degree track in Virology and Gene Therapy has two pathways to choose from:

The **REGULATORY/TRANSLATIONAL PATHWAY** student will gain a broad scope of gene therapy and will learn how to develop a gene based therapeutic from an idea to a validated product. Various gene therapy strategies will be considered in relation to a broad spectrum of human diseases illustrating how genes can be used for gene replacement, tissue engineering, destruction of unwanted tissues, or immune stimulation. Stages in the development of gene-based drugs & biologics will be studied from vector design through preclinical proof of efficacy, clinical protocol development, product manufacture, pharmacology and toxicology testing, analysis of clinical trial outcomes, regulatory affairs, patenting and partnering with industry. *The Regulatory/Translation pathway is designed for those learners who desire to conduct or participate in research that will identify therapies/devices that will move into manufacturing facilities.*

The **RESEARCH PATHWAY** student will learn from and work alongside faculty members who have primary interests in virology, viral vectors and gene therapy and will develop research skills in conducting and participating in vaccine and gene therapy discovery. These areas overlap with the fields of biochemistry, cell and molecular biology, genetics, and immunology and regulatory science. *The Research pathway is designed for learners who desire to be an informed member of a research team conducting or participating in Virology and Gene Therapy research.*

Coursework

Scholars in the Postdoctoral Master's Degree Program in virology and gene therapy are expected to gain competencies through carefully selected didactic coursework and a mentored research project.

Regulatory/Translation Pathway

CORE Courses (21 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6050	Critical Thinking & Scientific Writing	2 cr.
CTSC 5020	Regulatory Issues in Clinical Research	1 cr.
CTSC 5025	Introduction to Regulatory Science	1 cr.
CTSC 5035	Case Studies in Regulatory Science.....	1 cr.
CTSC 5300	Introduction to Clinical Epidemiology	1 cr.
CTSC 5600	Statistics in Clinical & Translational Research.....	2 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology	3 cr.
CORE 6770	Intro to Virology and Gene Therapy	3 cr.
CTSC 5040	Intro to the Principles of Current Good Manufacturing Practices (cGMP)	1 cr.
VGT 6740	Viruses and Vectors Journal Club (1 cr. /yr.)	1 cr.
VGT 6745	Current Topics in VGT (1 cr. /yr.).....	1 cr.

Research Pathway

CORE Courses (19 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE6050	Critical Thinking & Scientific Writing.....	2 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6200	Basic Graduate Immunology.....	3 cr.
CORE 6770	Intro to Virology and Gene Therapy.....	3 cr.
VGT 6888	Molecular Therapy Tutorial.....	2 cr.
VGT 6740	Viruses and Vectors Journal Club (1 cr. /yr.).....	1 cr.
VGT 6745	Current Topics in VGT (1 cr. /yr.).....	1 cr.

Research

It is expected that a minimum of one year be devoted to research.

Graduation Requirements

The degree requirements include:

- A minimum of 45 didactic credits
- VGT Written Qualifying Exam
- Preparation and oral defense of a thesis

Employee-Professional Master's Degree Program Descriptions and Track Requirements

- Biochemistry and Molecular Biology Track (BMB)
- Biomedical Engineering and Physiology Track (BMEP)
- Immunology Track (IMM)
- Molecular Pharmacology and Experimental Therapeutics Track (MPET)
- Neuroscience Track (NSC)
- Virology and Gene Therapy (VGT)

Master of Science – Mayo Employees

The Master of Science (M.S.) in Biomedical Sciences for Mayo employees is designed to develop the individual's information base in a basic science field and to enable the individual to become competent in acquiring knowledge independently. This Master's program emphasizes course work and a final project and does not include a research thesis.

The Master's program provides the Mayo employee with an organized plan of study to enhance their professional development. The Master's degree is the culmination of this educational program and documents the acquisition of a high level of knowledge in a particular area of science.

Eligibility

Enrollment is restricted to permanent Mayo employees and is available at all three sites: Arizona, Florida, and Rochester. Temporary roles are not eligible if you were hired with an appointment end date. The opportunity to take graduate school courses is a benefit and privilege for qualified employees, but not a guarantee. Permission to take courses may be restricted and/or forfeited at an employee supervisor's discretion if expectations of the learner's employment role are not being met. Any violation of Mayo Clinic policies may forfeit acceptance into a Master's degree program.

Applicants must have received a bachelor's degree from an accredited college or university, must have taken appropriate undergraduate science courses to adequately prepare for the Master's program, must have a minimum undergraduate grade point average that demonstrates a record of academic excellence. The employee's supervisor must endorse in writing the application of the employee and commit to allowing time to attend scheduled coursework.

Cost

A Program Fee is due upon admission. More details available on the MCGSBS Master's Programs intranet site, including options for financial support.

Application

Candidates must complete an Employee Master's Degree Application form. This form is available on the MCGSBS Master's Programs intranet site. Supporting documents include transcripts from previous colleges and three letters of recommendation - one preferred from your direct supervisor/manager.

Time Requirement

All requirements for the Master's degree must be completed within five years. The five-year period begins on the start date of the term the student is appointed to. Permanent Mayo employees whose Mayo employment terminates are required to notify MCGSBS; their MCGSBS appointments will also end.

Registration Requirement

At least 75% of the coursework for the Master's degree must be completed in MCGSBS.

Minimum Credit Requirements

Students must complete a minimum of 45 credits, including CORE 6000, "Responsible Conduct of Research." Six of the credits in the track must be didactic credits. The selection of the courses to be used to meet these requirements will be determined by the student and the track program director.

Transfer Credits

A total of 9 didactic credits may be transferred into the Employee Master's Program. For more details, see the Credit Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Mentor

A Master's degree mentor must have MCGSBS Full or Master's graduate faculty privileges. List of Faculty with Privileges can be found on the MCGSBS intranet site.

Official Degree Planning Tool

The use of a Degree Planning Tool (DPT) is required and allows students to list the course work to fulfill degree requirements, including transfer credits. Fifty percent of the credits counting toward degree must be graded on the A-F grading system.

The DPT must be completed during the first academic year and should be updated as courses are completed throughout the training program. Variation from the original course plan must be approved by the program director. A final completed DPT must be submitted to the school prior to completion of the scholarly review article (final project). The DPT is available on the MCGSBS intranet site under [For Students/General Forms/Resources/Master's Forms](#).

Minimum Grade Requirements

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Deficiencies and Unsatisfactory Progress Policy and Warning, Probation, Dismissal and Appeal Policy outlined on the MCGSBS Policies and Procedures intranet site.

Examinations

Written Qualifying Examination: At the completion of the required course work, students must pass the track written qualifying examination. MCGSBS must be informed of the date of the examination three weeks in advance so that the Master's Written Qualifying Examination Report form can be sent to the track Program director. The examination is designed to evaluate the student's depth and breadth of knowledge in the student's track and related fields of study. The written qualifying examination may be

taken after courses on the Degree Program Form are completed. The written qualifying examination may be taken no more than twice. If it is not passed on the first attempt, it must be taken within six months. Failing the examination twice will result in dismissal. The written qualifying examination must be passed before the Master's final project review may be scheduled.

Master's Project Review: At the completion of the Master's scholarly review article (final project), students must review their document with the Employee Master's Advisory Committee. MCGSBS must be informed of the date at least three weeks in advance so that the Master's Final Project Review Report Form can be sent to the Employee Master's Advisory Committee chair. Members of the Employee Master's Advisory Committee should receive copies of the scholarly review article (final project) at least three weeks prior to the final review.

Voting members of the Employee Master's Advisory Committee must be present in real time via physical presence or video- or teleconferencing at the review. Only one dissenting vote will be allowed for a "Pass." Thus, no more than one Employee Master's Advisory Committee member may be absent for the review. In the case where a student fails the review, the committee will recommend to the student and to MCGSBS remedial studies that should be undertaken by the student before the student reviews his/ her review article (final project) again with the Employee Master's Advisory Committee. The review may occur no more than twice. If it is not passed on the first attempt, it must be taken within six months. Failing the review twice will result in dismissal.

Scholarly Review Article (Final Project)

Master's degree tracks will specify the requirements for a scholarly review article (final project) to be completed as a required component of the degree program. This scholarly review article (final project) needs to be under the supervision of a faculty member with graduate faculty privileges. The scholarly review article (final project) needs to be approved by the track Program Director.

Employee Master's Advisory Committee

The Employee Master's Advisory Committee must consist of four members, one of whom is the student's mentor, who serves as chair of the committee. Any additional members beyond four will be designated as "ex-officio." All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. No more than two members may have teaching/examining privileges. The composition of this committee will be determined by MCGSBS upon recommendation by the student and the student's track Program Director. The recommendations are submitted on the Employee Master's Advisory Committee form available on the MCGSBS intranet site.

Graduation

Students are granted degrees four times a year (3rd Friday except in May it is the date of commencement): February, May, August, and November. Students are allowed no more than 30 days to complete M.S. degree requirements after the final Scholarly Review Article is successfully presented.

Biochemistry and Molecular Biology (BMB) – Employee-Professional Masters

John R. Hawse, IV, Ph.D., *Program Director*

Matthew J. Schellenberg, Ph.D., *Associate Program Director*

Biochemistry and Molecular Biology Track:

Biochemistry and Structural Biology; Cell Biology and Genetics; Cancer Biology Subtracks

Employee Master’s Degree

The Biochemistry and Molecular Biology (BMB) Track offers a customizable course load and training environment for Employee Master’s study that can be designed to emphasize one of three areas of broad specialty: Biochemistry and Structural Biology (BSB), Cell Biology and Genetics (CBG) or Cancer Biology (CB). The requirements for the Employee Master’s Degree in Biochemistry and Molecular Biology conform to the general requirements of the MCGSBS.

Course Requirements

A total of **45 credits** with maintenance of at least a 3.0 GPA are required for graduation.

Core Courses (10 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology	3 cr.
CORE 6250	Molecular Cell Biology.....	3 cr.

MGS Course (6 credits required)

MGS 6400	Master’s Scholarly Review Article (Final Project)	6 cr.
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Journal Clubs (2 credits required)

BMB 6500	BMB Journal Club (1 cr./yr.)*	2 cr.
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*Two credits maximum. Students must attend all years after completing the written qualifying exam and present at least once. The second journal club credit may be obtained by taking and participating in any other JC offered by the graduate school should a different JC be more aligned with the student’s area of interest.

Elective Courses (27 credits required)

Any course approved for graduate credit regardless of the “track” it is offered by.

Written Qualifying Exam

The Master’s candidate must pass the BMB Written Qualifying Exam to complete the degree requirements. Students take the written qualifying exam once they have completed the core courses and have considered whether to take the other courses featured in the exam (see below). The exam is a one-day exam held at the beginning of July and consists of demonstrating critical evaluation and understanding of two published primary research papers relevant to the broad field of Biochemistry and Molecular Biology as covered in the core courses CORE 6100, CORE 6150 and CORE 6250. Three sets of papers reflecting the three areas of emphasis of the track: BSB, CBG and CB, will be made available to the students three days before the exam. On the day of the exam, students are required to answer a series of specific questions associated with any two of the six papers. The questions will cover foundation of

knowledge in addition to synthesis of concepts. The exam is prepared and graded by the faculty and an overall grade of 70% is required for successful completion of the exam.

Master's Scholarly Review Article (Final Project)

As a part of the Employee Master's, the candidate must write a critical literature review of a selected topic in biochemistry and molecular biology and associated with your area of emphasis: Biochemistry and Structural Biology; Cell Biology and Genetics or Cancer Biology. The topic for review should be selected by the candidate in consultation with a faculty member who will act as an advisor for the scholarly review article (final project). The review article (final project) should be written and formatted as a standard review article published in a relevant scientific journal of your choosing. This review article is required to be submitted for publication to the selected journal, however final acceptance of the review is not required, but is encouraged, for successful completion of the Master's degree.

The review article should be appropriately referenced and include illustrations/figures/tables as necessary. This document must be written in close consultation with the advisor and must be submitted to the Employee Master's Advisory Committee for review and approval.

A defense meeting consisting of 4 committee members and the student must be scheduled within 30 days of completing the review article. During this meeting, the committee will provide final feedback and overall assessment of the student's performance. Any final suggested edits to the document will be made. Significant deficits in the scholarly review article will require the student to revise and resubmit the document to the committee within 30 days of the defense. Three of four committee members must vote to pass the student and a form signed by all committee members must be submitted to MCGSBS immediately upon completion of the defense. Following successful completion of these requirements, the review article must be submitted to the scientific journal of choice.

Advisory Committee

Each student must have an advisory committee consisting of four members of the graduate faculty. This committee will be responsible for evaluating the scope and content of the Master's scholarly review article (final project). Selection of members of this committee should be discussed with the mentor and the program director and arranged prior to beginning the Master's scholarly review article (final project). The committee will be chaired by the mentor and meet with the student before starting the Master's scholarly review article (final project) and composition will be subject to the rules and regulations of the graduate school.

Biomedical Engineering and Physiology (BMEP) – Employee-Professional Masters

Kristin Zhao, Ph.D., *Program Director*

Leigh Griffiths, Ph.D., *Associate Program Director*

Employee Master’s Degree

The Employee Master’s Degree track in Biomedical Engineering and Physiology is open only to permanent employees of Mayo Clinic. Admission to the program requires an interview with the program director.

Course Requirements

A total of **45 credits** with maintenance of at least a 3.0 GPA are required for graduation.

Core Courses (6 credits required)

CORE 6000	Responsible Conduct of Research	1 cr.
CORE 6050	Critical Thinking and Scientific Writing	2 cr.
CORE 6300	Molecular Biophysics	3 cr.

MGS Course (6 credits)

MGS 6400	Master’s Scholarly Review Article (Final Project).....	6 cr.
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Track Requirements (24 credits required)

BMEP 5200	Mathematics in Biomedical Engineering and Physiology.....	4 cr.
BMEP 5452	Biomechanics	3 cr.
BMEP 5704	Bio-Instrumentation and Signal Processing	3 cr.
BMEP 5800	Introduction to Medical Imaging.....	6 cr.
BMEP 6600	Biomedical Engineering and Physiology Seminars.....	1 cr.
BMEP 6650	BMEP Journal Club.....	1 cr.
BMEP 6700	Physiology from Cells to Organism	6 cr.

Electives (9 credits)

Thirty-six total credits are required to complete the program. In addition to the core and track requirements, 9 elective credits should be selected after consultation between the student and the program director. A minimum GPA of 3.0 will be required for combined coursework.

Written Qualifying Exam

The qualifying examination for the Employee Master’s Degree in Biomedical Engineering and Physiology is comprised of a written qualifying exam. The written exam is administered at the beginning of August and will cover track-required courses. A form signed by the track program director will be submitted to MCGSBS upon successful completion of the written qualifying exam.

Advisory Committee

In consultation with the program director, the student will select a Master’s degree mentor within the first year of the program. The mentor must have graduate school privileges and must not be the employee’s direct supervisor. In consultation with the program director and the Master’s degree mentor, the student will select an Employee Master’s Advisory Committee comprised of four faculty members. This committee must include, at a minimum, either the program director or the associate program

director. This committee should meet at least every six months to assess the student's progress and provide guidance regarding the project. A form indicating the composition of the committee must be submitted to MCGSBS.

Master's Scholarly Review Article (Final Project)

The Master's scholarly review article (final project) forms the central element of the Master's degree. The student should enroll in BMEP 6400 during the final quarter of tenure in the program in order to finalize the project. In general, the project will take the form of a substantial and scholarly review of the current field related to a specific topic of interest to the student. The final form of the scholarly review article (final project) must be approved in advance by the Biomedical Engineering and Physiology Education Committee. This document must be written in close consultation with the Master's degree mentor and the Employee Master's Advisory Committee, and must be submitted to the Employee Master's Advisory Committee for review at least one month prior to the final review date.

The final evaluation of the scholarly review article (final project) is the final committee meeting. Prior to this meeting the committee will carefully review, edit, and critique the scholarly review article (final project) and will provide any changes to the student during the meeting. Committee members may orally examine the student's general and specific knowledge. Significant deficits in the scholarly review article (final project) will require the student to revise and resubmit the document to the committee within 30 days of the meeting. Three of four committee members must vote to pass the student and a form signed by all committee members must be submitted to MCGSBS immediately upon completion of the review.

Immunology (IMM) – Employee-Professional Masters

Kay L. Medina, Ph.D., *Program Director*

Haidong Dong, M.D., Ph.D., *Associate Program Director*

Henrique Borges da Silva, Ph.D. *Associate Program Director, ARZ*

Course Requirements

A total of **45 credits** with maintenance of at least a 3.0 GPA are required for graduation.

Core Courses (4 credit minimum)

CORE 6000	Responsible Conduct of Research (required).....	1 cr.
CORE 6200	Basic Graduate Immunology.....	3 cr.

MGS Course (6 credits)

MGS 6400	Master’s Scholarly Review Article (Final Project)	6 cr
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Track Requirements (13 credit minimum).

IMM 6862	Current Topics in Cell Activation and Signaling.....	1 cr.
IMM 6863	*Current Topics in Immunology	1 cr.
IMM 6878	Tutorial in Innate Immunity and Immunometabolism	2 cr.
IMM 6879	Tutorial in Cellular Activation.....	2 cr.
IMM 6880	Tutorial in Immunopathology.....	2 cr.
IMM 6882	Tutorial in Mucosal Immunology.....	2 cr.
IMM 6884	Tutorial in Tumor Immunology.....	2 cr.
IMM 6885	Tutorial in the Generation and Function of B Cells	2 cr.

**Current Topics courses may be taken more than once*

Students who are not currently enrolled in a degree program (including all employee master’s students) must first obtain a signature from the Immunology program director before enrolling in any IMM tutorial course.

Electives (22 credit minimum)

The remainder of the credits can be selected from any field; with no more than nine credits in seminar or journal club style courses.

Written Examination

The Master’s candidate must pass the Immunology written qualifying exam to complete the degree requirements.

Master’s Scholarly Review Article (Final Project)

Master’s degree candidates must complete a written scholarly review article (final project) under the direction of a faculty mentor. The written review article should provide an independent scholarly review of an important topic in immunology or a scientific grant proposal consisting of a major hypothesis, background, preliminary data (if any), and outline of experimental strategies.

Advisory Committee

The Advisory Committee consists of the student’s faculty mentor and three additional members with graduate faculty privileges. The committee must be approved by the program director and MCGSBS. The committee will evaluate the scope and content of the Master’s scholarly review article (final project), and three of the four members must vote to pass the student for successful completion of the Master’s review article (final project).

Molecular Pharmacology and Experimental Therapeutics (MPET) – Employee-Professional Masters

Martin E. Fernandez-Zapico, M.D., *Program Director*
TBD, *Associate Program Director*

Employee Master’s Degree

The requirements for the Employee Master’s Degree in Molecular Pharmacology and Experimental Therapeutics conform to the general requirements of MCGSBS.

Course Requirements

A total of **45 credits** with maintenance of at least a 3.0 GPA are required for graduation.

Core Courses (13 credits required)

CORE 6000	Responsible Conduct of Research	1 cr.
CORE 6100	Chemical Principles of Biological Systems	3 cr.
CORE 6150	Genome Biology	3 cr.
CORE 6250	Molecular Cell Biology	3 cr.
CORE 6450	Molecular Pharmacology and Receptor Signaling.....	3 cr.

Track Requirements (7 credits required)

MPET 5808	Introduction to Molecular Pharmacology.....	4 cr.
MPET 6800	Research Seminars in Pharmacology	1 cr.
MPET 6805	Drug Metabolism and Pharmacogenomics.....	2 cr.

Track Tutorials (5 credits required or 3 tutorials required)

MPET 6400	Introduction to Principles of Pharmacokinetics	2 cr.
MPET 6450	Applied Data Science and Artificial Intelligence in Pharmacology.....	2 cr.
MPET 6655	Mechanisms of Cell Growth and Death	2 cr.
MPET 6812	Tutorial in Molecular Pharmacology and Receptor Signaling.....	1 cr.
MPET 6813	Tutorial in Systems Pharmacology.....	2 cr.
MPET 6814	Cellular Pharmacology of Agents that Target Cancer	2 cr.
MPET 6815	Neurobehavioral Pharmacology	2 cr.

Electives (14 credits required)

Any courses approved for graduate credit; select in consultation with your project mentor.

MGS Course (6 credits)

MGS 6400	Master’s Scholarly Review Article (Final Project)	6 cr.
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Written Qualifying Examination

The Master’s candidate must pass the MPET Written Qualifying Exam to complete the degree requirements.

Master’s Scholarly Review Article (Final Project)

Master’s degree candidates must complete a written scholarly review article (final project) under the direction of a faculty mentor with graduate faculty privileges. The written scholarly review article (final project) should provide an independent scholarly review of an important topic in pharmacology, propose an important question related to the topic, and outline an experimental strategy to address the question.

Advisory Committee

Advisory committees shall consist of the student's faculty mentor and three additional members with graduate faculty privileges. The committee must be approved by the program director and MCGSBS. The committee will evaluate the scope and content of the Master's scholarly review article (final project) during an oral defense of the project. Three of the four members must vote to pass the student for a successful defense.

Neuroscience (NSC) – Employee-Professional Masters

Owen A. Ross, Ph.D., *Program Director, Mayo Clinic in Florida*

Long-Jun Wu, Ph.D., *Associate Program Director, Mayo Clinic in Rochester*

Wolfdieter Springer, Ph.D., *Associate Program Director, Mayo Clinic in Florida*

Employee Master's Degree

The Employee Master's Degree track in Neuroscience is only open to permanent employees of Mayo Clinic. Admission to the program requires an interview with the program director.

Course Requirements

A total of **45 credits** with maintenance of at least a 3.0 GPA are required for graduation.

Core Courses (12 credits required)

CORE	6000	Responsible Conduct of Research.....	1 cr.
CORE	6100	Chemical Principles of Biological Systems.....	3 cr.
CORE	6150	Genome Biology.....	3 cr.
CORE	6250	Molecular Cell Biology.....	3 cr.
CORE	6510	Molecular Mechanisms of Human Disease.....	2 cr.

Track Requirements (20 credits required)

REGS	5200	Fundamentals of Regenerative Sciences.....	2 cr.
NSC	6210	Neurobiology of Disease.....	3 cr.
NSC	6250	Skills for Effective Presentations.....	2 cr.
NSC	6310	Methods in Neuroscience Research.....	2 cr.
NSC	6401	Practical Neuroanatomy	2 cr.
NSC	6600	Neuroscience Journal Club (1 cr./yr.)*.....	3 cr.
NSC	6857	Systems Neuroscience and Behavior.....	3 cr.
NSC	6862	Molecular and Cellular Neuroscience.....	3 cr.

* Three credits maximum

Suggested Electives (7 credits required)

NSC	5600	Behavioral Neurology.....	2 cr.
BMEP	6300	Tutorial in Neurophysiology	3 cr.
MPET	6820	Regenerative Medicine	2 cr.
CORE	6200	Basic Graduate Immunology.....	3 cr.
CORE	6400	Molecular Genetics.....	3 cr.
CORE	6450	Molecular Pharmacology and Receptor Signaling.....	3 cr.
REGS	5300	Stem Cells and Development.....	3 cr.

Final Project (6 credits) (You must registrar for this during your final quarter)

MGS	6400	Master's Scholarly Review.....	6cr.
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Written Qualifying Examination

The qualifying examination for the Employee Master's Degree in the Neuroscience Track is a single written qualifying exam composed of knowledge-based and research-based questions based on assigned research articles. A form signed by the track program director will be submitted to MCGSBS upon successful completion of the written qualifying exam.

Advisory Committee

In consultation with the program director, the student will select a Master's project mentor within the first year of the program. The mentor must have MCGSBS faculty privileges and *must not be* the employee's direct supervisor. In consultation with the program director and the Master's project mentor, the student will select an Employee Master's Advisory Committee comprised of four faculty members. This committee must include, at a minimum, either the track program director or the associate program directors. This committee should meet yearly to assess the student's progress and to provide guidance regarding the Master's scholarly review article (final project). A form indicating the composition of the committee must be submitted to MCGSBS.

Master's Scholarly Review Article (Final Project)

The project forms the central element of the Master's degree. The student should enroll in MGS 6400, Master's Scholarly Review Article (Final Project) during the final quarter of tenure in the program in order to finalize the scholarly review article (final project). In general, the project will take the form of a substantial and scholarly review of the current field related to a specific topic of interest to the student. While the final form of the scholarly review article (final project) is at the discretion of the Employee Master's Advisory Committee, a 50-100 page, double-spaced document comprised of text, figures, and tables as appropriate, is recommended. This document must be written in close consultation with the Master's project mentor and must be submitted to the Employee Master's Advisory Committee for review at least one month prior to the final scholarly review article (final project) defense date. Upon successful completion of the defense and careful editing of the document, the track will pay to have 3 copies bound (one for the Master's project mentor, one for the track, and one for the student). Binding should be coordinated with the program director or associate program directors.

The scholarly review article (final project) defense is the final committee meeting. Prior to this meeting the committee will carefully review, edit, and critique the scholarly review article (final project) and will provide any changes to the student during the meeting. Committee members may orally examine the student's general and specific knowledge. Significant deficits in the project will require the student to revise and resubmit the document to the committee within 30 days of the defense. Three of four committee members must vote to pass the student and a form signed by all committee members must be submitted to MCGSBS immediately upon completion of the defense.

Virology and Gene Therapy (VGT) - Employee-Professional Masters

Michael A. Barry, Ph.D., *Program Director*

Autumn J. Schulze, Ph.D., *Associate Program Director*

There are two pathways to choose from:

The **REGULATORY/TRANSLATIONAL PATHWAY** student will gain a broad scope of gene therapy and will learn how to develop a gene based therapeutic from an idea to a validated product. Various gene therapy strategies will be considered in relation to a broad spectrum of human diseases illustrating how genes can be used for gene replacement, tissue engineering, destruction of unwanted tissues, or immune stimulation. Stages in the development of gene-based drugs & biologics will be studied from vector design through preclinical proof of efficacy, clinical protocol development, product manufacture, pharmacology and toxicology testing, analysis of clinical trial outcomes, regulatory affairs, patenting and partnering with industry. The Regulatory/Translation pathway is designed for those learners who desire to conduct or participate in research that will identify therapies/devices that will move into manufacturing facilities.

The **RESEARCH PATHWAY** student will learn from and work alongside faculty members who have primary interests in virology, viral vectors and gene therapy and will develop research skills in conducting or participate in vaccine and gene therapy discovery. These areas overlap with the fields of biochemistry, cell and molecular biology, genetics, and immunology and regulatory science. The Research pathway is designed for learners who desire to be an informed member of a research team conducting or participating in Virology and Gene Therapy research.

Course Requirements

A total of 45 credits to be completed over two to four years with maintenance of at least a 3.0 GPA are required for graduation.

CORE Courses (12 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CORE 6050	Critical Thinking & Scientific Writing	2 cr.
CORE 6100	Chemical Principles of Biological Systems.....	3 cr.
CORE 6150	Genome Biology.....	3 cr.
CORE 6770	Intro to Virology and Gene Therapy.....	3 cr.

Journal Club (2 credits required)

VGT 6740	Viruses and Vectors Journal Club (1 cr. /yr.)	1 cr.
VGT 6745	Current Topics in VGT (1 cr. /yr.).....	1 cr.

Track Requirements - (7 or 5 credits required based on chosen pathway)

Regulatory/Translation Pathway (7 credits required)

CTSC 5020	Regulatory Issues in Clinical Research.....	1 cr.
CTSC 5025	Introduction to Regulatory Science.....	1 cr.
CTSC 5035	Case Studies in Regulatory Science.....	1 cr.
CTSC 5300	Introduction to Clinical Epidemiology	1 cr.
CTSC 5600	Statistics in Clinical & Translational Research.....	2 cr.
CTSC 5040	Intro to the Principles of Current Good Manufacturing Practices (cGMP).....	1 cr.

Research Pathway (5 credits required)

CORE 6200	Basic Graduate Immunology.....	3 cr.
VGT 6888	Molecular Therapy Tutorial.....	2 cr.

Electives (20 or 18 credits required based on chosen pathway)

Any courses approved for graduate credit; select in consultation with your mentor.

MGS Course (6 credits required)

MGS 6400	Master's Scholarly Review Article (Final Project)	6 cr.
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Clinical Master's Degree Program Descriptions and Track Requirements

- Dentistry
 - Orthodontics (ODON)
 - Periodontics (PDON)
 - Prosthodontics (PROS)

- Obstetrics and Gynecology
 - Female Pelvic Medicine/Reconstructive Surgery (GYNP)
 - Gynecologic Oncology (GYNO)
 - Maternal Fetal Medicine (MFM)
 - Reproductive Endocrinology and Infertility (REPR)

- Orthopedics (OR)

Master of Science – Clinical Specialties

The primary purpose of the Master of Science (M.S.) in Biomedical Sciences degree program in select clinical specialties is to enhance the scholarly dimension of the education of physicians and dentists who have an interest in academic medicine. Training in research is emphasized. The degree program provides a structure for development of a plan to address a research problem, an orderly approach to the project, assurance of the credentials of the mentor, appropriate supervision, and a suitable approach to the analysis and presentation of the results.

Courses in basic biomedical sciences are required to provide the student with the knowledge to address a research problem, conduct the research and evaluate the results. Courses in the track are required in addition to provide special skills, techniques or knowledge related to the specialty track. General program requirements and specialty track descriptions are outlined on the following pages. Degree candidates must be enrolled in the program at least one year prior to graduation.

Eligibility

This program is designed for Mayo residents who hold appointments to the clinical programs of Mayo School of Graduate Medical Education. Potential candidates for the degree must hold appointments of sufficient duration to complete degree program requirements.

The opportunity to take graduate school courses is a benefit and privilege for qualified trainees, but not a guarantee. Permission to take courses may be restricted and/or forfeited at the discretion of the learner's program director if expectations of the learner's primary training role are not being met. Any violation of Mayo Clinic policies may forfeit acceptance into a Master's degree program.

Tuition

No tuition or program fee; incorporated into residency training.

Application

Candidates must complete an Application for Graduate Training Master's Program in Biomedical Sciences-Clinical Specialties form. The application must be approved by the track program director and MCGSBS. This form is available from the MCGSBS Master's Programs web page.

Time Requirement

All requirements must be satisfied within 30 days of the thesis defense.

Registration Requirement

At least 75% of the coursework for the Master's degree must be completed in MCGSBS. Enrollment in the degree program for a minimum of one year is required. It is expected that a minimum of six months will be devoted to research.

Minimum Credit Requirements

Students must complete a minimum of 12 credits in basic biomedical sciences and 12 additional credits in the track (credits may vary depending on the chosen track but the minimum MCGSBS credit requirement must be met). Six of the 12 credits in the track must be didactic credits. It is expected that a minimum of six months will be devoted to research. Students are not admitted to a specialty track unless there is reasonable assurance that course work required for completion of degree requirements is available.

Transfer Credits

A total of 6 didactic credits may be transferred into the Clinical Master's Program. For more details, see the Credit Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Mentor

A Master's degree mentor must have MCGSBS full or Master's graduate faculty privileges. A List of Faculty with Privileges can be found on the MCGSBS intranet site.

Official Degree Planning Tool

The use of a Degree Planning Tool (DPT) is required and allows students to list the course work to fulfill degree requirements, including transfer credits. Fifty percent of the credits counting toward degree must be graded on the A-F grading system.

The DPT must be completed during the first academic year and should be updated as courses are completed throughout the training program. Variation from the original course plan must be approved by the program director. A final completed DPT must be submitted to the school when your defense date has been determined. The DPT is available on the MCGSBS intranet site under [For Students/General Forms/Resources/Master's Forms](#).

Minimum Grade Requirements

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Deficiencies and Unsatisfactory Progress and Warning, Probation and Dismissal policies outlined on the MCGSBS intranet Policies and Procedures webpage.

Examinations

Written Examination: A comprehensive written examination must be taken before completion of the training program. MCGSBS must be informed of the date of the examination three weeks in advance so that the Master's Written Examination Report form can be sent to the track program director. The written examination may be taken no more than twice. If it is not passed on the first attempt, it must be retaken by the end of the quarter following the quarter in which it was first taken. Failing the examination twice will result in dismissal. The written examination must be passed before the final oral examination may be scheduled.

Final Oral Examination: Candidates for the Master's degree are expected to pass the final oral examination before completion of the Mayo residency or fellowship training program. The final oral examination may be taken after: 1) the written examination has been passed, 2) all course work shown on the Degree Program form has been completed, and 3) the thesis is reviewed. MCGSBS must be informed of the date of the examination three weeks in advance so that the Master's Final Oral Examination Report form can be sent to the Thesis Advisory Committee chair.

The student's mentor must sign a form indicating that he/she has read the thesis and that it is ready for defense prior to distribution to the Thesis Advisory Committee members. The Verification that the Thesis is Ready to Defend form can be accessed on the MCGSBS intranet site. A copy of the title page of the thesis and the form must be submitted to the MCGSBS office. The thesis must be submitted to the Thesis Advisory Committee at least three weeks before the final oral examination.

Voting members of the Thesis Advisory Committee must be present in real time via physical presence or video- or teleconferencing at the final oral examination. Only one dissenting vote will be allowed for a "Pass." Passage of the final oral examination requires a minimum of three passing votes; otherwise a determination of "Fail" must be made. Thus, no more than one Thesis Advisory Committee member may be absent for the final oral examination. The final oral examination may be taken no more than twice. If it is not passed on the first attempt, it must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination twice will result in dismissal.

Thesis

Thesis Protocol: This protocol must clearly define the candidate's role in the project and must have sufficient detail to permit review by an advisory committee. An Outline for the Master's Thesis Protocol is available on the MCGSBS intranet site. The Recommended Action on Thesis Protocol for Clinical Master's Degree form ([thesis protocol form](#)) is also available on the intranet site.

The Mayo Institutional Review Board must review all protocols for research involving the use of human subjects. It is the candidate's responsibility to secure approval of any such protocols before the research is undertaken.

Thesis Advisory Committee: With the thesis protocol, students must submit the Master's [Thesis Advisory Committee e-form](#) recommending the members of their thesis advisory/ final oral examining committee and the Degree Program form. All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. The examining committee must consist of four members, one of whom is the student's mentor, who serves as chair of the committee. Any additional Thesis Advisory Committee members beyond four will be designated as "ex officio" and will not vote at the final defense. No more than two members of the committee may have teaching/examining privileges. The recommended committee must be approved by the track program director and MCGSBS.

Progress Meetings: The Master's Thesis Advisory Committee must meet every six months from the date of committee approval. Documentation of student progress, using the [progress meeting form](#), must be signed by all members of the Thesis Advisory Committee, and saved within the program.

Preparation of Thesis: The thesis is the most important document that the Master's candidate will prepare during the course of graduate study and is a record of the scientific accomplishments that justify the awarding of the degree. The thesis is submitted to Proquest. Consequently, MCGSBS has developed a standard for its format and style, which should be closely followed. Guidelines for Master's thesis are available on the MCGSBS intranet site at For Students/General Forms/Resources.

Final Thesis Corrections: After the student has passed the final oral examination, the chair of the Thesis Advisory Committee must sign a form indicating he/she is satisfied that the final corrections to the thesis have been made. The chair must sign before the student will be cleared for graduation. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted.

Graduation

Students are granted degrees four times a year (3rd Friday except in May it is the date of commencement): February, May, August, and November. Students are allowed no more than 30 days to complete M.S. degree requirements after a successful thesis defense. If a student does not meet this deadline, he/she will be required to re-defend their thesis.

Dentistry – Orthodontics (ODON) – Clinical Master’s Degree

Chad M. Rasmussen, D.D.S., *Program Director (through February 2023)*

Sarah K. Lee, D.D.S., *Interim Program Director (new effective March 2023)*

Clinical Master’s Degree

In addition to the following courses, successful completion of the requirements for the Certificate in Orthodontics is required.

Course Requirements

A total of **47 credits** with maintenance of at least a 3.0 GPA are required for graduation.

Biomedical Sciences Courses (all 16 credits required)

BMEP	5453	Fundamental Concepts in Biomechanics	3 cr.
CORE	6000	Responsible Conduct of Research.....	1 cr.
CTSC	5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC	5602	Utilizing Statistics in Clinical Research.....	1 cr.
DERM	6870	Mucous Membrane Course	1 cr.
ODON	6857	Research in Selected Problems.....	8 cr.
		(1 cr./qtr. – 8 qtrs. required)	

Orthodontic Didactic Courses (all 7 credits required)

ODON	6806	Orthodontic Seminar: Technique	2 cr.
		(1 cr./qtr. - 2 qtrs. required)	
ODON	6807	Orthodontic Seminar: Literature Review	1 cr.
ODON	6808	Orthodontic Seminar: Case Presentation.....	1 cr.
ODON	6809	Surgical Orthodontic Seminar	1 cr.
ODON	6810	Clinical Oro-Facial Pathology and Developmental Disorders	1 cr.
PDON	6884	Periodontics/Orthodontics Seminar.....	1 cr.

Orthodontic Clinical Courses (all 24 credits required)

ODON	6804	Clinical Orthodontics	12 cr.
		(6 cr./qtr. – 2 qtrs. required)	
ODON	6805	Advanced Clinical Orthodontics	12 cr.
		(6 cr./qtr. – 2 qtrs. required)	

Dentistry – Periodontics (PDON) – Clinical Master’s Degree

Scott Gruwell, D.D.S., M.S., M.B.A., *Program Director (through February 2023)*

Miao Xian (Cindy) Zhou, D.M.D., M.S., *Program Director (new effective March 2023)*

Course Requirements

A total of **61 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 36 credits are clinical.

Biomedical Sciences Courses (all 18 credits required)

CORE	6000	Responsible Conduct of Research.....	1 cr.
CTSC	5300	Fundamentals of Epidemiology.....	1 cr.
CTSC	5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC	5602	Utilizing Statistics in Clinical Research.....	1 cr.
DERM	6870	Mucous Membrane Course	1 cr.
PDON	6857	Research in Selected Problems.....	12 cr.
		(2 cr./qtr. - 6 qtrs. required)	

Periodontics Didactic Courses (all 7 credits required)

PDON	6883	Periodontal Seminar/Current Literature	3 cr.
		(1 cr./qtr. - 3 qtrs. required)	
PDON	6884	Periodontics/Orthodontics Seminar.....	1 cr.
PDON	6886	Classic Literature in Periodontics.....	2 cr.
PROS	6870	Occlusion.....	1 cr.

Periodontics Clinical Courses (all 36 credits required)

PDON	6880	Clinical Periodontics	36 cr.
		(3 cr./qtr. - 12 qtr. required)	

Dentistry – Prosthodontics (PROS) – Clinical Master’s Degree

Sarah K. Lee, D.D.S., M.S., *Program Director*

Course Requirements

A total of **93 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 64 credits are clinical.

Biomedical Sciences Courses (all 17 credits required).

CORE	6000	Responsible Conduct of Research.....	1 cr.
CTSC	5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC	5602	Utilizing Statistics in Clinical Research.....	1 cr.
DERM	6870	Mucous Membrane Course	1 cr.
PROS	6857	Research in Selected Problems (2 cr./qtr. - 6 qtrs. required)..... (Master’s application must be accepted by MCGSBS to enroll in this course.)	12 cr.

Prosthodontic Didactic Courses (all 12 credits required)

PROS	6841	Prosthodontic Seminar (Complete Dentures)..... (1 cr./qtr. - 2 qtrs. required)	2 cr.
PROS	6843	Prosthodontic Seminar (Partial Dentures).....	1 cr.
PROS	6845	Prosthodontic Seminar (Fixed).....	1 cr.
PROS	6847	Seminar: Maxillofacial Prosthetics–Advanced Prosthodontics.....	1 cr.
PROS	6848	Seminar: Current Literature.....	1 cr.
DENT	5100	Interdisciplinary Current Literature in Dental Specialties.....	1 cr.
PROS	6862	Dental Materials	1 cr.
PROS	6870	Occlusion.....	1 cr.
PROS	6871	Physiology, Pharmacology and Pre-Prosthetic Surgery	1 cr.
PROS	6873	Cranio-mandibular Disorders and Facial Pain	1 cr.
PROS	6874	Prosthodontic Management of the Geriatric Patient	1 cr.

Prosthodontic Clinical Courses (all 64 credits required)

PROS	6840	Clinical Prosthodontics: Complete Dentures..... (6 cr./qtr. - 2 qtrs. required)	12cr.
PROS	6842	Clinical Prosthodontics: Partial Dentures..... (6 cr./qtr. - 4 qtrs. required)	24 cr.
PROS	6851	Dental Roentgenology.....	1 cr.
PROS	6852	Oral Diagnosis and Treatment of Cranio-mandibular Disorders	2 cr.
PROS	6854	Implant Prosthodontics..... (6 cr./qtr. - 3 qtrs. required)	18 cr.
PROS	6856	Oral and Maxillofacial Surgery.....	1cr
PROS	6880	Dental Laboratory Technology.....	6 cr.

Obstetrics & Gynecology- Female Pelvic Medicine/Reconstructive Surgery (GYNP) - Clinical Master's Degree

John A. Occhino, M.D., *Program Director*

Course Requirements

A total of **69 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 24 credits are clinical.

Biomedical Sciences Courses Didactic (all 37 credits required)

CORE	6000	Responsible Conduct of Research.....	1 cr.
CTSC	5010	Clinical Research Protocol Development.....	2 cr.
CTSC	5100	Publishing in the Sciences.....	1 cr.
CTSC	5110	Grant Writing for the Sciences.....	1 cr.
CTSC	5370	Introduction to Epidemiology (formerly CTSC 5310)	2 cr.
CTSC	5390	Advanced Applied Epidemiologic Methods.....	2 cr.
CTSC	5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC	5602	Utilizing Statistics in Clinical Research.....	1 cr.
CTSC	5610	Introductory Statistical Methods II.....	3 cr.
OBG	6840	Research in Obstetrics-Gynecology (6 cr./qtr. – 4 qtrs. required)	24 cr.

Master's program application must be accepted by MCGSBS to enroll in this course.

Additional elective courses may be taken after discussion and approval by the program director.

Courses available but are not limited to:

CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis.....	1 cr.
CTSC	5720	Clinical Trials Design and Conduct	1 cr.
CTSC	5740	Systematic Reviews and Meta-Analysis	2 cr.
CTSC	5761	Evidence-Based Medicine for Clinical Researchers	1 cr.
CTSC	5820	Introduction to Survey Research	1 cr.
CTSC	5910	Economic Evaluation in Health Care	1 cr.

Urogynecology/Reconstructive Pelvic Surgery Didactic Courses (all 6 credits required)

ANAT	6000	Anatomy of the Pelvis-Perineum	2 cr.
		Register winter quarter; attendance required winter and spring quarters	
OBG	5803	Introduction to Surgical Gynecology (1 cr./qtr. - 4 qtrs. required)	4 cr.
		Begin summer quarter of first year of fellowship; student must register for 4 consecutive quarters.	

Urogynecology/Reconstructive Pelvic Surgery Clinical Courses (all 24 credits required)

OBG	6870	Advanced Urogynecologic Operative Surgery.....	24 cr.
		(6 cr./qtr. - 4 qtrs. required) Begin summer quarter of second year of fellowship.	
		Student must register for 4 consecutive quarters.	

Obstetrics & Gynecology- Gynecologic Oncology (GYNO) - Clinical Master's Degree

Carrie L. Langstraat, M.D., *Program Director*

Course Requirements

A total of **76 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 30 credits are clinical.

Biomedical Sciences Courses

Didactic (all 37 credits required)

CORE	6000	Responsible Conduct of Research	1 cr.
CTSC	5010	Clinical Research Proposal Development.....	2 cr.
CTSC	5100	Publishing in the Sciences.....	1 cr.
CTSC	5110	Grant Writing for the Sciences.....	1 cr.
CTSC	5370	Introduction to Epidemiology (formerly CTSC 5310)	2 cr.
CTSC	5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC	5602	Utilizing Statistics in Clinical Research.....	1 cr.
CTSC	5610	Introductory Statistical Methods II.....	3 cr.
OBG	6840	Research in Obstetrics-Gynecology	24 cr.
		(6 cr./qtr. – 4 qtrs. required)	

Master's program application must be accepted by MCGSBS to enroll in this course.

***Students in this master's program will complete their thesis research and thesis document, and defend their thesis prior to completion of all required course work and the written examination.**

Elective Courses (3 elective credits required)

Electives require discussion with and approval by the program director to tailor courses to student's interest and career pathway. Elective courses may be taken after discussion and approval by the program director. Courses available but are not limited to:

CTSC	5080	Introduction to Health Disparities.....	1 cr.
CTSC	5390	Advanced Applied Epidemiologic Methods.....	2 cr.
CTSC	5640	Logistic Regression	1 cr.
CTSC	5641	Comparative Effectiveness Research: Observational Studies and Pragmatic Trials.....	1 cr.
CTSC	5650	Survival Analysis.....	1 cr.
CTSC	5720	Clinical Trials Design and Conduct	1 cr.
CTSC	5740	Systematic Reviews and Meta-Analysis	2 cr.
CTSC	5810	Qualitative Research Design, Methods, and Analysis	1 cr.
CTSC	5820	Introduction to Survey Research	1 cr.

Gynecologic Oncology Didactic Courses (all 6 credits required)

ANAT	6000	Anatomy of the Pelvis-Perineum	2 cr.
		Register winter quarter; attendance required winter and spring quarters.	
OBG	5803	Introduction to Surgical Gynecology	4 cr.
		(1 cr./qtr. – 4 qtrs. required)	
		Begin summer quarter of first year of fellowship; student must register for 4 consecutive quarters.	

Gynecologic Oncology Clinical Courses (all 30 credits required)

*OBG	6857	Gynecologic Oncology (6 cr./qtr. - 5 qtrs. required).....	30 cr.
		Begin summer quarter of second year of fellowship. Student must register for 5 consecutive quarters.	

Obstetrics & Gynecology- Maternal Fetal Medicine (MFM) - Clinical Master's Degree

Carl H. Rose, M.D., *Program Director*

Course Requirements

A total of **66 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 24 credits are clinical.

Biomedical Sciences Courses Didactic (all 37 credits required)

CORE	6000	Responsible Conduct of Research.....	1 cr.
CTSC	5010	Clinical Research Proposal Development.....	2 cr.
CTSC	5110	Grant Writing for the Sciences.....	1 cr.
CTSC	5370	Introduction to Epidemiology (formerly CTSC 5310).....	2 cr.
CTSC	5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC	5602	Utilizing Statistics in Clinical Research.....	1 cr.
CTSC	5610	Introductory Statistical Methods II.....	3 cr.
OBG	6840	Research in Obstetrics-Gynecology	24 cr.

(6 cr./qtr. - 4 qtrs. required)
Master's program application must be accepted by MCGSBS to enroll in this course.

Elective Courses (2 elective credits required) available but not limited to:

CTSC	5100	Academic Publishing.....	1 cr.
CTSC	5390	Advanced Applied Epidemiologic Methods.....	2 cr.
CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis.....	1 cr.
CTSC	5820	Introduction to Survey Research	1 cr.
CTSC	5910	Economic Evaluation in Health Care	1 cr.

Maternal Fetal Medicine Didactic Courses (all 4 credits required)

OBG	5804	Introduction to Maternal Fetal Medicine	4 cr.
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(1 cr./qtr. - 4 qtrs. required)
Begin summer quarter of first year of fellowship. Student must register for 4 consecutive quarters.

Maternal Fetal Medicine Clinical Courses (all 24 credits required)

OBG	6875	Maternal Fetal Medicine	24 cr.
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(6 cr./qtr. - 4 qtrs. required)

Obstetrics & Gynecology- Reproductive Endocrinology and Infertility (REPR) - Clinical Master's Degree

Elizabeth A. Stewart, M.D., *Program Director*

Course Requirements

A total of **70 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 30 credits are clinical.

Biomedical Sciences Courses Didactic (all 31 credits required)

CORE 6000	Responsible Conduct of Research.....	1 cr.
CTSC 5110	Grant Writing for the Sciences.....	1 cr.
CTSC 5300	Fundamentals of Epidemiology.....	1 cr.
CTSC 5600	Statistics in Clinical and Translational Research.....	2 cr.
CTSC 5602	Utilizing Statistics in Clinical Research.....	1 cr.
OBG 6840	Research in Obstetrics-Gynecology	24 cr.
	(6 cr./qtr. – 4 qtrs. required)	
	Master's program application must be accepted by MCGSBS to enroll in this course.	

Must choose one of the following basic science courses: (3 credits required)

CORE 6150	Genome Biology	3 cr.
CORE 6250	Molecular Cell Biology	3 cr.
CORE 6400	Molecular Genetics.....	3 cr.

Additional elective courses may be taken after discussion and approval by the program director.

Courses available but are not limited to:

BMB 6660	Transcription, Chromatin, and Epigenetics	2 cr.
CTSC 5010	Clinical Research Proposal Development.....	2 cr.
CTSC 5100	Academic Publishing.....	1 cr.
CTSC 5370	Introduction to Epidemiology (formerly CTSC 5310)	2 cr.
CTSC 5390	Advanced Applied Epidemiologic Methods	2 cr.
CTSC 5610	Introductory Statistical Methods II.....	3 cr.
CTSC 5640	Logistic Regression	1 cr.
CTSC 5650	Survival Analysis.....	1 cr.
CTSC 5820	Introduction to Survey Research	1 cr.
CTSC 5910	Economic Evaluation in Health Care	1 cr.

Reproductive Endocrinology & Infertility Didactic Courses (7 credits required)

ANAT 6000	Anatomy of the Pelvis-Perineum	2 cr.
	Register winter quarter; attendance required winter and spring quarters	
OBG 5805	Introduction to Reproductive Endocrinology and Infertility	5 cr.
	(1 cr./qtr. - 5 qtrs. required)	
	Begin summer quarter of first year of fellowship; student must register for 5 consecutive quarters.	

Reproductive Endocrinology and Infertility Clinical Courses

OBG 6865	Reproductive Endocrinology and Infertility	30 cr.
	(6 cr./qtr. - 5 qtrs. required)	
	Begin summer quarter of first year of fellowship; register for 5 consecutive quarters.	

Orthopedics (ORS) - Clinical Master's Degree

Matthew P. Abdel, M.D., *Program Director*

Course Requirements

A total of **51 credits** with maintenance of at least a 3.0 GPA are required for graduation, of which 15 credits are clinical.

Biomedical Sciences Courses (all 29 credits required)

ANAT	6855	Orthopedic Anatomy	4 cr.
		(2 cr./qtr. - 2 qtrs. required)	
CORE	6000	Responsible Conduct of Research.....	1 cr.
ORS	6890	Research in Orthopedics.....	24 cr.
		(6 cr./qtr. - 4 qtrs. required)	

Orthopedics Didactic Courses (all 7 credits required)

ORS	5803	Prosthetics for Orthopedics	1 cr.
ORS	6550	Microvascular Surgery Skills	2 cr.
ORS	6860	Basic Knowledge and Motor Skills of Orthopedic Specialties.....	4 cr.

Orthopedics Clinical Courses (all 15 credits required)

ORS	6852	Adult Reconstruction	3 cr.
ORS	6853	Surgery of the Hand	3 cr.
ORS	6854	Pediatric Orthopedics.....	3 cr.
ORS	6855	Orthopedic Oncology.....	3 cr.
ORS	6856	Fractures and Related Injuries.....	3 cr.

Certificate Program Description and Track Requirements

- Artificial Intelligence in Healthcare (AIHC)
- Clinical and Translational Science Track (CTS)

Artificial Intelligence in Healthcare (AIHC) – Certificate

David Holmes III, Ph.D, *Program Director*

Certificate – 12 credits required

The Certificate track in Artificial Intelligence in Health Care is open only to Mayo Clinic employees who have a doctoral degree in a discipline applicable to research. Doctoral candidates may be considered. Potential candidates for the degree must hold Mayo Clinic appointments of sufficient duration to complete the program requirements.

Pre-Requisite Course Work (See AIHC Program Pre-requisite Requirements)

- 1) Introduction to statistics: Data summarization and statistical testing (like CTSC 5600)
- 2) Linear Algebra: Matrix Math
- 3) Calculus: Single variable (“Calc 1”)
- 4) Introduction to Scientific Programming (Python and/or R preferred)

Course Work

The curriculum for the Certificate consists of **12 credits**. The student must complete all of the required courses listed below:

Course Requirements

AIHC	5010	Introduction to Machine Learning.....	3 cr.
AIHC	5020	Introduction to Data.....	3 cr.
AIHC	5030	Introduction to Deployment, Adoption and Maintenance.....	2 cr.
CTSC	5300	Fundamentals of Epidemiology.....	1 cr.
CTSC	5350	Ethical Issues in Artificial Intelligence and Information Technologies.....	1 cr.
AIHC	5615	Fundamentals of Statistics for AI.....	2 cr.

Project Work

Students will be required to complete an AI project in which the student undertakes independent learning of an AI approach and generates a technical result.

Clinical and Translational Science (CTS) – Certificate

Prasad G. Iyer, M.D., *Program Director (through April 2023)*

M. Hassan Murad, M.D., MPH, *Program Director (new effective April 2023)*

CTS Basic Science Certificate

The [Certificate Program in Clinical and Translational Science](#) is open only to Mayo Clinic employees who have a doctoral degree in a discipline applicable to clinical research and are pursuing a clinical and translational research project that will lead to improvements in human health. Potential candidates for the Certificate must hold Mayo Clinic appointments of sufficient duration to complete the program requirements. Visiting research fellows are eligible to apply. However, visiting clinicians and research trainees are not eligible.

Course Work

The curriculum for the Certificate award consists of **13 credits**. The student must complete all of the required courses listed below:

CORE Course Requirements (1 credit required)

CORE 6000 Responsible Conduct of Research.....1 cr.

Track Requirements (7 credits required)

CTSC 5010 Clinical Research Proposal Development.....2 cr.

CTSC 5100 Academic Publishing1 cr.

CTSC 5370 Introduction to Epidemiology.....2 cr.

CTSC 5600 Introduction to Statistics in Clinical and Translational Research
.....2 cr.

Elective Courses (5 credits required)

Students can choose to focus their elective credits into one of the concentration areas listed below or select their elective credits based on recommendations from their mentor or based on their professional goals. Students are encouraged to select their elective credits from CTSC courses – CORE courses are also acceptable. However, other courses listed in the MCGSBS catalog may be taken with prior approval from the CCaTS Postdoctoral Executive Committee.

Concentration Requirements

Biomedical Ethics (BET) (5 credits required)

CTSC 5260 Advanced Methods in Biomedical Ethics Research.....1 cr.

CTSC 5261 Theoretical and Historical Foundations of Biomedical Ethics.....2 cr.

CTSC 5262 Case Studies in Health Policy and Biomedical Ethics.....1 cr.

CTSC 5263 Ethical Issues in Population Health Science.....1 cr.

Clinical Innovation & Entrepreneurship (CIE) (5 credits required)

CIE 6150 Case Studies in Entrepreneurship.....2 cr.

CIE 6151 Case Studies in Entrepreneurship: Key Resources & Revenue Streams.....1 cr.

CIE 6152 Case Studies in Entrepreneurship: Risk Assessment, Prototyping, and Commercialization Plan.....1 cr.

CTSC 6170 The Science of Team Science: Strategies for Success.....1 cr.

Clinical Trials (CLTR) (5 credits required)

CTSC 5020	Regulatory Issues in Clinical Research.....	1 cr.
CTSC 5025	Introduction to Regulatory Science.....	1 cr.
CTSC 5602	Introduction to Utilizing Statistical Software in Clinical and Translational Research	1 cr.
CTSC 5720	Clinical Trials: Design and Conduct.....	1 cr.
CTSC 6170	The Science of Team Science: Strategies for Success.....	1 cr.

Health Care Delivery (HCD) (5 credits required)

CTSC 5900	Introduction to Health Services Research.....	1 cr.
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Select 4 credits from:

CTSC 5640	Advanced Statistics in Clinical and Translational Research: Logistic Regression with Statistical Software.....	1 cr.
CTSC 5715	Publication Quality Tables and Figures.....	1 cr.
CTSC 5740	Systematic Reviews and Meta-Analysis.....	2 cr.
CTSC 5810	Qualitative Research Design, Methods and Analysis.....	1 cr.
CTSC 5820	Introduction to Survey Research.....	1 cr.
CTSC 5910	Economic Evaluation in Health Care	1 cr.
CTSC 5940	Secondary Data Analysis	1 cr.

Individualized Medicine (IDVM) (5 credits required)

CTSC 5340	Ethical Issues in Individualized Medicine.....	1 cr.
CTSC 5400	Introduction to Bioinformatics Concepts and Core Technologies.....	1 cr.
CTSC 5410	Molecular Variant Evaluation.....	1 cr.
CTSC 6160	Genomic Analysis and Data Interpretations for Rare and Undiagnosed Diseases.....	2 cr.

Mixed Methods Research (MIXM) (5 credits required)

CTSC 5810	Qualitative Research Design, Methods, and Analysis.....	1 cr.
CTSC 5815	Qualitative and Mixed Methods Research for Translational Science.....	2 cr.
CTSC 5820	Introduction to Survey Research.....	1 cr.

Select 1 credit from:

CTSC 5263	Ethical Issues in Population Health Science.....	1 cr.
CTSC 5720	Clinical Trials: Design and Conduct...1 cr.	
CTSC 5860	Behavioral Interventions in Clinical Trials.....	1 cr.
CTSC 5900	Introduction to Health Services Research and Policy.....	1 cr.
CTSC 5940	Secondary Data Analysis.....	1 cr.

Quantitative Research Methods (QUAN) (5 credits required)

CTSC 5602	Introduction to Utilizing Statistical Software in Clinical and Translational Research	1 cr.
CTSC 5610	Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software	3 cr.

Select 1 credit from:

CTSC 5640	Advanced Statistics in Clinical and Translational Research: Logistic Regression with Statistical Software	1 cr.
CTSC 5650	Advanced Statistics in Clinical and Translational Research: Survival Analysis with Statistical Software	1 cr.

Course Listings

Course Listings – Symbols and Explanations

The following symbols are used throughout the course descriptions in lieu of page footnotes:

A-F	Standard Letter Grading Scale
S-N	Pass / Fail Grading Scale
f,w,sp,su	Following course number indicates fall, winter, spring, or summer quarters respectively.
i	Following course number indicates instructor approval required.

Course Directors: The course director is the first faculty listed for each course; they are the primary contact for questions about the course, assigns final grades, etc.

ANATOMY

- ANAT 6000w. ANATOMY OF THE PELVIS AND PERINEUM. (2 cr.; S-N) C. Langstraat, W. Pawlina– Six two-hour dissection and demonstration periods on the female pelvis and perineum. Primarily intended for residents and fellows in Obstetrics and Gynecology.
- ANAT 6855f,w,sp,su. ORTHOPEDIC ANATOMY. (2 cr.; S-N) M. Morrey – Lectures, prosections and demonstrations of gross anatomy of the musculoskeletal system with special emphasis on relationships and surgical approaches.

*Only Anatomy courses which are required for degree completion in clinical programs are listed.

ARTIFICIAL INTELLIGENCE IN HEALTH CARE

- AIHC 5010w. INTRODUCTION TO MACHINE LEARNING. (3 cr.; A-F; pre-req. Programming skills in Python or R is required) Liu, Kline – This course offers a broad introduction to both the theoretical and practical aspects of the design and implementation of modern machine learning techniques. On the theory side, the course will focus on understanding key concepts of the algorithms and the relationships between them. On the applied side, the course will focus on effectively using machine learning methods to solve real-world problems.
- AIHC 5020su. INTRODUCTION TO DATA. (3 cr.; A-F; pre-req. Data summarization and statistical testing, Programming skills in Python or R is preferred, J. Juskewitch,) A. Knopp – Data is the foundation of knowledge generation and the raw material by which machine learning and artificial intelligence are fueled. The use of machine learning and artificial intelligence for the betterment of patient care and healthcare delivery is now coming into its own. An in-depth understanding of the nature of data is a crucial aspect for understanding and leveraging machine learning and artificial intelligence to its fullest. This foundation course will delve into the many attributes of data with a particular focus on the clinical data generated in the medical evaluation and treatment of patients along with the additional regulatory, privacy/confidentiality, and security issues involved with use of clinical data sets.
- AIHC 5030sp. INTRODUCTION TO DEPLOYMENT, ADOPTION & MAINTENANCE. (2 cr.; A-F; pre-req. BMEP 5200, CTSC 5300, AIHC 5010, AIHC 5615, , AIHC 5020) A. Aakre, S. Overgaard – This course will provide a high-level overview with multiple concrete examples of how to vet artificial intelligence for health care. Creating a model or algorithm is just one step in the journey to real-

world artificial intelligence (AI). Deploying means turning your model/algorithm into a useable service that is integrated into an existing production environment where it can take in an input, return an output and deliver value. You will learn to assess whether and when an AI algorithm should be used, and the steps required in AI translation and project execution. You will learn how to define an algorithm's business model, perform a business and financial effects assessment plan, and ensure that your AI solution meets ethical and regulatory requirements.

- AIHC 5045f. FDA & ISO SOFTWARE VERIFICATION AND VALIDATION. (1cr.; A-F;) Lifson, Vidal – This course will include a full overview of the lifecycle of regulated software from ideation through Food & Drug Administration (FDA) clearance and into post market monitoring and changes. You will be given the tools and resources needed to navigate regulations in this new and innovative area of medical practice. This course is required for the (AIHC) Regulatory/Translational Concentration and can also be taken as an elective for any other student..
- AIHC 5500sp. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING JOURNAL CLUB. (1cr.; S-N;) D. Holmes , K. Peterson, J. Reed, – The goal of this course is to enable students to become thought leaders in the domain of AI in health care. This is achieved through exposure to a broad range of AI topics and methodologies via weekly seminars. Each student will give two seminar presentations about notable AI-related publications. Seminars will also include presentations from guest speakers (from inside and outside of Mayo Clinic) about AI-related projects, tools, and methodologies.
- AIHC 5615f. FUNDAMENTALS OF STATISTICS FOR ARTIFICIAL INTELLIGENCE. (2cr.; A-F;) J. Mirth – This course will review basic concepts in statistics, specifically with regards to hypothesis testing for a variety of experimental designs regression techniques as useful statistical modeling approach, practical examples using the selected concept, and presentation of findings. The focus of this course will be in the implementation of software code to complete the model development, assessment of the statistical model utility, and visualization of the performance.
- AIHC 5960f. INTRODUCTION TO MEDICAL INFORMATICS (2cr.; A-F) V. Herasevich, B. Pickering – This course is intended to provide an introduction to the principles of medical and clinical informatics. Information science (IS) and Information Technology (IT) is now playing a major role in clinical medicine and research studies, from managing data to integration of data, information, and knowledge. Information infrastructure, guided by appropriate principles and expertise, could determine the success or failure of a study.
- AIHC 5961w. HEALTH INFORMATION TECHNOLOGY EVALUATION: CLINICAL INFORMATICS METHODS. (1cr.; A-F; pre-req. Basic Epidemiology and Statistics courses) V. Herasevich, B. Pickering – Governments and clinical providers are investing in health information technologies with little evidence as to their ultimate value. For years, health information technology (HIT) has been implemented with the goals of improving clinical care processes, health care quality, and patient safety. A systematic approach to the evaluation and testing allows for comparison of different HIT interventions with the goal of promoting those which improve clinical care and outcomes. In addition, structured evaluations of a projects impact are an essential element of the justification for investment in HIT. The question of the day is no longer “why perform evaluations,” but “how to perform evaluations.”
- This course will present basic concepts, theory, and methods associated with HIT evaluation.

- AIHC 5962w. CLINICAL SURVEILLANCE, ALERTING, AND DATA REPRESENTATION (1cr.; A-F; pre-req. AIHC 5960) V. Herasevich, B. Pickering, A. Bhattacharyya– Electronic Health Records are designed to improve patient health care and information management. Traditionally organized as databases, modern EMRs still lack deep integration with related workflows and decision support system available in other industries rather than healthcare. Clinical systems divert attention to serious medical situations by delivering notifications to the right place, at the right time, and to right person. However, further development is needed. On other hand, clinical data representation in current EMR solutions utilized standard controls and frameworks with 30+ years legacy. This course is designed to provide fundamental knowledge for understanding clinical surveillance and alerting systems, as well as modern clinical data visualization approaches.
- AIHC 5963sp. HEALTH INFORMATION SECURITY (1cr.; A-F; pre-req. AIHC 5960) V. Herasevich, P. Zummo – Increased access to advances in information technology enhances healthcare opportunities. However, it also presents significant threats to personal information and confidential data. Improved access, along with developing and implementing new technology, has made cybersecurity one of the most emerging industries and disciplines. A cyberattack on a hospital could not only compromise operations, but also endanger patient care which has become increasingly dependent on information technology. This course will provide introductory knowledge, theory, and methods associated with Information Security including policy, procedures, architectures, and risk assessment and focuses on strategical thinking to address cybersecurity challenges in healthcare context.
- AIHC 5964sp. AI & HIT IMPLEMENTATION (1cr.; A-F; pre-req. AIHC 5960) V. Herasevich, B. Pickering – Improved healthcare delivery and patient outcomes are the ultimate goals of software applications in healthcare. However, beside evaluation of impact that applications appropriate translation to clinical practice is critical task. This course is designed for people that are new to project management and give a solid foundation of implementation process.

BIOCHEMISTRY AND MOLECULAR BIOLOGY

- BMB 5000f. CANCER BIOLOGY I: INTRODUCTION TO CANCER BIOLOGY; MOLECULAR, CELLULAR AND GENETIC BASIS OF CANCER. (3 cr.; A-F) J. Hawse, M. Fernandez-Zapico – This course will provide an introductory foundation for understanding cancer biology through the discussion of normal and abnormal tissue pathology, and the molecular, cellular and genetic mechanisms that contribute to tumorigenesis. Topics that will be covered in the course include: the histopathology of cancer, tumor initiation and promotion, oncogenes and tumor suppressors, cell cycle control, cell migration and angiogenesis. In addition, several lectures will focus on the cellular, molecular and genetic approaches to study cancer in vitro and in animal models.
- BMB 5200f. BMB WORKS IN PROGRESS. (1 cr; S-N) J. Hawse – Works-in-Progress presentations on experimental research projects, given by graduate students in the Biochemistry and Molecular Biology tracks. Register in fall quarter only (1 cr./yr.). Attendance required fall, winter and spring. At least 70% attendance is required. Students present annually after year 1.
- BMB 5350sp. HORMONES AND CANCER. (1 cr.; S-N; offered odd years) J. Hawse – This course is a didactic class design to give the student an overview of hormonal carcinogenesis. The malignancies to be covered include breast cancer, prostate cancer, endometrial cancer, ovarian cancer, and thyroid cancer. The course will review epidemiology, signaling pathways, the role of hormones, and novel therapeutic approaches of the mentioned cancers.

- BMB 5520w. BIOLOGY OF AGING. (2cr; A-F) D. Baker– Studying the mechanisms underlying the process of aging promises to be one of the next great frontiers in biomedical science. Understanding the biology of aging is important not only for the long-term possibility of increasing life span, but for the more immediate benefits it will have on age-related diseases. As demographics of industrialized countries have changed, age-related diseases such as cancer, cardiovascular disease, stroke, osteoporosis, arthritis, and Alzheimer's disease have assumed epidemic proportions. A thorough understanding of the aging process is an important pre-requisite for designing rational therapeutic interventions for the treatment of these age-related disorders. We will focus on examining the biology of aging primarily through the examination of studies of a molecular, cellular, genetic, and demographic nature.
Topics will include: Genomic Instability, Telomere Attrition, Epigenetic Alterations, Proteostasis Deficiency, Deregulated Nutrient Sensing, Mitochondrial Dysfunction, Cellular Senescence, Stem Cell Exhaustion, Epigenetics and reprogramming.
- BMB 5660f,w,sp. EPIGENOMICS JOURNAL CLUB. (1cr ***only offered in Fall for credit**.; S-N) A. Gaspar Maia – Epigenetics, and its genome-wide applications, are rapidly emerging disciplines, seeking to define how genomes are regulated to give rise to distinct normal and diseased phenotypes. Students will gain a better understanding of Epigenomics concepts and methodologies through discussions of relevant reviews and original articles. The course covers scientific advances in DNA methylation, histone modifications, chromatin dynamics, and regulatory RNA molecules.
- BMB 6070w. CANCER BIOLOGY II: MOLECULAR MECHANISMS OF CANCER: SIGNAL TRANSDUCTION PATHWAYS AND NETWORKS. (3 cr.; A-F; offered even years; pre-req. BMB 5000) J. Hawse, M. Fernandez- Zapico – This course will provide a basic CORE of information on the molecular mechanisms through which cells receive and respond to external signals in the normal state, while highlighting how dysregulation of these signaling pathways contributes to tumorigenesis. Emphasis will be on the principles of cell signaling through specific cell surface receptors or within specific signaling networks. In addition, the molecular, genetic and biochemical strategies by which cell signaling pathways are being elucidated will be discussed. Topics to be covered include: the regulation of cell signaling pathways through cell surface receptors and hormone receptors, intracellular kinases and GTP-binding proteins, NF- κ B, apoptosis, and DNA damage signaling.
- BMB 6100w. MACROMOLECULAR STRUCTURE AND DYNAMICS. (2cr.; A-F; offered even years; pre-req. CORE 6100) M. Shellenberg, G. Mer – This course will cover the principles and methods used to analyze and define the structure and dynamic motion of biological macromolecules that drive the cellular processes essential for life. Topics covered will include NMR spectroscopy, X-ray crystallography, Cryo-EM, and other solution-based structure analysis techniques.
- BMB 6175w. PRINCIPLES AND APPLICATIONS OF X-RAY CRYSTALLOGRAPHY. (3cr.; A-F, offered odd years; pre-req CORE 6100 or equivalent, or permission of instructor) M. Schellengerg - Lectures and discussion sessions will cover the principles and methods of macromolecule structure determination using X-ray crystallography. Topics covered will include protein crystallization, properties of crystals, X-ray diffraction, structure determination, and analysis of crystal structures with an emphasis of validation and interpretation of crystal structures as they relate to biological systems. Lectures will be paired with discussion of literature examples and data processing workshops to emphasize learned material.

- BMB 6315f,w,sp. EXTRACELLULAR VESICLES INTEREST GROUP MEETING. (1 cr. A-F; register Fall term, present Fall, Winter, or Spring) E. Kostallari – This course offers the possibility to practice the understanding and communication skills by presenting a work-in-progress research project and a recent paper to an audience interested in extracellular vesicles.
- BMB 6390f,w,sp,su. INDEPENDENT STUDY IN BIOCHEMISTRY AND MOLECULAR BIOLOGY. (2-3 cr.; P/F) TBA– Tutorials arranged on an individual basis in selected advanced topics in biochemistry and molecular biology. Students are expected to define a topic and specific reading list in consultation with a member of the faculty. Mastery of the subject matter is assessed by examination or by submission of a formal review of the subject area.
- BMB 6500f,w,sp. BMB JOURNAL CLUB. (1 cr.; S-N) J. Hawse – Students of the Biochemistry and Molecular Biology program present a peer review article relevant to BMB, in some cases associated with the research of the seminar speaker coming the following week. Register in fall quarter only (1 cr. /yr.; total of 4 cr.). Attendance required fall, winter and spring at the journal club and the associated BMB Seminar. At least 70% attendance is required at both the journal club and seminar.
- BMB 6510f. CANCER BIOLOGY JOURNAL CLUB. (1 cr. /qt.; S-N) M. Fernandez-Zapico, J. Hawse – This journal club will discuss current primary literature covering all aspects of cancer biology. The journal club will meet once per week and be conducted under the open discussion format with directed student and faculty presentations. During the fall quarter, journal articles of fundamental and historic interest in the area of cancer biology will be read and discussed. Topics to be covered include: cell cycle, oncogenes, tumor suppressors, growth factors, signal transduction, metastasis, DNA tumor viruses, and retroviruses.
- BMB 6515f,w,sp. MUSCULOSKELETAL JOURNAL CLUB. (1 cr/yr.; S-N; Register in fall quarter only) J. Westendorf – Graduate students, postdoctoral fellows and residents present peer-reviewed articles that describe new and high impact work in musculoskeletal research fields. MCGSBS students from any track or program are welcome to attend and lead discussions in this interdisciplinary forum that spans molecular and cellular biology, biomechanics, endocrinology, orthopedics, osteoimmunology, physiology, and other disciplines. *This is a shared course with the Biomedical Engineering and Physiology and track.* Attendance required in consecutive fall, winter and spring quarters. Students must present and lead one discussion during one of the quarters and attend 75% of meetings over all three quarters to earn credit.
- BMB 6520f,w,sp. CURRENT TOPICS IN AGING RESEARCH. (1 cr./yr.; S-N; register in fall quarter only; attendance required fall, winter, and spring) D. Monroe, J. Miller – Current topics in aging research utilizes the Kogod Center’s “Aging Mondays” to expose students to a range of topics related to the basic biology of aging presented in four concurrent series: journal club, works-in-progress, NERDs and seminars presented by an international group of seminar speakers. Each series meets at noon on a different Monday of the month. There are no course prerequisites, but attendance requires preapproval by the course director. Presentation at the Aging JC or WIP during the quarter is required for credit.
- BMB 6650sp. RECEPTOR TRAFFICKING AND SIGNALING TUTORIAL. (2 cr.; A-F; offered odd years; pre-req. CORE courses 6100, 6150 and 6250) B. Horazdovsky – This tutorial focuses on understanding the molecular basis of receptor traffic and signaling in eukaryotic cells. Special attention is directed toward contributions by the cytoskeleton and vesicular transport machinery during endocytosis and secretion. Students prepare oral presentations describing a synthesis of appropriate topics.

- BMB 6660f. TRANSCRIPTION, CHROMATIN, AND EPIGENETICS. (2 cr.; A-F; offered even years; pre-req. CORE courses 6100, 6150 and 6250) K. Robertson, T. Ordog – This course will cover in depth mechanisms of transcriptional regulation within a modern conceptual framework focused on epigenetics. Topics will include chromatin structure and dynamics, nuclear structure and nuclear domains, and chromosomal territories. The application of epigenetics to human development and diseases will be discussed.
- BMB 6665w. CURRENT TOPICS IN NUCLEIC ACIDS BIOCHEMISTRY. (3 cr.; A-F; offered even years; pre-req. CORE courses: CORE 6100, CORE 6150, and CORE 6250 or consent of instructor) J. Maher – The three objectives of this tutorial are 1) to familiarize advanced graduate students with biochemical and biophysical principles of nucleic acids and their interactions with proteins; 2) to introduce molecular viewing tools to facilitate atomic-level understanding of macromolecular structure, and 3) to apply these principles and tools to current biological problems and processes involving nucleic acids.
- BMB 6680f. NMR SPECTROSCOPY, MICROSCOPY, AND METABOLOMICS. (1cr; S-N; offered odd years) S. Macura, I. Vuckovic – NMR methods can roughly be divided in spectroscopy (structure and dynamics of molecules), microscopy (imaging of and dynamics in organs and organisms) and metabolomics (identification and quantitation of metabolites in body fluids and tissues/cellular extracts). In this course the basic principles of these methods will be described and explained with emphasis on the experiment design and data interpretation.
- BMB 6700sp. METABOLISM AND METABOLOMICS. (3 cr.; A-F) D. Povero, B. Fernandez Gil – The Metabolism and Metabolomics course is a didactic experience designed to develop learners' intellectual abilities on human metabolic pathways, their cellular regulation in health and disease and tools and approaches used to investigate metabolic pathways and to analyze metabolomics data. The course will cover metabolism of carbohydrates, lipids, amino acids and nucleotides, their regulation by hormones, nutritional status, cellular stress, immune system and carcinogenesis. Learners will also have an opportunity to develop skills on the current tools and approaches to study metabolism systemically and at the cellular level. Through a diverse learning experience which includes lectures, discussions, pop-up questions, learning-based assessments, and shark-tank style presentations, this course will help learners answer the following questions: 1) what are the metabolic pathways; 2) how, when and why metabolic pathways are regulated? 3) what are the tools and approaches to study metabolism in cells and organ-systems? 4) how do we analyze and interpret metabolomics data? 5) how could we exploit metabolic pathways to identify novel therapeutic strategies for human diseases?
- BMB 6801f,w,sp,su. CONCEPTS OF MEMBRANE-CYTOSKELETAL DYNAMICS JOURNAL CLUB. (1 cr. /qt.; S-N; pre-req. CORE 6250) G. Razidlo – This Journal Club is a cell biology-based discussion of recent literature detailing the mechanisms of basic cellular processes, including membrane trafficking and dynamics, cytoskeletal remodeling, organelle interactions, cell migration, and autophagic/nutrient signaling.
- BMB 6900f,w,sp,su. BMB THESIS PROPOSAL. (2 cr.; S-N) TBA – Thesis proposal: The written thesis proposal matches the new format of NIH R01 grants and, hence, is limited to 8 pages, including illustrations but not including references. In the student's own words, the proposal should outline the rationale for the proposed project and how it is to be executed. The proposal is subdivided into the following sections:
- Abstract: Summary of your project (1 page).
 - Specific Aims: Describe briefly the aims of your project and hypotheses (1 page).

- Research Strategy: This includes “Significance” - put your project into context with what is known about this area of biology and show the importance of the questions you are asking (~ 1-1.5 pages), “Innovation” - how is the project you are proposing novel and groundbreaking (~0.5-1 page) and “Approach” - describe what you plan to do and how you plan to do it. Include preliminary data for each aim that sets the scene and supports your hypotheses (3.5-4.5 pages).

Register for course credit the quarter AFTER you have prepared your proposal and taken the oral exam. Submit note signed by your committee to the course director indicating that your thesis proposal was satisfactory.

BIOMEDICAL ENGINEERING AND PHYSIOLOGY *Course Auditing with Instructor Approval

BMEP 5100f. RADIOLOGICAL HEALTH. (2 cr.; S-N; offered odd years; consent of instructor required prior to registration) G. Sturchio – An introduction to concepts of radiological health, philosophy and principles of radiation protection, interpretation of standards and regulations, and planning of facilities and activities.

BMEP 5160sp. INTRODUCTION TO RADIATION PHYSICS. (3 cr.; A-F; offered even years, pre-req. calculus, atomic or modern physics) J. Johnson, H. Seum, S. Wan Chan Tseung – This is an introductory graduate course designed for those interested in the radiation sciences. The course will introduce the student to the basic concepts and physical principles that underlie modern radiation physics including atomic structure, radiation, interactions of radiation with matter, introduction to cavity theory, biological effects of radiation (dose), x-ray production and dosimetry techniques.

BMEP 5200su, f. MATHEMATICS IN BIOMEDICAL ENGINEERING & PHYSIOLOGY. (Begins Summer term to be completed prior to Fall, must register for both terms, 4 cr., 2 per quarter; A-F) A. Manduca,, M. Urban – This course will introduce mathematical topics used in biomedical engineering and quantitative physiological applications including a brief review of trigonometry and calculus, then covering linear algebra, vector analysis, complex variables and functions, Fourier series and transforms, dimensional analysis, ordinary differential equations, and basic concepts in probability. A basic introduction to MATLAB and mathematical modeling is included.

BMEP 5250w. ANATOMY FOR BIOMEDICAL ENGINEERS. (2 cr.; S-N; offered odd years) W. Pawlina – Students dissect selected regions of the human body and learn correct names and locations of associated anatomical structures. Each student then gives a detailed presentation to the class of the region studied.

BMEP 5450f. LABORATORY METHODS IN BIOMEDICAL IMAGE PROCESSING. (3 cr.; A-F) Holmes – An introduction to important concepts in applied biomedical imaging, including digital processing of images, image signal characteristics, histogram analysis, domain processing, digital filters, image compression, reconstruction from projections, discussions of image composition, interactive 3D display, image processing and segmentation, registration and quantitative analysis. Practical applications in basic science and medicine are discussed. Students will use ANALYZE biomedical imaging software developed at Mayo to investigate these topics.*offered any quarter if enough students are participating*

- BMEP 5452w. BIOMECHANICS. (3 cr.; A-F) K. Zhao,– This course provides an overview of the mechanical properties and structural behavior of biological tissues. Specific course topics include cell matrix level mechanics, structure and function relationships in tissues and organs, analysis of forces in human function and movement, and application of stress and strain analysis to biological tissues.
- BMEP 5453w. FUNDAMENTAL CONCEPTS IN BIOMECHANICS. (3 cr.; A-F) K. Kaufman – This course is an introduction to biomechanics and addresses the fundamental topics of kinematics and kinetics.
- BMEP 5460sp. FINITE ELEMENT ANALYSIS. (3CR.; A-F; rep-req. Calculus, Linear Algebra) D. Dragomir-Daescu – This is a combination of in-class teaching and self-directed study to help the students acquire a working knowledge of Finite Element Analysis (FEA). The goal is to teach the fundamental principles using tutorials and computer labs for an accelerated understanding of how the students can use FEA in their specific area of biomedical engineering research.
- BMEP 5550sp. IMAGE GUIDED PROCEDURES IN BIOMEDICAL APPLICATIONS. (4 cr.; A-F; pre-req. BMEP 5450 or equivalent) D. Holmes – An introduction to the concepts, methods and applications of image guided technology and interventions, including device tracking, advanced visualizations, workflow emulation and virtual reality simulations in biomedical research and clinical procedures.
- BMEP 5704sp. BIOINSTRUMENTATION AND SIGNAL PROCESSING. (3 cr.; A-F). D. Holmes – This course will provide an introduction to basic principles of bioinstrumentation and related signal processing. The course will begin with discussion of the basics of sensing and theoretical treatment of signals, with an emphasis on bioinstrumentation applications. The remaining portion of the course will focus on analog and digital signal processing, involving both theoretical analysis and practical implementation.
- BMEP 5740sp. MAGNETIC RESONANCE IMAGING SYSTEMS. (3 cr.; A-F; offered odd years; pre-req. advanced calculus, Fourier analysis, and a course in modern physics) S. Riederer – An introduction to physics and engineering aspects of modern diagnostic magnetic resonance imaging (MRI).
- BMEP 5800f,w,sp. INTRODUCTION TO MEDICAL IMAGING. (Course will span f, w, sp quarters = 6cr. 2cr./quarter; A-F) S. Leng, S. Hsieh – An introduction to the fundamental principles of medical image acquisition and analysis. Diagnostic imaging modalities to be covered include radiographic imaging, x-ray computed tomography, digital radiography, nuclear medicine, ultrasound and magnetic resonance imaging. This course has been accredited by the Commission on Accreditation of Medical Physics Education Programs (CAMPEP); please contact the instructor for further information.
- BMEP 5802sp. ADVANCED PRINCIPLES OF BIOMECHANICS. (3 cr.; A-F; pre-req. BMEP 5453) C. Zhao – Advanced concepts of orthopedic biomechanics, including kinematics and kinetics, mechanics of deformable bodies, stress analysis, tissue engineering and fluid mechanics.
- BMEP 6000i. TUTORIAL IN EXERCISE PHYSIOLOGY. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration) M. Joyner – This course is designed for selected physiology graduate students who seek a broad overview in integrative physiology. The focus will be on presenting broad biological concepts related to integration, regulation, homeostasis, and the multitude of organ systems and how they adapt to various environmental and physical stresses. The course meets once a week for 1½ to 2 hours. It is taught using a collegial problem-

solving approach. Students take a major role in where the course goes. The course runs one full academic year.

- BMEP 6100sp. MEDICAL HEALTH PHYSICS. (2 cr.; A-F; pre-req. BMEP 5100 or equivalent, or consent of instructor) G. Sturchio – Radiation protection philosophy and principles as applied to the medical environment: protection of patients, public, and employees; procedures for obtaining Nuclear Regulatory Commission license. This course has been accredited by the Commission on Accreditation of Medical Physics Education Programs (CAMPEP); please contact the instructor for further information.
- BMEP 6151w. RADIATION ONCOLOGY PHYSICS. (3 cr.; A-F; pre-req. BMEP 5160) N. Remmes, J. Ma, D. Moseley – Physics principles of the application of ionizing radiation in radiation therapy, including radiation characteristics, dose calculation, treatment planning/dosimetry, brachytherapy and quality assurance. This course has been accredited by the Commission on Accreditation of Medical Physics Education Programs (CAMPEP); please contact the instructor for further information.
- BMEP 6300i. TUTORIAL IN NEUROPHYSIOLOGY. (3 cr.; A-F; offered only once per year with consent of instructor required prior to registration) G. Sieck – This course will provide an understanding of the basic concepts in cell and neurophysiology. The application of current experimental methods and techniques will be emphasized. Classic papers from the literature will be assigned and discussed. Laboratory demonstrations and computer modeling will be included if class size permits.
- BMEP 6302i. TUTORIAL IN ULTRASONIC IMAGING. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration)K. Fatema – Principles of ultrasound physics and interaction of ultrasound with biological tissues; principles and methods of tissue imaging using ultrasound; evaluating mechanical properties of tissue by ultrasound; measuring blood flow and tissue motion by Doppler method; artifacts in ultrasound imaging and in Doppler techniques; overview of recent and advanced techniques in medical ultrasound clinical applications of ultrasound.
- BMEP 6350sp. ADVANCED CONCEPTS IN MOLECULAR BIOPHYSICS. (4 cr.; A-F; offered even years) BMEP TBA – This course focuses on the biophysics of ion channels, solute transporters, molecular motors, elastic proteins, molecular recognition, protein dynamics and enzyme kinetics. A set of technical lectures will cover patch clamp recording, single channel kinetic analysis, x-ray crystallography, mass spectrometry and fluorescence spectroscopy. Didactic lectures are complemented by student presentations of a corresponding scientific paper.
- BMEP 6375w,sp,su. CONCEPTUAL INTEGRATION AND COMMUNICATION IN MULTIDISCIPLINARY SCIENCE. (2 cr. S-N) J. Miller, D. Linden - The goal of this multi-quarter course will be to emphasize conceptual integration across multiple biomedical disciplines and the ability to concisely and effectively communicate concepts. Via this integrative approach, the student is expected to be able to communicate, especially in written form, basic knowledge gained through the core curriculum of the graduate program in biomedical engineering and physiology. The learning model will consist of faculty lead discussions.

In the first quarter emphasis will be on effective written communication and identifying key concepts in the core curriculum. The student will be provided writing examples for discussion, given writing assignments, and given timed writing assignments. The student will be provided core curriculum objectives and discuss identification of key concepts to organize and chunk learning material.

In the second and third quarters the emphasis will be on conceptual integration of core curriculum. Writing assignments and discussions will emphasize communication of concepts across multiple disciplines.

Student evaluations will be based largely on class participation and performance on assignments. A comprehensive final exam will consist of four questions with each question testing conceptual understanding and effective written communication of concepts integrated between two core courses.

- BMEP 6470f. TWO-DIMENSIONAL DIGITAL SIGNAL PROCESSING. (4 cr.; A-F; pre-req. BMEP 6704 or working knowledge of linear system theory and one-dimensional digital signal processing) TBA – Fundamentals of 2-D digital signal processing, including 2D discrete Fourier and Z-transforms, 2D discrete cosine transforms, and 2D linear and nonlinear Finite Impulse Response filters. Other topics covered are histogram equalization, edge-detection methods, morphology, compression routines and fuzzy logic filters. This class is a foundation for image processing. There will be homework and class projects.
- BMEP 6490w,. ADVANCED TOPICS IN BIOMEDICAL IMAGE PROCESSING. (3 cr.; A-F; offered based on student interest) C. Schwarz, A. Manduca – Please contact Drs. Schwarz and Manduca if you are planning to take this course, as the course is held is based on student interest. An in-depth study of difficult problems in imaging science as they relate to biomedical images. Areas of study include image segmentation, image registration, texture analysis, shape description and matching, deconvolution, multispectral analysis and denoising.
- BMEP 6500i. SPECIAL TOPICS IN IMAGING SCIENCE. (2 cr.; A-F; pre-req. BMEP 5450, BMEP 6700; consent of instructor required prior to registration) TBA – Special topics in the imaging sciences applied to biomedical problems and data; including 3-D imaging, volume rendering, surface rendering, image segmentation, image registration and fusion, shape description and analysis, multi-spectral analysis and classification, virtual reality visualization, image modeling.
- BMEP 6600i. PHYSIOLOGY & BIOMEDICAL ENGINEERING SEMINARS. (1 cr.; S-N; consent of instructor required prior to registration) A. Matveyenko, M. Urban – Presentations of research topics related to physiology and biomedical engineering. All BMEP students are required to attend seminars. In addition to attendance, students are required to give two short (30 min) presentations related to their own research projects, one prior to the start of winter quarter in their third year and the second in their fifth year. Students should register in the quarter in which they give their second presentation.
- BMEP 6650f,w,sp. BIOMEDICAL ENGINEERING & PHYSIOLOGY JOURNAL CLUB. (1 cr.; S-N) D. Holmes, C. Haider – The Biomedical Engineering Journal Club provides a forum for discussion of recent advances in biomedical engineering and physiology. Development of critical reading and writing skills will be incorporated as they apply to manuscript and grant reviewing and writing. Each student is expected to present at least one paper per year. Faculty will be invited to participate as appropriate. Students are required to attend for 3 consecutive quarters in a given year - fall, winter and spring (register for course in spring).
- BMEP 6700su,f,w. PHYSIOLOGY FROM CELLS TO ORGANISM. (Must be taken sequentially beginning with summer; 6 cr.; 2 cr. per quarter; A-F) J. Miller, D. Linden – The goal of this course will be an emphasis on the importance of integrative physiology in the evolving area of functional genomics.

Laboratory demonstrations will provide exposure to state-of-the-art physiological techniques with applications from cell physiology to human disease.

- BMEP 6710w. NUMERICAL METHODS IN BIOMEDICAL RESEARCH. (3 cr.; A-F) A. Manduca – This course provides an overview of advanced mathematical and numerical methods commonly used in biomedical research including: theory and solution of ordinary and partial differential equations, common transforms, function fitting, interpolation and extrapolation, optimization and search algorithms, and filtering and time series analysis.
- BMEP 6720w. DEEP LEARNING FOR MEDICAL IMAGING (3 cr.; S-N; offered even years) B. Erickson – We will cover deep learning methods, with particular emphasis on applications in medical imaging. Moderate Python programming skills are required. The course will consist of a series of videos to be viewed on the student's own time, and classroom time will consist of discussion of principles covered. The course will also include a major project that serves as the "final exam" for the course.
- BMEP 6730w. LABORATORY METHODS IN MAGNETIC RESONANCE IMAGING. (2 cr.; S-N; offered even years; pre-req. BMEP 5740, previous or concurrent registration or course director approval) H. Edmonson – Introduction to MRI laboratory methods. Firsthand experience in basic and advanced MR image acquisition strategies, experimental tradeoffs, image reconstruction, and data interpretation.
- BMEP 6740w. ADVANCED TOPICS IN MAGNETIC RESONANCE IMAGING SYSTEMS. (3 cr.; S-N; offered even years; pre-req. BMEP 5740) S. Riederer – A technical study of advanced topics in contemporary magnetic resonance imaging (MRI). Topics to be discussed include vascular imaging and flow assessment, motion effects and compensation, echo-planar imaging, parallel acquisition, cardiac imaging, and diffusion.
- BMEP 6745su. ADVANCED MEDICAL IMAGE RECONSTRUCTION: THEORY AND APPLICATIONS. (3 cr.; A-F; offered odd years; pre-req. BMEP 5200 and BMEP 5800 or equivalent coursework) J. Trzasko – The objective of this course is to provide imaging students in-depth training in the theory and applications of advanced signal processing techniques for medical image reconstruction (all modalities), including statistical and iterative techniques for limited data and quantitative imaging applications.
- BMEP 6750f,sp. MAGNETIC RESONANCE TECHNICAL SEMINAR. (1 cr.; S-N; offered odd years; consent of instructor required prior to registration) S. Riederer – Seminar held weekly consisting of a presentation of some contemporary technical research topic in magnetic resonance.
- BMEP 6755f. X-RAY COMPUTED TOMOGRAPHY. (3 cr; A-F; offered even years; pre-req. BMEP 5800) L. Yu, S. Leng, C. McCollough – The objective of this course is to give students in-depth training in X-ray computed tomography, including analytical and iterative reconstruction; dose measurement, management and reduction; cardiac and multi-energy CT; current clinical applications; and emerging techniques. Hands-on lab work and programming will be required as part of this course.
- BMEP 6820i. ADVANCED APPLICATIONS IN BIOMECHANICS. (2cr.; S-N; pre-req. BMEP 5452) K. Zhao - This course incorporates advanced anatomy, kinematics, kinetics, and protocol development, with a focus on the student's specific research topic and interest. The course will culminate in a project that integrates the methods and applies them to a research question related to the student's thesis work.

- BMEP 6830w. LABORATORY METHODS IN PHYSIOLOGY. (2 cr.; A-F) T. Meier – This course provides instruction and hands-on experience in the use of common methods and techniques in physiology. It will acquaint students with regulations, information sources, and ethical considerations of responsible animal use in research. Lab directors will teach students techniques such as appropriate handling, sampling, anesthesia, and surgery of animal subjects, with an emphasis on rodents, including transgenic methods and rodent models.
- BMEP 6840f. LABORATORY METHODS IN BIOMECHANICS. (2 cr.; A-F) K. Kaufman – This course is an introduction to biomechanics laboratory methods, covering techniques spanning from the in-vitro tissue level to in-vivo joint biomechanics. The course will include hands-on experience in material testing, motion tracking, force measurement, EMG measurement, device accuracy testing, and data processing. Students will also become familiar with IRB and IACUC study requirements.
- BMEP 6853i. READINGS IN BIOMEDICAL ENGINEERING. (2 cr.; S-N; consent of instructor required prior to registration) BMEP Faculty – Review of contemporary topics in Biomedical Engineering literature to be arranged with individual BMEP faculty members. Prior approval from Program Director. Name of faculty with syllabus required for approval.
- BMEP 6855i. TUTORIAL IN CARDIOVASCULAR PHYSIOLOGY. (3 cr.; A-F; offered only once per year with consent of instructor required prior to registration) J. Miller – Students will be exposed to advanced topics in cardiovascular physiology with an emphasis on Integrative control mechanisms in health and disease, structure and function, sex-based medicine and translational approaches to investigations. Students will be required to critically evaluate current literature, provide a historical overview of a specific topic and to write a review article on a topic of mutual interest to the group.
- BMEP 6856i. TUTORIAL IN RESPIRATORY PHYSIOLOGY. (3 cr.; A-F; offered only once per year with consent of instructor required prior to registration) G. Sieck – The goal of this course is to provide an in-depth account of the functional components of the respiratory system and their integration in health and disease.
- BMEP 6858i. TUTORIAL IN SMOOTH MUSCLE PHYSIOLOGY. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration) Y. Prakash – Students will be exposed to advanced topics related to smooth muscle signaling pathways, intracellular calcium regulation, pharmaco-mechanical coupling, etc.
- BMEP 6859i. TUTORIAL IN RENAL PHYSIOLOGY. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration) M. Romero – Renal hemodynamics, glomerular function, mechanisms and regulation of electrolyte transport.
- BMEP 6860i. TUTORIAL IN ENDOCRINE PHYSIOLOGY. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration) A. Matveyenko – This course focuses on several aspects of endocrine physiology, including mechanisms of hormone action, calcium homeostasis, glucose, and fatty acid metabolism, pituitary, thyroid and adrenal physiology, immunologic aspects of endocrinology, and endocrine effects on bone biology.
- BMEP 6861i. TUTORIAL IN SKELETAL MUSCLE PHYSIOLOGY. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration) G. Sieck – The goal of this course is to explore muscle physiology from the protein- protein interactions that establish the molecular basis of muscle contraction to the biomechanics of movement.

- BMEP 6862i. TUTORIAL IN NEUROMOTOR CONTROL PHYSIOLOGY. (2 cr.; A-F; offered only once per year with consent of instructor required prior to registration) G. Sieck – The goal of this course is to explore modeling and analysis of complex physiological systems: respiratory control, sleep apnea, and locomotion. A laboratory session and journal reviews are also planned to prove some of the above concepts and their applications.
- BMEP 6863f. TUTORIAL IN NEURAL ENGINEERING. (2 cr.; A-F; offered odd years; pre-req: BMEP 6700, BMEP 5704, BMEP 5200) G. Sieck, G. Worrell – Course offered at the discretion of the instructors, or Fall term if the first option is not possible. This course is designed to explore the engineering applications in neuroscience. Included topics are the fundamental physical principles governing neural interface systems, relevant anatomy and physiology of the nervous system, and the conceptual design, optimization and implementation of neural interface technology. The course focuses mainly on neural interfaces and prosthetics.
- BMEP 6864f. NEURAL ENGINEERING TUTORIAL – ELECTROPHYSIOLOGY OF THE BRAIN. (2 cr; A-F; offered odd years; pre-req: BMEP 6700, BMEP 5704, BMEP 5200) G. Sieck, G. Worrell – This course is designed to explore the engineering applications in neuroscience. Included topics are the fundamental physical principles governing neural interface systems, relevant anatomy and physiology of the nervous system, and the conceptual design, optimization and implementation of neural interface technology. This course focuses mainly on neural interfaces and prosthetics.
- BMEP 6870f. SYSTEMS PHYSIOLOGY I. (3 cr.; A-F) M. Romero – In Systems Physiology I; The Cell as a Complex Biological System – the students will obtain a broader view of traditional “Cellular Physiology.” All systems are made up of components which must communicate and respond. This course will focus on the fundamental organization that exists at the molecular, cellular, tissue, organism and population levels.
- BMEP 6871w. SYSTEMS PHYSIOLOGY II. (3 cr.; A-F) G. Sieck – Development, Growth and Regeneration – concepts of intracellular communications as taught in Systems Physiology I will be reinforced, and the concept of intercellular communication will be introduced as they relate to the development, growth, and regeneration of issues. Roles of stem and progenitor cells along with contributions from various model systems will be incorporated.
- BMEP 6876w. ADAPTIVE AND NONLINEAR PHYSIOLOGICAL SYSTEMS. (3 cr.; A-F; pre-req. BMEP 6875) TBA – The course covers the modeling and analysis of the following complex physiological systems: Respiratory Control, Cardiac Dysrhythmias, Sleep Apnea, Neutrophil Density Regulation, Cardiovascular Variability, and Circadian Rhythms. Adaptive and nonlinear control concepts are explained and applied to these physiological systems, and where Matlab and Simulink are used for simulation. A laboratory session and journal reviews are also planned to prove some of the above concepts and their applications.
- BMEP 6878i. TUTORIAL IN BONE PHYSIOLOGY. (3 cr.; A-F; offered only once per year with consent of instructor required prior to registration) Margaux. B. Linde – Lectures and discussions in physiology of both normal and abnormal bone. Classes are a combination of lectures and current topical literature. Topics will vary, depending on the interest of enrolled students.

CLINICAL INNOVATION AND ENTEPRENEURSHIP

- CIE 6150su,w. CASE STUDIES IN ENTREPRENEURSHIP (2 cr.; A-F) M. Rotman, S. Ekker, R. Hale, A. Sreedhar - This course was developed in collaboration with the Mayo Clinic Department of Business Development. In this course, we will use experiential learning approaches to learn about entrepreneurship through the actual development and execution of a startup idea.
- CIE 6151f. CASE STUDIES IN ENTREPRENEURSHIP: KEY RESOURCES AND REVENUE STREAMS (1 cr.; A-F; pre-req. CIE 6150) M. Rotman, S. Ekker, R. Hale, A. Sreedhar – The Financial Business Modeling builds on the outcomes of the Fundamentals course OE 6150, and is part of the Certificate / Concentration in Clinical Innovation and Entrepreneurship.
- CIE 6152sp. CASE STUDIES IN ENTREPRENEURSHIP: RISK ASSESSMENT, PROTOTYPING, AND COMMERCIALIZATION PLAN (1 cr.; A-F; pre-req. CIE 6150) M. Rotman, S. Ekker, R. Hale, A. Sreedhar – This course builds off the CIE 6150 and CIE 6151 courses and continues to help students de-risk both the business and scientific side of their startup idea.
- CIE 6153su. CASE STUDIES IN ENTREPRENEURSHIP: ACCELERATING SBIR/STIR FUNDING PROPOSALS FOR HEALTHCARE INNOVATIONS (1 cr.; A-F; pre-req. CIE 6150, CIE 6151, CTSC6152) M. Rotman, S. Ekker, P. Dillon, R. Hale, A. Sreedhar – This course collates the oral and writtendeliverables completed during CIE 6150, CIE 6151 and CIE 6152 to learn the key components of a 116 high-quality research proposal for future submission at the Department of Health and Human Services (HHS), National Institutes of Health, or the Food and Drug Administration, or the Centers for Disease Control and Prevention).
- CIE 6154w. ENTREPRENEURIAL LEADERSHIP LAUNCH (1cr. A-F) R. Hale - In this course, we will use experiential learning approaches to launch students into a higher level of confidence and effectiveness in leadership and career achievement. Students will develop and execute on an individualized leadership growth plan organized around achieving a significant professional goal each student selects in this course.

CORE COURSES:

- Summer: CORE 6000 (1 cr.), CORE 6150 (3 cr.)
Fall: CORE 6100 (3 cr.), CORE 6200 (3 cr.)
Winter: CORE 6000 (1 cr.), CORE 6250 (3 cr.), CORE 6400 (3 cr.), CORE 6770 (3 cr.)
Spring: CORE 6050 (2 cr.), CORE 6300 (3 cr.), CORE 6450 (3 cr.), CTSC 6100 (3 cr.)

CORE 6000w,su. RESPONSIBLE CONDUCT OF RESEARCH. (1 cr.; S-N) Z. Master – This course aims to provide instruction on the responsible conduct of research (RCR) and is an NIH requirement. The course is designed to provide learners with key fundamental principles and best practices surrounding RCR and to set the tone for future generations of researchers. Core 6000 will be delivered in a blended format of online and face-to-face discussions (as conditions allow). The course consists of 10 key topics delivered in 10 didactic style lectures. For each lecture/topic there will be a short quiz and online discussion post that will be required. Topics include research misconduct, responsible data management, public responsibilities with scientists, scientific authorship and publication, peer review, ethical use of animal research and human research, mentor/mentee responsibilities, and research collaboration with industry.

CORE 6001 RESPONSIBLE CONDUCT OF RESEARCH REFRESHER COURSE. (0 cr.; pre-req CORE 6000) Z. Master – The NIH requires Responsible Conduct of Research (RCR) instruction at least

once during each career stage, and at a frequency of no less than once every four years. The RCR Refresher Course consists of eight hours of instruction within CORE. Ph.D. and M.D-Ph.D. students will be notified by MCGSBS when they are required to take the refresher course.

- CORE 6010f. RIGOR AND REPRODUCIBILITY (0 cr; S-N.) B. Horazdovsky – This course will focus on key concepts in scientific rigor and reproducibility. CORE 6010 curriculum will be delivered in a blended format that consists of online modules through Blackboard, in-person lectures, and face-to-face discussions (as conditions allow). **to be offered beginning winter term 2022 only during last 6 weeks of winter term*
- CORE 6050sp. CRITICAL THINKING AND SCIENTIFIC WRITING. (2 cr.; S-N; pre-req. enrollment in a degree-granting program of the Mayo Clinic College of Medicine and Science or consent of instructors) L. Lujan, P. McLean – This course is intended for first year graduate students across all tracks. The course will involve two components. The first will be a didactic element that introduces the scientific method, techniques and tools for searching and organizing the scientific literature, practical bioinformatics approaches, applied biostatistical analysis, scientific manuscript writing, and grant preparation. In parallel, students will choose a topic of interest and will prepare an NIH-style small grant proposal (e.g. 6-12 page R01 format) that will be critiqued by the course directors, the instructors, and by the other students in the class in a “study section” setting. Via a series of weekly roundtable forums discussing the merits and faults of each proposal throughout the writing process, the students will learn to craft a coherent and well-reasoned grant.
- CORE 6051su. SCIENTIFIC WRITING PART II. (1cr; S-N; pre-req. CORE 6050) J.L. Lujan, P. McLean – The purpose of this course is to have students prepare a polished, submission-ready F31 grant to be submitted during their second year of beginning of their third year of training. The course is open to students who have completed CORE 6050 (Part I) and is intended for PhD students entering year 2 of the PhD program.
- CORE 6100f. CHEMICAL PRINCIPLES OF BIOLOGICAL SYSTEMS. (3 cr.; A-F; pre-req. calculus, organic chemistry, quantitative analytical chemistry, or consent of instructor) J. Maher – An introduction to the fundamental principles of biomacromolecular structure and function, including nucleic acids, proteins, and biomembranes. The course also provides a survey of methods of structure determination and analysis, principles of catalysis, kinetics and bioenergetics.
- CORE 6150su. GENOME BIOLOGY. (3 cr.; A-F) B. Horazdovsky – This course will explore the organization and function of the genome, with an emphasis on the features that are critical for the regulation of gene expression in mammalian systems. Topics to be examined include genome packaging and replication, as well as transcription, RNA processing, translation, and protein processing.
- CORE 6200f. BASIC GRADUATE IMMUNOLOGY. (3 cr.; A-F) H. Borges da Silva – Structure, genetics, and function of immunoglobulins; biosynthesis of antibody; cellular regulation of immune response; tumor and transplantation immunology; immune response to infectious agents; autoimmunity and immune deficiencies.
- CORE 6250w. MOLECULAR CELL BIOLOGY. (3 cr.; A-F) D. Radisky, S. Zhu – Class is designed to convey the central principles of how eukaryotic cells function at the structural and biochemical level. Emphasis of topics is on: the cytoskeleton, extracellular matrix and cell-cell interactions, protein transport in the secretory and endocytic pathways, and cell cycle, mitosis, programmed cell death. Course format utilizes didactic lectures combined with student presentations and interactive problem sets.

- CORE 6300sp. MOLECULAR BIOPHYSICS. (3 cr.; A-F) Q. Peterson – This course is an introduction to the molecular organization, dynamics and intermolecular interactions of biologically important macro-molecules with emphasis on proteins. Introductory courses in organic chemistry, biochemistry and calculus are recommended prerequisites.
- CORE 6400w. MOLECULAR GENETICS. (3 cr. ; A-F) P. Harris, X. Xu – Overview of topics in genetics of general importance to biomedical research with emphasis on molecular aspects.
- CORE 6450sp. MOLECULAR PHARMACOLOGY AND RECEPTOR SIGNALING. (3 cr.; A-F) S. Sine – Receptor-ligand interactions underpin a multitude of biological processes, and are central to the field of pharmacology. This course will develop mechanistic understanding of receptor-ligand interactions and how they are linked to biological responses. Types of receptor ligand interactions will include agonists, partial agonists, competitive and non-competitive antagonists, and allosteric modulators. Quantitative aspects of the mechanisms will be considered from both steady state and kinetic perspectives. Hands on computational methods using MATLAB will solidify understanding of how different types of ligands interact with receptors and elicit or modify their biological responses. Selected topics will include neurotransmitter-gated ion channels, G-protein coupled receptors, Ghrelin receptors, tyrosine kinase receptors, enzymes as receptors, and structure-guided drug design. Grading is based on homework assignments, midterm exam, and a mini-proposal on a receptor system of choice.
- CORE 6770w. VIROLOGY AND GENE THERAPY. (3 cr.; A-F) R. Cattaneo – The Virology and Gene Therapy core course is the sum of three one-credit courses that will be held consecutively during the spring quarter: Molecular Virology, From Viruses to Vectors, and Gene Therapy.

CLINICAL AND TRANSLATIONAL SCIENCE *CTSC course auditing is NOT allowed

- CTSC 5010f,sp. CLINICAL RESEARCH PROPOSAL DEVELOPMENT. (2 cr.; A-F; pre-req., CTSC 5300 and CTSC 5370 either completed or taken concurrently) A. Rule – The goal of this course is to systematically teach the process by which one takes a conceptual idea for a clinical research project and converts it into a research proposal or grant application. It is expected that students will already have begun to formulate their research question and refine their research project. Students will use their own research question to build a proposal for a research project that they intend to conduct in the future. By the end of the course, students will have a proposal for an important, valid, feasible research project that can serve as the foundation for a Certificate or Master's thesis research project or a grant application.
- CTSC 5011su. INDEPENDENT CLINICAL RESEARCH PROPOSAL DEVELOPMENT. (1 cr.; A-F; pre-req., CTSC 5300 and CTSC 5370 either completed or taken concurrently; Mayo CTSC MD/MS program scholars only) L. Roberts – The goal of this online course is to systematically teach the process by which one takes a conceptual idea for a clinical research project and converts it into a research proposal or grant application. It is expected that scholars will already have begun to formulate their research question and refine their research project. Scholars will use their own research question to build a proposal for a research project that they intend to conduct in the future. By the end of the course, scholars will have a proposal for an important, valid, feasible research project that can serve as the foundation for a Master's thesis research. **NOTE:** *This course is offered to Mayo CTSC MD/MS program scholars only. Scholars admitted to other CTS programs should take CTSC 5010 – Clinical Research Proposal Development.*

- CTSC 5020w,su. REGULATORY ISSUES IN CLINICAL RESEARCH. (1 cr.; A-FN. Madigan, T. Armbrust – This course is designed to introduce students to regulatory issues pertaining to clinical research. Topics will expose students to the various external and internal regulatory agencies, including the Institutional Animal Care and Use Committees (IACUC), Institutional Review Board (IRB) and U.S. Food and Drug Administration (FDA), with a focus on how the agencies affect investigator’s research responsibilities. Students will view lectures by content experts and engage in activities that include, but are not limited to, analyzing an actual IRB protocol, reviewing regulator documents and attend an IRB Overview/IRB Meeting session. Evaluation will be based on completion of online modules, assessments and attending one IRB Overview/ IRB Meeting session.
- CTSC 5025su. INTRODUCTION TO REGULATORY SCIENCE. (1 cr.; A-F) A. Windebank, D. Witter - As medical treatments and technologies continue to advance at an unparalleled pace, there is a need to develop new scientifically based standards and metrics to assess the safety, efficacy, and quality of diagnostic and therapeutic products. Development of techniques and measurements to assess these characteristics of clinical products is known as “regulatory science.” In this online course, participants will learn about focus areas of regulatory science, as defined by the FDA’s “Advancing Regulatory Science” report. Lectures will focus on concepts for the evaluation of innovative therapeutics such as; digital health, artificial intelligence, precision medicine, advanced manufacturing, regenerative biotherapeutics, and use of real-world evidence in regulatory decision making. Students will leave with a firm understanding of FDA-regulated product lifecycle management, including the navigation of federal requirements for the clinical use of novel investigational products such as exosomes, 3D printed products, bacteriophages, and engineered cellular therapies. Evaluation will include attendance and participation in class discussion, online quizzes, and a final paper determining what methods of safety, efficacy, and quality assessment would be necessary from a regulatory standpoint for a new treatment or technology.
- CTSC 5035sp. CASE STUDIES IN REGULATORY SCIENCE. (1 cr; A-F; pre-reqs CTSC 5020 and CTSC 5025) A. Windebank – In this course participants will be tasked with evaluating real-life case studies for new medical technologies and therapies, analyzing related regulations and guidelines, and synthesizing these ideas to suggest new paradigms for assessment of product safety, efficacy, and quality. Each week, one student will work with a content expert to prepare, present, and discuss an assigned case study.
- CTSC 5040su. INTRODUCTION TO THE PRINCIPLES OF CURRENT GOOD MANUFACTURING PRACTICES (cGMP) (1 cr; A-F;) H. Wang, C. Schmidt , A. Windebank,– This course is a broad introduction to the principles of current good manufacturing practices (cGMP). Through a series of presentations by content experts students will learn how to apply these principles to individual types of manufacturing areas.
- CTSC 5070sp. INTRODUCTION TO COMMUNITY ENGAGEMENT - WHAT EVERY RESEARCHER SHOULD KNOW. (1 cr.; A-F)TBD– Community-engaged research consists of a variety of research methods and tools that explore the bi-directional relationships of community members, patients, community leaders, and researchers. This introductory course will use didactic and interactive lectures to provide learners with a foundation in community engaged research principles. Learners will expand their knowledge base on community engaged research techniques and will be introduced to the methodological approaches of participatory research, Active Community Engagement Continuum, rapid assessment methods, deliberative democracy, and community-based participatory research. Learners will interact with investigators and staff who conduct community engaged research.
- CTSC 5080f. WHAT RESEARCHERS NEED TO KNOW ABOUT ELIMINATING HEALTH DISPARITIES. (1 cr.; A-F) TBD – The course provides students with basic information on populations who experience disease burden and introduced to the concept of health equity.

Reflection on past events both in the context of biomedical research and health care will serve as starting points for class discussions. The course gives an introduction to some of the thinking, paradigms, and active work of leading experts in health disparities research. Students will also interact with investigators who conduct research in underrepresented populations.

- CTSC 5100f,w,sp,su. ACADEMIC PUBLISHING. (1 cr; S-N) M. Hassan Murad– The course covers the whole process of academic publishing, including decisions about what to publish, learning the unique writing style called academic or scholarly writing style, crafting the appropriate narrative or message based on target audience, choosing the right journal, preparing a manuscript, choosing a title, avoiding pitfalls such as plagiarism and publication bias, authorship considerations, going through the submission and peer review process, learning about galley proofs and communicating with the media, and anticipating post publication activities such as letters to the editor and corrections. CTSC 5110f. GRANT WRITING IN THE SCIENCES. (1 cr; S-N) M. Sherman – The goal of this course is to provide a basic primer on grant writing, to help students learn about resources and approaches for developing grants, and to initiate the development of skills in grant planning and preparation. Throughout the course, students will be offered mentorship and guidance on developing research activities and career planning as well as fostering a collegial environment amongst students to provide peer support. This course is not intended to convey information primarily, but rather to help you develop perspectives and learn about available resources and strategies. CTSC 5140f. EPIGENETICS AND EPIGENOMICS: IMPACT ON TRANSLATIONAL RESEARCH AND FUTURE MEDICAL PRACTICE. (2 cr.; A-F; offered odd years) T. Ordog, K. Robertson – This introductory course is designed to introduce students to Epigenetics and Epigenomics, which are promising to become an important foundation of modern medicine, including individualized health care delivery. Of great interest to translational medicine, emerging data demonstrate that epigenetic changes are often amenable to therapeutic intervention. In this course, students will discuss molecular mechanisms underlying epigenetic events, the tools for the design and execution of research in this discipline, how to generate and analyze data and the application of Epigenomics to diagnostic and therapeutic treatments. The course will consist of didactic evidence- based lectures and class discussions, writing exercises and critical research literature which aim at gaining a deeper insight on the impact of Epigenomics to human health.
- CTSC 5210su. ETHICAL ISSUES IN REGENERATIVE MEDICINE. (1 cr.; A-F) Z. Master – The ethical, legal/policy, and social (ELS) issues surrounding regenerative medicine, including its clinical translation, continues to receive significant attention by the public, professionals, and policy-makers. Research scientists and clinicians need to be cognizant of ELS quandaries surrounding the field of regenerative medicine along with understanding ELS implications of their particular research or practice. This course meets learner demands for obtaining a richer understanding of the norms and practices related to contemporary regenerative medicine technologies. More specifically, this course will provide a deeper understanding of several ELS issues of regenerative medicine including stem cell research, gene editing, chimeras and organoids, and the FDA’s Expanded Access Program and federal Right-to-Try law. Learners will be able to have greater appreciation for a diversity of views and be able to communicate the ELS ramifications of regenerative medicine to the public.
- CTSC 5250su. SCIENCE BEYOND THE LAB: INTERSECTIONS OF SCIENCE, SOCIETY AND POLICY. (1 cr; A-F) A. Kumbamu - This course is intended to provide an overview of the contemporary culture of science and its implications for science production and translation, socio-political relations in the scientific community, and the general public. Students will be introduced to various structural, institutional and policy aspects that influence and are influenced by their research. In addition to social and policy aspects, students will also learn about dynamics of professionalism

and ethics in science production and translation, and inclusion and diversity aspects in science enterprise. The importance of scientists' engagement with various social institutions, policy makers and institutions (civic engagement), and the public communication of science will be discussed in this course.

- CTSC 5260su. ADVANCED METHODS IN BIOMEDICAL ETHICS RESEARCH. (1 cr.; A-F) J. Tilburt –The methods of biomedical ethics provide a rigorous analytic framework for engaging ethical challenges in medicine and translational research. The aim of this workshop-based course is to prepare participants to develop research studies that examine topics in bioethics, develop their scholarly interest in biomedical ethics, and identify ethical issues in their work. Individual sessions will examine how to develop a research topic, how to identify and critically assess relevant literature, how to design robust empirical research studies in bioethics, and how to select among potential research methods. Specific case studies will be used to illustrate exemplary bioethics research. A textbook is required for this course.
- CTSC 5261f. THEORETICAL AND HISTORICAL FOUNDATIONS OF BIOMEDICAL ETHICS (2 cr.; A-F) J. Hirsch, A. Barwise – This course serves as an introduction to central topics, events, and principles in biomedical ethics with the goal of recognizing historic seminal cases that have influenced the development of contemporary biomedical ethics that we are familiar with today. In addition to conducting a historical review of the medical, legal, philosophical, & ethical aspects of seminal cases, learners will acquire the skills necessary to reflect upon and begin articulating the implications of these perennial challenges to contemporary case examples and probable future challenges in which innovative technologies are being rapidly translated into clinical care. Learners will gain familiarity with the terminology, methods, and major frameworks of ethical analysis in biomedical ethics. Topics for discussion & examination will include reproductive technologies & termination of pregnancy, end of life decision making, futility of care, physician aid in dying, ethical issues in human subjects research, organ transplantation, fair distribution of scarce medical resources, and genetics.
- CTSC 5262w. CASE STUDIES IN HEALTH POLICY AND BIOMEDICAL ETHICS RESEARCH (1 cr.; A-F) R. Sharp, A. Barwise – Advances in medicine and technology are allowing researchers to make discoveries faster than at any time before, yet the societal and human consequences of these discoveries often go unchecked. The unique value of biomedical ethics research is to help inform our understanding of these consequences. This course is designed to illustrate how biomedical ethics research and normative analyses in bioethics can advance our thinking about particularly complex situations in clinical practice, translational research, and health policy. This course will showcase several high visibility cases that highlight the impact biomedical ethics research findings has on the direction and evolution of medicine & public policy. We will also explore lesser known cases that might serve as examples for students to model in their own research projects. Cases will span multiple topics and methodologies in biomedical ethics research. Although the course is a required element of the Biomedical Ethics Research concentration, it is open to other students and may be of particular interest to learners interested in related forms of translational research, such as health outcomes research, health disparities research, and community based participatory research.
- CTSC 5263sp. ETHICAL ISSUES IN POPULATION HEALTH SCIENCE (1 cr.; A-F) K. Meagher – The contemporary emphasis on population health raises ethical questions about the good of the many versus the good of the few. Traditional bioethics principles must be interpreted and applied to population health and the research methodologies it uses. This overview course will give learners an introduction to ethical issues in the science of population health, science of healthcare delivery, and community engagement.

- CTSC 5300f,w,sp,su. FUNDAMENTALS OF EPIDEMIOLOGY. (1 cr.; A-F) K. Fischer, R. Jimison – This standalone asynchronous course provides an overview of basic epidemiologic terminology and methodology used in clinical research. Topics include: foundational concepts (experiments, causality, bias and error, and reliability and validity); descriptive studies (incidence, prevalence, time, place, and person); bias and causal inference; confounding, mediation, and interaction; and case-control, cohort, and clinical trial studies. Upon completion of this course, scholars will be equipped to understand and interpret epidemiologic studies in the literature, and to contribute to research teams in which an epidemiologist is involved.
- NOTE: This course is targeted towards CCaTS KL2 scholars, as well as scholars in MCGSBS tracks other than CTS. For scholars seeking more detailed coursework aimed at preparing them to lead their own epidemiologic or clinical research studies (master's and predoctoral), take CTSC 5370: Introduction to Epidemiology and CTSC 5390: Advanced Applied Epidemiology.*
- CTSC 5330w. ETHICAL ISSUES IN BIOMEDICAL ENGINEERING. (1cr.; A-F) TBA – This course is an introductory course on the ethics of innovation, engineering, and technology. The goal of the course is to enable the student to employ greater discernment in identifying the ethical issues raised by technologies, and to routinely prospectively consider and address ethical challenges and implications in the development and implementation of new technologies. The history of bioethics is a history of surprised reaction to new developments in biomedical technology. The technologies on the horizon, near and far, are of such power and potential for harm, as well as good, that we cannot afford to remain in reactive mode. Increasingly, biomedical and other technological innovations have dual use potential, that is, the potential to be weaponized, or be used in ways contrary to respect for human life and human dignity in addition to their usually intended beneficial use. Innovators, engineers and technologists have a moral obligation if possible to anticipate, prevent, and mitigate potential harms and misuse before the damage is done. Those in developmental pathways are in the ideal position to identify those issues early, but only if they embrace this task. This course will examine similarities between medical ethics and engineering ethics, reviewing professional codes for engineering ethics, discussing classic cases of engineering misadventures, and examining contemporary challenges now facing us.
- CTSC 5340f. ETHICAL ISSUES IN INDIVIDUALIZED MEDICINE. (1 cr.; A-F) R. Sharp – Advances in medicine and technology are allowing researchers to analyze genome sequencing to understand more nuanced relationships between genes and disease. This course will examine the ethical implications of this emerging capacity to analyze genetic information and apply it to patient care. Topics will include: non-invasive prenatal testing; DNA biobanking; broad data sharing and consent; managing incidental findings; return of uncertain research results; genetic screening; and direct-to-consumer genetic testing. Multiple case examples from the Mayo Clinic Center for Individualized Medicine will be used to facilitate discussion. Using these case studies, several cross-cutting ethical issues will be examined in greater, including: privacy and confidentiality, the right to know genetic information, who has access to genetic information, and the acceptability of genetic exceptionalism. This course is targeted toward scholars conducting research in the field of individualized medicine and/or scholars seeking more advanced bioethics training.
- CTSC 5350sp. ETHICAL ISSUES IN ARTIFICIAL INTELLIGENCE AND INFORMATION TECHNOLOGIES. (1cr.; A-F) B. Barry,M. McGowan– Artificial Intelligence (AI) applications to medicine and healthcare are growing exponentially each year, and with them, concerns about the Ethical, Social, and Legal Implications (ELSI) of such technologies on our current health structures. Due to the predicted scoping and disruptive impact of AI, many members of the medical community have expressed interest in understanding the technologies themselves and being able to critically evaluate them for ELSI concerns. This class will serve as an introduction to current and future uses of AI in medicine and the already understood and documented ELSI impacts associated

with them. Additionally, this class will give learners the opportunity to engage in current hot-topic discussions about emerging applications of the technology and develop a tool kit to critically evaluate and future applications. Specifically, learners will be introduced to the processes of developing AI tools and implementing them into practice, and asked to view them through various ethical lenses including bias, transparency, privacy and confidentiality, and distinctions between research and practice.

CTSC 5370w,su. INTRODUCTION TO EPIDEMIOLOGY (2 cr.; A-F) M. Hassan Murad, K. Mohammed, T. Rajjo, A. LeMahieu - This course is the first in a series of two courses about the principles and application of epidemiologic methods. This first course, Introduction to Epidemiology (CTSC 5370), is an introduction to epidemiologic concepts and study design methodology. The second course, Advanced Applied Epidemiologic Methods (CTSC 5390), concentrates on application of these methods. Thus, the two course series equates to a typical 4-credit graduate level introductory epidemiology course. This course will focus on developing a common terminology to discuss epidemiologic concepts. We will begin by focusing on the foundational concepts for all study designs including topics such as incidence, prevalence, and sampling. Next, we will compare and contrast cross-sectional studies, case-control studies, cohort studies, and randomized trials. Finally, we will address practical issues related to the collection and assessment of quality for research data. *Note: This course is targeted towards CCaTS certificate master's and predoctoral scholars, as well as for scholars seeking more detailed coursework aimed at preparing them to lead their own epidemiologic studies. For those more interested in a high-level overview of epidemiology, please consider CTSC 5300: Fundamentals of Epidemiology.*

CTSC 5390f. ADVANCED APPLIED EPIDEMIOLOGIC METHODS (2 cr.; A-F; pre-req. CTSC 5370 and CTSC 5600) M. Hassan Murad, K. Mohammed, Z. Wang, A. LeMahieu - This course will increase the ability of students to interpret and criticize research articles in medical literature. One or more articles for each of the following major types of epidemiological studies will be discussed: 1) prevalence and incidence study, 2) case-control study, 3) cohort study, and 4) clinical trial. For each type of study, the instructor will explain the general terminology and give guidelines on how to read the articles. The students will then be assigned to read an article (or two articles) and to write a summary report for each article following a standardized format (article abstracting form). The instructor and the students will jointly interpret and discuss each article in the following session. All students are expected to participate in the discussion. Three additional lectures will be an introduction, a discussion of bias, and a discussion of confounding and interaction.

CTSC 5400w. INTRODUCTION TO BIOINFORMATICS CONCEPTS AND CORE TECHNOLOGIES FOR INDIVIDUALIZED MEDICINE APPROACHES (1 cr.; A-F) V. Sarangi – The purpose of this course is to orient researchers and clinicians in the field of Individualized Medicine and familiarize them with the key 'omics' technologies and bioinformatics approaches being employed in clinical and preclinical initiatives. The course combines lectures and practical exercises to introduce students to the core conceptual and practical elements of high throughput data generation, processing and analysis. Individuals will gain understanding of available technologies and data types and be familiarized with use-cases, user-friendly analytical approaches and available online tools and resources.

CTSC 5410w. MOLECULAR VARIANT EVALUATION (1 cr; A-F) M. Ellingson, J Balcom, A. Pickart - This course aims to provide the foundational knowledge and skills used to assess the clinical significance of molecular DNA variants and formulate recommendations for the classification of these variants. Hands-on application of the tools and processes via online modules in conjunction with class discussions will provide experiential education and prepare students for analysis of

molecular variants and their contribution to human genetic variation and disorders. Students will learn and apply concepts related to molecular variant nomenclature, genetic variation within the general population, calculation of allele frequencies, utilization of computational tools as well as reported occurrences of variants in the literature and online databases. Critical evaluation of the literature and functional studies, together with standard published guidelines will be used to recommend a variant classification and creation of interpretive comments.

CTSC 5420su. GENOMIC DATA EXPLORATION WITH GRAPHICAL USER INTERFACES (1 cr.; A-F) K. Kalari - This course is designed to continue exposure of graphical user interfaces for laboratory - and clinical based investigators to explore genomics data. This course will leverage open-source tools (free) for graphically exploring data from BAM, VCF, BED, and other standard file types. As these tools expect highly specific inputs, the course will also cover the details regarding file and nomenclature types that you need to be aware of when exploring genomic data. We will highlight common pitfalls when exploring genomic data regarding poor data quality & structural variants, inconsistent annotation sources, and poor experimental design. Upon completion of this course, the student will have a basic understanding of navigating through the different tools so that they can explore their own data.

CTSC 5500w. MODERN GENETIC EPIDEMIOLOGY. (1 cr.; A-F; offered even years; pre-req. CTSC 5300 or CTSC 5370 and CTSC 5600) N. Larson, B. Coombs – This course will introduce students to fundamental concepts of population- and clinic-based genetic studies, including study design principles and analytical approaches used for the purpose of understanding complex disease etiology and prognosis. Topics covered will include quality control and analysis of large genome-wide association studies as well as next-generation DNA sequencing data and rare-variant analyses. Students will also be exposed to advanced topics, including biological pathway analysis, gene-environment interactions, Mendelian randomization, and polygenic risk scores. Evaluation will be based upon critical review and discussion of journal articles and a final project summarizing results from a large genetic association study. Basic foundational knowledge of human genetics is highly recommended.

CTSC 5600w,su. INTRODUCTION TO STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH. (2 cr.; A-F) J. Aakre, K. King – This online course introduces basic statistical methods used in a variety of clinical study designs. Course materials use published or ongoing clinical research studies and emphasize statistical reasoning and concepts. General concepts covered are exploratory data analysis, descriptive statistics, estimation, and inference. Statistical techniques covered are those for comparing counts/proportions, for comparing means, and for comparing diagnostic tests. Coverage of each statistical technique includes identifying what research questions it can address, verifying that assumptions are adequately met, and identifying limitations of the conclusions.

CTSC 5602sp,su. INTRODUCTION TO UTILIZING STATISTICAL SOFTWARE IN CLINICAL AND TRANSLATIONAL RESEARCH. (1 cr.; A-F; pre-req. CTSC 5600 taken concurrently or prior) J. Aakre, K. King– This course introduces statistical software for introductory statistical methods including descriptive statistics, estimation, and inference; students also participate in in-person discussion of the pros and cons of methods used in the literature. The focus of the course is on determining the correct statistical method for a given situation, introducing the corresponding method in the BlueSky statistical software, and correctly interpreting the results of the BlueSky analysis. BlueSky is a Gui interface to R. Note: Accelerated version offered during spring only.

CTSC 5610f. STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH: LINEAR REGRESSION CONCEPTS, INTERPRETATION, AND STATISTICAL SOFTWARE (3 cr.; A-F; pre-req. CTSC 5600

and CTSC 5602) S. Winham, S. Jenkins, K. King, A. Todd – This course provides an introduction to methods for statistical modeling and introduces some extensions of these methods such as logistic regression and Cox regression. Specific topics covered include simple linear regression and multiple linear regression. General concepts taught include graphical methods, descriptive statistics, and statistical inference. Particular attention is given to verification of model assumptions, interpretation, and generalization of results. Additionally, the course provides a broad overview of basic statistical regression methods, especially the underlying concepts, reasoning, and methods of linear models. The course is a combination of lectures and computer labs; assignments require the use of statistical software (BlueSky). Evaluation includes homework assignments, midterm and final examinations. *Note: A grade of 'B' or higher is required in CTSC 5600 and CTSC 5602 to ensure success in this course. Specifically, knowledge of basic univariate and bivariate statistics will be assumed as well as familiarity with the Bluesky statistical software package.*

CTSC 5640w. ADVANCED STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH: LOGISTICAL REGRESSION WITH STATISTICAL SOFTWARE. (1 cr.; A-F; pre-req. CTS 5600, CTSC 5601 (prior to 2020/2021) or CTSC 5602 and CTSC 5610) B. Coombes, K. King, S. Jenkins – Logistic regression is often used as an analytic tool for medical studies with binary endpoints. Evaluation will include computer laboratory sessions, individual homework assignments, and a final exam. In this course, we will: Identify appropriate occasions to use logistic regression and describe how logistic regression may be used to estimate the magnitude of association for a predictor versus a binary outcome variable using an odds ratio. Interpret odds ratios for binary, categorical, and continuous predictor variables, describe how the odds ratio may be influenced by confounding variables and/or interactions among variables, and how logistic regression may be used to adjust for the presence of confounders and to test for the presence of interaction. Explore the assessment of statistical significance, model building, and model assessment strategies in the presence of several risk variables. Apply the use of logistic regression in score development and validation with the associated receiver-operator characteristic (ROC) curve. From this course, students will learn how to use statistical software (BlueSky) to perform logistic regression and select appropriate models depending on research questions. Evaluation will include computer laboratory sessions, individual homework, and a final exam.

CTSC 5641sp. COMPARATIVE EFFECTIVENESS RESEARCH: OBSERVATIONAL STUDIES AND PRAGMATIC TRIALS. (1 cr.; A-F); X. Yao, Y. Deng, – Comparative effectiveness research involves a comparison of two or more interventions or approaches, including strategies for prevention, screening, diagnosis, and treatment of medical conditions, interventions to improve care delivery, reduce health disparities, and improve medical communication and decision-making process, etc. The findings can assist patients, clinicians, health systems, payers, policymakers, and other stakeholders in making informed decisions. Randomized control trials (RCT) are considered as the gold standard but they are time-consuming and expensive to conduct, and the results may not apply to patients in routine clinical practice. This course will provide an introduction to innovative approaches to generate evidence at a faster pace and lower cost, including propensity score in observational studies and pragmatic clinical trials embedded into everyday workflow to facilitate a learning health system.

CTSC 5650sp. ADVANCED STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH: SURVIVAL ANALYSIS WITH STATISTICAL SOFTWARE (1 cr.; A-F; pre-req. CTSC 5600, CTSC 5601 (prior to 2020/2021) or CTSC 5602 and CTSC 5610) N. Foster – This course will introduce students to methods for summarizing and analyzing time-to-event data, which commonly occur in clinical trials and epidemiological studies. Basic quantities (e.g., survival function, hazard function) and their relationships will be introduced. Non-parametric approaches (such as the Kaplan-Meier method) and parametric approaches (e.g., Exponential) for estimating these quantities for a given data set of event times will be covered. Associated tests (such as the log-rank

test) to compare event times originating from multiple groups will be discussed. The widely used semi-parametric Cox proportional hazards regression model will be introduced and related topics including variable selection, assumption testing, and model building will be covered, along with real life examples.

- CTSC 5710f. PRACTICAL DATA COLLECTION. (1 cr.; A-F) J. Larson – This course introduces the general principles and practical exercise of data management in medical research including laboratory experiments, cohort observational studies, and clinical trials. While these principles can be used for any data collection system, in this course, students will learn how to apply these principles in REDCap as it is Mayo Clinic endorsed free alternative to Excel and Access. Students will be allowed to use their own data and research studies to complete some of the assignments. Evaluation will be based on in-class short quizzes, in-class exercises, and take home assignments.
- CTSC 5715w. PUBLICATION QUALITY TABLES AND FIGURES. (1cr.; A-F; pre-req. CTSC 5600, and CTSC 5601 (prior to 2020/2021) or CTSC 5602) J. Larson – This course introduces sound practical data presentations by tables and graphs which are aimed to deliver the appropriate inferences regarding data in an efficient yet objective manner. This course will utilize the R software to generate reproducible summary statistics and figures via programming. Evaluation will be based on in-class assignments and take home assignments. This course involves learning how to program within R as opposed to using a graphical user interface (GUI) like the one used by the BlueSky software. By learning how to program within R directly, you will be able to generate code to make analysis repeatable.
- CTSC 5720w. CLINICAL TRIALS: DESIGN AND CONDUCT. (1 cr.; A-F; pre-req. CTSC 5600 or equivalent) N. Foster –This course will focus on the statistical considerations and practical issues involved in the design and conduct of clinical trials. The foundation and practical considerations involved in drug development for humans will be presented. The Phase I-III paradigm for clinical trials will be discussed including issues about aims, endpoints, statistical power, early stopping rules, and analytic techniques. There will be a focus on several case studies of clinical trials. Issues about subject selection, study design, masking treatment assignment, outcome measures, goals, and post hoc analyses will be reviewed.
- CTSC 5740w. SYSTEMATIC REVIEWS AND META-ANALYSIS. (2 cr.; A-F; pre-req. CTSC 5300 or CTSC 5370 and CTSC 5600; limited to students admitted to CTS program w/priority to MS students; approval of the selected topic with course faculty is required prior approved admission) M. Murad, C. West, Z. Wang – By the end of this problem-based course, the learner will be comfortable with the methods of evidence synthesis and will have completed a systematic review/meta-analysis, from protocol to journal-ready manuscript, in a topic of their choice. The small group tutorials include expert faculty to discuss key concepts and troubleshoot the students' reviews in progress. Each session will represent a step in conducting a systematic review. A series of selected readings for each session will help students prepare to participate in discussions. Hands-on activities include developing thorough and systematic search strategies, in coordination with Mayo Library experts, and learning how to use meta-analysis statistical software. Evaluation will be based on the methodological quality of the final systematic review/meta-analysis.
- CTSC 5761sp. EVIDENCE-BASED MEDICINE FOR CLINICAL RESEARCHERS. (1 cr.; A-F; pre-req., CTSC 5300 or CTSC 5370 and CTSC 5600) I. Hargraves, M. Murad Z. Wang –Course participants will learn the principles of evidence-based medicine (EBM) through applying the GRADE framework (Grading of Recommendations, Assessment, Development and Evaluation), to research in their own field. By teaching these appraisal and decision-making principles, this course helps researchers design and produce evidence that warrants high certainty and fulfills the needs of

evidence users (patients, clinicians, and policy makers). Students will benefit the most from this course if they have conducted clinical research and participated in designing a study.

- CTSC 5770sp. DIAGNOSTIC TESTING STRATEGIES. (1 cr.; A-F; pre-req. CTSC 5600) C. West – This course is designed to enable students to become skilled in the formulation and revision of diagnostic testing strategies for common medical problems, within a Bayesian framework (e.g., pre-test probabilities, test operating characteristics/likelihood ratios and post-test probabilities). The first five sessions will introduce material in a discussion format. Subsequent sessions will be organized around student presentations on clinical topics selected from a pool of over 50 which have been formally analyzed in the text. Students will review the relevant background for the clinical problem, the prevalence of the disease in question, the operating characteristics (sensitivity/specificity, etc.) of the pertinent history and exam components and diagnostic tests, and the range of post-test probabilities that might be expected to result from the application of various diagnostic strategies. Discussion will be initiated by presenting a hypothetical case and requesting input as to suggested plans for diagnostic testing. The instructor will provide a brief summary of learning points at the end of each session. The course grade will be based on the presentation and a take-home examination.
- CTSC 5810sp. QUALITATIVE RESEARCH DESIGN, METHODS, AND ANALYSIS. (1 cr.; A-F) A. Kumbamu – This course provides an overview and comparative analysis of selected qualitative research methodologies, methods and analytic strategies. Focus is on developing rigorous qualitative designs that contribute to the development of health care knowledge for diverse populations. This application based course will provide numerous examples from the qualitative research field as well as practical, hands-on experience for the participant.
- CTSC 5815w. QUALITATIVE AND MIXED METHODS RESEARCH FOR TRANSLATIONAL SCIENCE. (2 cr.; A-F; No pre-req; however, CTSC 5810: Qualitative Research Design, Methods, and Analysis or previous qualitative methods coursework or experience as well as quantitative methods coursework or experience (e.g. survey methods) are both strongly recommended.) K. Boehmer, J. Griffin, J. Ridgeway – Qualitative and mixed methods are increasingly recognized for their potential to assist in the development of successful interventions in practice, and the translation of scientific knowledge into next-phase research or practice; An understanding of quantitative and qualitative methods is an important prerequisite to learning these skills, but more specific learning is required to understand the nuances of mixed methods research and the ways in which methods can be combined to support research translation. In this course, students will begin by examining applications of qualitative methods and mixed method designs and exploring the clinical and translational research questions that these methods are best designed to answer. They will then incorporate their own translational science interests to evaluate an existing clinical program, or to develop a mixed methods grant/IRB proposal. The course will use readings, discussion, student presentations, and writing to accomplish its learning objectives. A textbook is required for this course.
- CTSC 5820sp. INTRODUCTION TO SURVEY RESEARCH. (1 cr.; A-F; pre-req. CTSC 5600) K. Yost – This course provides an overview of survey research. It is intended to familiarize students with the theory and application of survey research in data collection. The overall goal of this course is to provide students with a foundation that will allow them to conduct a survey or be aware of the issues to consider in the design and implementation of a survey. Specific topics covered are question writing, questionnaire design, scale development, reliability and validity, sampling, sample size estimation, survey types, statistical analysis and presentation of results. No prior survey research experience is required or expected.

- CTSC 5860f. BEHAVIORAL INTERVENTIONS IN CLINICAL RESEARCH. (1 cr.; pre-req CTSC 5010; A-F, offered even years) S. Ehlers – This course will focus on techniques for operationalizing, implementing, and monitoring the fidelity of behavioral interventions in clinical trials. Topics will include treatment development, assessing feasibility and acceptability of treatments, study design, recruitment and retention, rationale and techniques for assessing treatment fidelity, participant adherence, and dissemination of results. The course will also examine successes and pitfalls in implementing clinical trials involving behavioral interventions.
- CTSC 5870sp. SOCIAL AND BEHAVIORAL FOUNDATIONS OF HEALTH IN HEALTH SCIENCES RESEARCH. (1 cr.; A-F) TBD – This course is designed to help students develop a basic understanding of the role of social constructs and behavioral processes in health and interaction with the healthcare system. The course is intended to provide insight into concepts and theories of social and health behavior. The underlying framework of the course is the biopsychosocial model of health. In this perspective, health is influenced by biologic, social, behavioral, and environmental factors that frequently interact with each other to a greater or lesser extent.
- CTSC 5900w. INTRODUCTION TO HEALTH SERVICES RESEARCH AND POLICY. (1 cr.; A-F) S. Meier – This course provides a broad overview of health policy and health services research from a policy and economics perspective. The course includes review of the role of government in policy development and components of the health policy process. The course reviews key concepts used in the field of health services research, and provides an overview of models, frameworks and methods typically used to evaluate the performance of health care systems. The course highlights the normative aspects of system evaluation and introduces students to seminal writing in the field of health economics.
- CTSC 5910f. ECONOMIC EVALUATION IN HEALTH CARE. (1 cr.; A-F); V. Thao, J. Moriaty – In a world of rising health care costs and fixed budgets, economic evaluation plays an increasingly important role in technology assessment and payment decisions. This course will present basic concepts, theory, and methods associated with economic evaluation in health care. Specific topics include: decision trees, Markov models, cost-effectiveness analysis, outcomes measurement and analysis (clinical outcomes, costs, health-related quality of life), guidelines and reference standards, and the use of economic models in decision-making. This course will be presented in the form of lectures and computer labs. Class discussion/interaction will be encouraged.
- CTSC 5930su. INTRODUCTION TO THE U.S. HEALTH CARE SYSTEM. (1 cr.; A-F) S. Meier – This course is a survey of the U.S. health care system providing an introduction to health care financing, exposure to the organization of health care, and other relevant topics about the worlds most complex and expensive health system. This course covers the theoretical basis underlying health care delivery and organization along with practical knowledge of the U.S. health care system. We will use this background to evaluate current and historical health policy issues and the programs to address these issues, such as the Affordable Care Act and Accountable Care Organizations.
- CTSC 5940f. SECONDARY DATA ANALYSIS. (1 cr.; A-F; pre-req. CTSC 5600) M. Jeffery, R. McCoy – Secondary data analysis takes advantage of data originally collected for other purposes in order to answer distinct health services research questions. There are many secondary data sources readily available, yet they are typically underutilized. As such they provide a rich opportunity for empirical investigation and subsequent publication. This course provides the student an introduction to secondary data analysis using publicly available data sources. Data sources covered in this class include survey data, administrative data (hospital, outpatient and administrative claims), clinical electronic data, and cancer and clinical registry data. Note: No data analysis will

be completed. However, by completing this class you will grasp not only what is possible but also how to proceed with a secondary data analysis project idea.

- CTSC 6100sp. MOLECULAR MECHANISMS OF HUMAN DISEASE. (3 cr.; A-F), D. Mukhopadhyay, J. Grande, A. Windebank – This course is designed to introduce students to the basic organization, histology, and function of major organ systems and provide an appreciation for pathophysiological conditions leading to disease and therapeutic interventions. Lecture topics will focus on five different systems: renal, immunologic, cardiovascular, gastroenteric, and endocrine with emphasis given to the importance of each system’s structure and function. Students will have the opportunity to review case studies including imaging, pathology and treatments. By the end of the course, students will have gained skills in cross-disciplinary communication, specifically with those in the medical field.
- CTSC 6110f,w,sp,su. CTS WORKS IN PROGRESS (1 cr. ; S-N; registration limited to CTS PhD students only) A. Windebank – CTS Works in Progress is open to CTS predoctoral students only. This course provides a forum for CTS predoctoral students to present their research to and have their presentations evaluated by a group of their peers. CTS PhD students register only in the quarter in which they present (1cr. - /yr.).
- CTSC 6120w. CASE STUDIES IN TRANSLATION. (2 cr.; A-F, CTS PhD students have priority registration) E. Enniga, A. Windebank– This course will explore the process by which the fundamental discoveries move from the first demonstration of an experimental observation to widespread use in medicine and public health. Examples will be chosen to represent the different classes of discovery that lead to improved health.
- CTSC 6130f,w,sp,su. CTS JOURNAL CLUB. (1 cr.; S-N; registration limited to CTS PhD students only) A. Windebank – CTS Journal Club is open to CTS predoctoral students only. This course provides a forum for CTS predoctoral students to select, present and lead a discussion on an original clinical and/or translational research article chosen by the student and their mentor. CTS PhD students register only in the quarter in which they present (1 cr. - /yr.).
- CTSC 6160sp. GENOMIC ANALYSIS & DATA INTERPRETATIONS FOR RARE & UNDIAGNOSED DISEASES MEDICINE (2 cr., A-F); E. Klee, L. Schimmenti, F. Pinto e Vairo - Analysis of genomic data from patients suffering from genetic disorders is now an essential skill for physicians and scientists in the clinical and translational arena. Patients who suffer from rare and undiagnosed disease are sometimes referred to as “medical mysteries”. To find a diagnosis for a medical mystery patient, sequencing of the entire coding region of the genome (exome sequencing), or the entire genome (genome sequencing), is employed. Currently, there is a shortage of individuals who possess the bioinformatics and genetics knowledge to analyze the sequencing data and identify potentially pathogenic variants leading to a diagnosis for medical mystery patients. This course is designed to give students the essential skills to take exome or genome sequence data from real patients and identify a pathogenic sequence variant that leads to a diagnosis. In this course, students will be provided with clinical data from an actual medical odyssey patient from the Mayo Clinic. The cases have been previously solved by the Translational Omics Program (TOP) team through a Genomic Odyssey Board (GOB) within the Center for Individualized Medicine and identified to have pathogenic sequence variants that are consistent with their medical phenotype. Students will be given raw exome sequencing data and the medical phenotype of the patient only. Students will also be introduced to the use of RNAseq and other omic approaches as complementary tests to the DNA sequencing for identifying or clarifying variants of interest. The results of the sequencing data will not be revealed to the student who will then “solve” the medical

mystery and demonstrate an understanding of how arriving at a diagnosis for a patient is an example of precision medicine and will improve the medical management of the patient. To “solve” their assigned medical mystery, students will be taught a series of genomic data analysis skills over the course of 11 weeks. Students will take the raw sequencing data from the patient and in some situations, first degree relatives, analyses the data and by the end of the course, have sufficient sophistication to be able to solve their case. Students will give both an oral presentation and written description of their process of phenotype and sequence analysis during the last week of the course. This presentation and written description will count toward most of the points for the class.

CTSC 6170f. THE SCIENCE OF TEAM SCIENCE: STRATEGIES FOR SUCCESS (1 cr. A-F) H. Billings, K. Turkowski– This course offers practical guidance about engaging in team science to pursue complex research questions, work effectively with team members, and assess team performance in order to produce high-impact outcomes. Students will explore the basic principles of teamwork and multidisciplinary collaboration in order to accelerate translational research and strengthen the alignment of discovery science with the clinical practice.

DENTISTRY

DENT 5000f,w,sp,su. RESEARCH IN SELECTED PROBLEMS (2 cr; S-N) TBA, S. Lee, TBA - This course is the protected time given for research and scholarly activity in dental medicine. Research projects are conducted under the supervision of a faculty mentor.

DENT 5100f,w,sp,su. INTERDISCIPLINARY CURRENT LITERATURE IN DENTATL SPECIALTIES (1 cr; A-F) T. Salinas, S. Lee - This course is designed to promote in-depth discussions of subjects of interest in the areas of orthodontics, periodontology and prosthodontics. The interrelationship of the three fields is stressed.

DENT 5200f,w,sp,su. DENTAL SPECIALTIES LITERATURE REVIW (0.5 cr; S-N) S. Lee, TBA, TBA, S. Giri, O. Muller, T. Salinas, M. Xian - Dental Specialties Current Literature Review is an interdisciplinary, seminar-style didactic course within the Advanced Prosthodontics, Orthodontics, Periodontics, and Maxillofacial Prosthetics & Dental Oncology training programs. The course integrates all levels of learners in the training programs and incorporates readings, collaborative discussion, and learning with clinical applicability. The course is an interprofessional collaboration to review and discuss practical, clinical, and laboratory application of current literature in prosthodontics, periodontics, and related fields, with an emphasis on evidence-based appraisal of literature published in the last 3 years from the course’s schedule.

DENT 5300f,w,sp,su. PROFESSIONAL SKILLS IN DENTISTRY. (0.25 cr; A-F) TBA, S. Lee, TBA - This course will teach to important skills that are critical to the success of professional in the dental field. The course will cover a number of topics including, but not limited to growth mindset, teamwork, grit, and professional development. In addition, learners will learn and apply teaching strategies that help to communicate concepts to peers and colleagues.

DENT 5500sp. SCIENTIFIC WRITING. (0.25 cr; A-F) TBA, S. Lee, TBA - In this course, students will cover the concepts of scientific writing. Students will prepare a manuscript with the appropriate elements (abstract, introduction, results, etc.). As a part of this course, students will submit a manuscript for publication.

DENT 5600sp. SCHOLARLY PRESENTATION. (1 cr; S-N) TBA, S. Lee, TBA - Students will be expected to present scholarly works and findings to colleagues. Presentations will occur on a regular basis. There is also the expectation that students will present their work on a regional and/or national level. Presentations should clearly communicate complex topics and articulate findings in a clear and effective way. Students will register for the course in the Spring Quarter of each year of residency, and will present either on oral or poster presentation at the Carr Dental Scholarship Symposium.

DENT 5900f,w,sp,su. DENTAL SPECIALTIES MASTER'S THESIS PROPOSAL, DEVELOPMENT AND DEFENSE. (0.5 cr; A-F) TBA, S. Lee, TBA - This experience will allow students to begin developing their thesis proposal with appropriate oversight by the primary mentor and thesis advisory committee. The thesis proposal must be clearly defined and is subject to review by the Thesis Approval Committee (to be scheduled after your first presentation). Students must defend their thesis in a final oral examination.

DENT 6852sp. APPLIED ANATOMY FOR DENTAL RESIDENTS. (3 cr. A-F) TBA, S. Lee – Applied Anatomy for Dental Residents a collaborative course given jointly by the Departments of Clinical Anatomy and Dental Specialties. It is designed to provide learning opportunities to PGY1 and PGY2 dental residents that are directly applicable to patient care and clinical practice. Given to a multispecialty team of learners, it delivers knowledge relevant to periodontists, prosthodontists, and orthodontists. The course will be available every other year.

DENTISTRY – ORTHODONTICS

Orthodontics Didactic

ODON 6806f,w,sp,su. ORTHODONTIC SEMINAR: TECHNIQUE. (1 cr; A-F) J. Volz
Seminar on technical orthodontic procedures.

ODON 6807f,w,sp,su. ORTHODONTIC SEMINAR: LITERATURE REVIEW. (1 cr; A-F) J. Volz
Classical orthodontic literature as well as current literature review.

ODON 6808f,w,sp,su. ORTHODONTIC SEMINAR: CASE PRESENTATION. (1 cr; A-F) J. Volz
Cases with complete records reviewed and new patient treatment plans discussed.

ODON 6809f,w,sp. SURGICAL ORTHODONTIC SEMINAR. (1 cr; A-F) C. Viozzi - Case presentation, illustration, diagnostic and treatment procedures that encompass the various dental specialties.

ODON 6810w. CLINICAL ORO-FACIAL PATHOLOGY AND DEVELOPMENTAL DISORDERS. (1 cr; A-F; prerequisite D.D.S., D.M.D., M.D. or equivalent required) J. Volz - A review of the clinical presentations of many congenital and acquired pathological disorders, developmental deficiencies, and malformations important to the dental specialist.

Research

ODON 6857f,w,sp,su. RESEARCH IN SELECTED PROBLEMS. (1 cr/qtr; A-F) J. Volz - Arrangements for research in selected areas related to minor.

Clinical

ODON 6800f,w,sp,su. ORTHODONTIC LABORATORY TECHNIQUE. (3 cr; A-F) J. Volz - Initial technical procedures in preparation for clinical patient care. Technical procedures on the typodont, model preparation, photography, metallurgy, and cephalometrics.

ODON 6802f,w,sp,su. ORTHODONTIC CASE ANALYSIS. (6 cr; A-F) J. Volz - First phase involves complete review of previously treated cases. Second phase is application of basic analytic principles to clinical patients.

ODON 6803f,w,sp,su. ORTHODONTIC TREATMENT PLANNING. (6 cr; A-F) J. Volz - Mechanical principles coordinated with case analyses to provide the treatment plan. Force analysis and biomechanics of tooth movement.

ODON 6804f,w,sp,su. CLINICAL ORTHODONTICS. (6 cr; A-F) J. Volz - Individual treatment care and clinical observation. Treatment care coordinated with other services in selected instances in the hospital.

ODON 6805f,w,sp,su. ADVANCED CLINICAL ORTHODONTICS. (6 cr; A-F) J. Volz - Final treatment care of individual patients.

DENTISTRY – PERIODONTICS

Periodontics Didactic

PDON 6883f,w,sp,su. PERIODONTIC SEMINAR. (1 cr; A-F) TBA - Literature review and discussion.

PDON 6884su. PERIODONTICS/ORTHODONTICS SEMINAR. (1 cr; A-F; offered even years) J. Volz - Histopathology of periodontal disease. Oral mucous membrane; calcified tissues. Interdisciplinary Orthodontic and Periodontics case reviews and literature review.

PDON 6886f,w,sp,su. CLASSIC LITERATURE IN PERIODONTICS. (2 cr/qtr; A-F); TBA - Review of 55 years of classic literature from the Journal of Periodontology. Two one-hour sessions per week x 26 weeks.

Research

PDON 6857f,w,sp,su. RESEARCH IN SELECTED PROBLEMS. (2 cr; A-F) TBA

Clinical

PDON 6880f,w,sp,su. CLINICAL PERIODONTICS. (3 cr; A-F) TBA - Etiology, diagnosis, and treatment of periodontal disease.

DENTISTRY – PROSTHODONTICS

Prosthodontics Didactic

PROS 6841f,w,sp,su. COMPLETE DENTURE PROSTHODONTIC SEMINAR. (1 cr; A-F) O. Muller, T. Salinas, S. Lee - Literature review and discussion of past and current concepts and practices of complete denture prosthesis.

PROS 6843f,w,sp,su. REMOVABLE PARTIAL PROSTHODONTIC SEMINAR. (1 cr; A-F) O. Muller, T. Salinas, S. Lee- Literature review and discussion of past and current concepts and practices of removable partial denture prosthesis.

PROS 6845f,w,sp,su. FIXED PROSTHODONTIC SEMINAR. (1 cr; A-F) T. Salinas, S. Lee - Principles, practices, and concepts related to clinical and laboratory phases of fixed prosthodontics.

- PROS 6847f,w,sp,su. SEMINAR: MAXILLOFACIAL PROSTHETICS (INTRAORAL) ADVANCED PROSTHODONTICS. (1 cr; A-F) T. Salinas, S. Lee - Literature review and discussion of past and current concepts and practices of implant prosthodontics and maxillofacial prosthetics.
- PROS 6848f,w,sp, su. SEMINAR: CURRENT LITERATURE. (1 cr; A-F) T. Salinas, O. Muller, S. Lee - Review and discussion of practical, clinical, or laboratory applications of current literature in prosthodontics and related fields, with an emphasis on evidence-based appraisal of the literature.
- PROS 6862f,w,sp,su. DENTAL MATERIALS. (1 cr; A-F) T. Salinas, S. Lee - Discussion of physical properties, mechanical properties, technical procedures and the interrelationship of these with clinical procedures related to dental materials most commonly used in prosthodontics.
- PROS 6870f,w,sp,su. OCCLUSION. (1 cr; A-F) T. Salinas, S. Lee - A series of detailed discussions of the principles, practices, and concepts of occlusion.
- PROS 6871f,w,sp,su. PHYSIOLOGY, PHARMACOLOGY AND PRE-PROSTHETIC SURGERY. (1 cr; A-F) T. Salinas, S. Lee - Discussion of physiology of major organ systems in conjunction with pharmacologic management of disorders of these systems. Pre-prosthetic surgery is discussed and reviewed through an evaluation of the literature.
- PROS 6873f,w,sp,su. CRANIO-MANDIBULAR DISORDERS AND FACIAL PAIN. (1 cr; A-F; prerequisite Pros 6870) K. Reid, S. Lee - Literature review and discussion of past and current concepts and practices in the management of patients with cranio-mandibular disorders including myofascial pain dysfunction, temporomandibular disorders and atypical face pain.
- PROS 6874f,w,sp,su. PROSTHODONTIC MANAGEMENT OF THE GERIATRIC PATIENT. (1 cr; A-F) T. Salinas, S. Lee - Literature review and discussion of medical complications found in the geriatric patient with emphasis placed on special considerations made during prosthodontic treatment.

Clinical

- PROS 6840f,w,sp,su. CLINICAL PROSTHODONTICS: COMPLETE DENTURES. (6 cr; A-F) T. Salinas, O. Muller, S. Lee - Orientation and introduction to clinical and laboratory phases of prosthodontics in the medical center with emphasis on principles, concepts, and practices related to complete denture prosthesis.
- PROS 6842f,w,sp,su. CLINICAL PROSTHODONTICS: PARTIAL DENTURES. (6 cr; A-F) T. Salinas, O. Muller, S. Lee - Orientation and introduction to clinical and laboratory phases of prosthodontics in the medical center with emphasis on principles, concepts, and practices related to removable and fixed partial denture prosthesis.
- PROS 6851f,w,sp,su. DENTAL ROENTGENOLOGY. (1 cr; A-F) K. Reid, T. Salinas, S. Lee - X ray diagnosis and technique.
- PROS 6852f,w,sp,su. ORAL DIAGNOSIS AND TREATMENT OF CRANIO- MANDIBULAR DISORDERS. (2 cr; A-F) T. Salinas, S. Lee - Clinical diagnosis and treatment related to dental problems, including craniomandibular disorders and facial pain.
- PROS 6854f,w,sp,su. IMPLANT PROSTHODONTICS. (6 cr; A-F) O. Muller, T. Salinas, S. Lee - Clinical and laboratory procedures involved in the management of patients who receive prostheses supported and retained by endosseous implants.

PROS 6880f,w,sp,su. DENTAL LABORATORY TECHNOLOGY. (6 cr; A-F) T. Salinas, O. Muller, S. Lee - A full time clinical assignment to familiarize the resident with all aspects of laboratory technology used in the fabrication of removable and fixed partial and maxillofacial prostheses.

Electives

PROS 6856f,w,sp,su. ORAL AND MAXILLOFACIAL SURGERY. (1cr; A-F) K. Arce, J. Van Ess, C. Viozzi - Residents will work with the practitioners in the area of Oral and Maxillofacial Surgery to evaluate and treat patients who require surgical treatment of oral disease, elective treatment of partial and complete edentulism and maxillofacial defects. Residents will learn the diagnostic testing media for use with these patients. This will include standard intraoral, panoramic and cephalometric radiography along with lateral hypocyloidal tomography, computerized tomography and magnetic resonance imaging of teeth, jaws, temporomandibular joints and facial structures. Residents will learn techniques for treatment, especially in a multispecialty health care environment.

PROS 6875f,w,sp,su. DENTAL IMPLANT PROCEDURES. (1cr; A-F) T. Salinas, S. Lee - Provide an in depth knowledge of standard methods for the comprehensive approach to using dental implant for comprehensive patient treatment. Additional understanding is introduced of advanced pain control measures, preprosthetic surgery, infection control and sterile technique, dental implant treatment planning, dental implant surgery, dental implant restorative procedures, complication management, and maintenance. Understanding of the indications and benefits for nitrous oxide sedation is provided along with a familiarity with other methods of pain control such as intravenous sedation and general anesthesia. These axioms are taught alongside surgical residents to exchange mutually supportive care between surgery and prosthodontics to allow an in depth experience with this level of care.

PROS 6877f,w,sp,su. DENTOFACIAL ESTHETICS. (1cr; A-F) T. Salinas, S. Lee – Topics covered in formal instruction: Residents are instructed formally with the analysis from photographs, radiographs, and diagnostic casts to utilize for treatment of patients with prosthodontic needs. The resident will start with a critical analysis of facial esthetics and what is considered referenced normal and that of which is achieved through specific objectives. The resident will understand their use of analytic skills at the chairside to perform a thorough clinical assessment of that of facial esthetics and how it correlates to intraoral dental esthetics. After a specific litany of factor recording, the resident will augment their photographic skills with a standardized esthetic display format for mapping the esthetic continuum for patient esthetic dentofacial analysis. Digital Smile design is also introduced to the resident to augment their skills in evaluating these factors for prosthodontic treatment.

Research

PROS 6857f,w,sp,su. RESEARCH IN SELECTED PROBLEMS. (2 cr; A-F; offered 6 quarters during program, including all of final year) T. Salinas, O. Muller, S. Lee

DERMATOLOGY*

DERM 6870f. MUCOUS MEMBRANE COURSE. (1 cr; S-N; Oral - even years)
R. Rogers - This course provides knowledge of inflammatory, allergic, premalignant, and malignant conditions affecting the oral mucosa and other mucosal surfaces as well as the skin. Diagnosis utilizing clinical and pathologic tools will be emphasized. Treatment will be discussed.

** Only Dermatology courses which are required for degree completion in clinical programs are listed.*

IMMUNOLOGY

- IMM 5200su. INTRODUCTION TO FLOW CYTOMETRY. (1 cr; S-N) V. Shapiro – This course will teach the basics of flow cytometry, including how a cytometer functions, designing a panel compensation, statistics, analysis, and interpretation. New technology including new fluorochromes and mass cytometry (CyTOF) are also discussed. No prerequisites are required. The course consists of 10 hours of lecture from RST videoconferenced to AZ and FL, plus 4 hours of hands-in/demonstration plus a virtual demonstration/analysis.
- IMM 6862w,su. CURRENT TOPICS IN CELL ACTIVATION AND SIGNALING. (1 cr.; S-N) D. Billadeau, V. Shapiro – Weekly discussions of recent scientific literature on topics related to receptors, transmembrane signaling mechanisms, and gene expression.
- IMM 6863f,sp. CURRENT TOPICS IN IMMUNOLOGY. (1 cr.; S-N) H. Dong – Current literature on important areas of immunology. Critical review of methods, results and findings. Register in the quarter you present (1 cr./yr.). Attendance required fall and spring. IMM degree candidates are given preference for this course.
- IMM 6865f. REGENERATIVE T CELL IMMUNOTHERAPY AND CELLULAR ENGINEERING. (3cr.; S-N) S. Kenderian – Regenerative T Cell Immunotherapy and Cellular Engineering is a mini-course focusing on the development and wide-reaching applications of cellular immunotherapy covering topics ranging from basic T cell biology and cellular engineering techniques to applications of data science and implementation into the clinic. We will focus on some of the most successful developments in cell therapy to date providing a forum for lectures, discussions, and workshops surrounding these emerging fields of regenerative medicine and immunology. The course is assessed on attendance, assignment completion, and a final project where students work in teams to construct a content relevant specific aims page project that they will present to the class. *This class will be offered Fall 2023*
- IMM 6867w,sp. CURRENT TOPICS IN BARRIER IMMUNOLOGY. (1 cr.; A-F) K. Knoop – This journal club discusses recent work on the broad area of clinical and translational immunology occurring on barrier surfaces: skin, gastrointestinal tract, urogenital track, and respiratory track. Topics will include hypersensitivity responses, microbial influences on immunity, mucosal immunology, and mechanisms and treatment of immune-mediated diseases affecting barrier surfaces. Diseases on interest include allergic disorders, inflammatory bowel diseases, and urogenital infections.
- IMM 6878w. TUTORIAL IN INNATE IMMUNITY AND IMMUNOMETABOLISM. (2 cr.; A-F; offered odd years; pre-req. CORE 6200 or equivalent) S. Oh – Advanced course on innate immune cells including macrophages, IEL's, and NK cells, roles in health and disease, and regulation by metabolic pathways. Pre-requisite: CORE6200. Enrollment limited to matriculated Ph.D. and M.S. students except by permission of the course director. Offered in the first half of winter quarter during odd years only.
- IMM 6879w. TUTORIAL IN CELLULAR ACTIVATION. (2 cr.; A-F; offered even years; pre-req. CORE 6200 or equivalent, basic knowledge of receptor pharmacology is desirable but not a requisite) D. Billadeau, K. Medina, V. Shapiro, K. Khazaie, H. Zeng– This course focuses on the intracellular signaling pathways which regulate the activation, growth, and differentiation of lymphoid cells. Additional emphasis is placed on molecular mechanism of immunosuppression by cyclosporine, FK506, and related compounds.

- IMM 6880sp. TUTORIAL IN IMMUNOPATHOLOGY. (2 cr.; A-F; offered odd years) A. Johnson– Concepts in the immunopathology of virus and bacterial infection, autoimmunity, tumor immunology, and transplantation. Emphasis will be on immune mechanisms that the host uses to respond against pathologic agents, how dysregulation of these responses lead to autoimmunity, and adaptative strategies infectious agents use to evade immunity.
- IMM 6882w. TUTORIAL IN MUCOSAL IMMUNOLOGY. (2 cr.; A-F; offered odd years; pre-req. CORE 6200) K. Khazaie – The course will review aspects of mucosal immunology and sterile inflammation. This will include microbiota and their interaction with host, innate immunity, including innate lymphoid cells, NK cells, gdT-cells, dendritic and other myeloid cells, adaptive immunity with emphasis on intraepithelial lymphocytes, Tr1 cells, regulatory T-cells and immune regulation, the current knowledge of the receptors and molecules that are used by immune cells to recognize stress and microorganisms, organ specific immunity, the enteric nervous system and brain-gut axis, circadian rhythm.
- IMM 6884w. TUTORIAL IN TUMOR IMMUNOLOGY. (2 cr; A-F; offered even years; pre-req. CORE 6200 or equivalent) H. Dong, K. Khazaie, S. Markovic, K. Pavelko, I. Parney, R. Vile – Concepts in tumor immunology. This course is based on the current literature with heavy emphasis on student/faculty discussion.
- IMM 6885sp. TUTORIAL IN THE GENERATION AND FUNCTION OF B CELLS. (2 cr.; A-F; offered even years; pre-req. CORE 6200 or equivalent) K. Medina, A. Novak, V. Shapiro, H. Zeng – This course is designed to provide an in depth understanding of the generation and function of B lymphocytes in health and disease. The prerequisites are successful completion of Immunology CORE 6200 or Mayo Medical School, Block V, Normal Function, Immunology course. The final grade will be based on class participation and the grade achieved on the comprehensive final exam.
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M.D.-Ph.D.

- MDPH 5000f,w,sp,su. LABORATORY ROTATIONS FOR M.D.-Ph.D. STUDENTS. (1 cr.; S-N) TBA - Graduate thesis research (4 weeks) under supervision of staff.
- MDPH 5150w. GRANT WRITING FOR MD-PHD STUDENTS. (1 cr.; S-N; offered odd years) L. Schimmenti – This one-week colloquium will cover grant writing, submission and review processes. Students will be required to produce a draft grant application (F30 format) and a completed NIH biosketch. Limited to M.D.-Ph.D. students. Medical students may take with permission from course director.
- MDPH 5200w. CRITICAL READING SKILLS FOR MD-PHD STUDENTS. (1 cr.; S-N; offered even years) S. Kaufmann – This one-week colloquium is designed to enhance critical reading skills. The course involves large group discussions of recent literature articles, emphasizing best practices in experimental design, data analysis, presentation and interpretation as well as student presentations of paired articles, specifically articles that reach mutually incompatible conclusions. In addition, students will individually prepare brief written critiques of a recent article. Limited to M.D.-Ph.D. students. Medical students may take with permission of course director.
- MDPH 5300f. WEEKLY MD-PhD CONFERENCE. (1 cr.; S-N) S. Kaufmann, L. Schimmenti – Weekly MD-PhD Conference includes journal clubs (article presentation by students), clinical pathologic

correlations (clinical cases presented by students) and career development talks. MD-PhD students in the PhD phase must present one article per year and one clinical pathologic correlations case every other year. Attendance required: 70% of scheduled conferences. Registration limited to M.D.-Ph.D students in the PhD phase of the MD-PhD program. Register in fall quarter only (1 cr. /yr.).

MDPH 6100su. MD-PhD CLINICAL EXPERIENCE COURSE (0 cr.; S-N) L. Schimmenti – For MD-PhD students in the research years to maintain focused clinical training by selecting a MD mentor and performing history/physical exams, developing a clinical plan, and, where able, participating in surgeries. Minimum of 4 hours/month (longitudinal) or 80 hours over the course of an academic year. Pre-requisites: Successful completion of preclerkship coursework, Step 1 USMLE and Transitions to Clerkship course.

MDPH 6200f,w,sp,su. SENIOR POST GRADUATE MD-PHD RESEARCH EXPERIENCE. (1 cr.; S-N) S. Kaufmann, L. Schimmenti - This is an up to 16-week course during the last year of the MD-PhD program prior to graduation. This course is specifically for MD-PhD students who have completed their PhD, completed all required medical school clinical courses and electives and would like to return to the laboratory to work on a new project with a new laboratory mentor or complete a promising project that was started with their original mentor.

MAYO CLINIC GRADUATE SCHOOL OF BIOMEDICAL SCIENCES

MGS 5000f,w,sp*. FUNDAMENTAL SKILLS. (2 cr.; S-N) TBA – This required course will introduce students to core professional competencies and tools for success in graduate school. **Students register in Fall term only; course runs fall, winter, and spring terms. Required of all first year PhD students effective with 2021 matriculants and required of all MDPhD G1 students. Not open to other learners at this time.*

MGS 5100su. SURF ROTATION AND SEMINAR SERIES. (2 cr.; S-N) TBA – During this 10-week fellowship students will attend a weekly SURF seminar, other seminars and journal clubs within MCGSBS and present at an end-of-the year event hosted by their program. Students will receive hands-on research training during the 10-week full-time fellowship.

MGS 5101f,w,sp,su. Ph.D. LABORATORY ROTATION. (2 cr.; S-N) TBA – Graduate thesis research (4 weeks) under supervision of staff. This is used for 4th and 5th rotations only – requires Academic Affairs Committee approval prior to registration.

MGS 5102f,w,sp,su. Ph.D. LABORATORY ROTATION. (2 cr.; S-N) TBA – Graduate thesis research (8 weeks) under supervision of staff.

MGS 5104f,w,sp,su. OTHER ROTATION. (2 cr. S-N) TBA – PostBac, Master's, PREP, GREP and other similar lab experiences.

MGS 5200f,w,sp,su. CAREER DEVELOPMENT INTERNSHIP (CDI) (1 cr. S-N) J. Doles – Career Development Internships (CDIS) are opportunities for upper-level PhD students to explore biomedical career options, network with biomedical professionals, and contribute to the mission of the CDI partner organization. The goal of the CDI program is to provide MCGSBS students with hands-on experience in the diverse career environments to assist with making informed career path decisions.

- MGS 6100f,w,sp,su. MASTER'S THESIS PROTOCOL. (3 cr. S-N) TBA – For Basic Science Master's students only. Register during the quarter of which the thesis protocol is approved. May be taken only once for credit. Register with program director as course director.
- MGS 6400f,w,sp,su. MASTER'S SCHOLARLY REVIEW ARTICLE (FINAL PROJECT). (6 cr. S-N) TBA – For Employee Master's students only. Requires paper or equivalent in the area of the students' chosen track submitted as Employee Master's Project. Topic is chosen by the student with guidance from the mentor. Register during the final quarter of tenure in the program in order to finalize the scholarly review article (Final Project). May be taken only once for credit. Register with mentor as course director.
- MGS 6840f,w,sp,su. MASTER'S RESEARCH. (4 cr., S-N) TBA – For Basic Science Master's Program Student's only. Graduate research for Master's students under supervision of staff. Register with mentor as course director. 4 cr/qtr – 4 qtrs required.
- MGS 6890f,w,sp,su. PREDOCTORAL RESEARCH. (3 cr., S-N) TBA – Graduate thesis research for Ph.D. students under directed supervision of a faculty mentor. Student must enroll every quarter once a mentor/thesis laboratory is selected for remainder of program. Register with mentor as course director. 3 cr/qtr – 8 qtrs (minimum 24 credits required)

MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

- MPET 5808f. INTRODUCTION TO MOLECULAR PHARMACOLOGY. (4 cr.; A-F) S. Lee – This course covers the effects of drugs and other therapeutic agents on biological systems, with particular emphasis on how drugs interact with their receptors, are metabolized by humans, affect the functions of organ systems, and are used to treat diseases.
- MPET 6205f. CLINICAL PHARMACOLOGY AND PHARMACOGENOMICS JOURNAL CLUB. (1 cr.; S-N) R. Weinshilboum, Wang – This journal club meets once monthly. At each meeting, one participant chooses, along with their mentor, an original research article and leads the discussion. Articles deal with any aspect of the interactions between xenobiotics and man, spanning articles of fundamental laboratory-based science to clinical trials. This journal club will be of interest to graduate students in pharmacology, post-doctoral students in pharmacology, and trainees in clinical pharmacology. Register in fall quarter only (1 cr./yr.). Attendance required fall, winter, spring, and summer.
- MPET 6400sp. INTRODUCTION TO PRINCIPLES OF PHARMACOKINETICS. (2 cr.; A-F) J. Reid – This 12-week course will focus on the qualitative and quantitative description of the kinetics of drug absorption, distribution, and elimination. Learners will gain a basic and practical understanding of the physiological factors that influence these processes and will develop the skills necessary to fine tune dosing regimens for the purpose of optimizing drug levels. Rigorous mathematical derivation of important concepts will be minimized. This course will prepare learners to work in the pharmaceutical industry or take the board examination in clinical pharmacology.
- MPET 6450f. APPLIED DATA SCIENCE AND ARTIFICIAL INTELLIGENCE IN PHARMACOLOGY. (2 cr.; A-F; pre-req: basic statistics knowledge) A. Athreya – Introduction of engineering foundations of data science (DS) and artificial intelligence (AI) in the context of studying drug response and identifying biomarkers for laboratory experiments. In a hands-on approach using state-of-the-art computing infrastructure, the students will implement DS/AI concepts using real-world omics datasets and interpret results with the rigor needed for publications and grant preparations.

- MPET 6655f. MECHANISMS OF CELL GROWTH AND DEATH. (2 cr.; A-F; offered even years; pre-req. CORE 6100, 6150 and 6250 or consent of instructor) L. Karnitz, S. Kaufmann – This tutorial provides in-depth coverage of a series of cellular signaling pathways including those activated by receptor tyrosine kinases, cell death receptors, and DNA damage. Specific topics include receptor tyrosine kinases and the Ras and phosphatidylinositol 3-kinase pathways, cell death receptors and caspase activation, and the ATM/ATR-dependent signaling pathways. Alterations in the signaling pathways in disease states are discussed.
- MPET 6700f. APOPTOSIS JOURNAL CLUB. (1 cr.; S-N) S. Kaufmann – The course is a journal club reviewing recent articles on the cellular mechanisms of apoptosis. An emphasis is placed on reviewing articles describing new, universal molecular and biochemical pathways of apoptosis. The course meets monthly throughout the year. No prerequisites are required. Register in fall quarter only (1 cr./yr.). Attendance required fall, winter, and spring.
- MPET 6800f. RESEARCH SEMINARS IN PHARMACOLOGY. (1 cr.; S-N) A. Kanakkanthara – The purpose of this course is to provide a forum for development of graduate speaking skills in a seminar setting. Students prepare talks presented to students, faculty, fellows, and research technicians. Register in fall quarter only (1 cr./yr.) Attendance required fall, winter, and spring.
- MPET 6805w. DRUG METABOLISM AND PHARMACOGENOMICS. (2 cr.; A-F) R. Weinshilboum, J. Reid – Principles of disposition of drugs in biological systems. Lectures on absorption, distribution, excretion, and metabolic transformation of drugs; descriptions of enzyme systems and factors affecting them. General principles of pharmacogenomics are also presented.
- MPET 6811w. TUTORIAL IN CARDIOVASCULAR PHARMACOLOGY. (2 cr.; S-N; offered even years) TBA – Advances in physiology, pharmacology, genomics, and regenerative medicine are in the process of creating new therapeutic opportunities in cardiovascular medicine. The present course will examine recent literature to explore advanced topics related to understanding innovative pharmacological approaches to treating cardiovascular disease. Previous completion of the Principles of Pharmacology course in the Medical School or Graduate School is required.
- MPET 6812sp. TUTORIAL IN MOLECULAR PHARMACOLOGY AND RECEPTOR SIGNALING. (1 cr.; S-N) L. Karnitz – Student-led discussions and presentations on current topics in receptor biology (runs concurrently with CORE 6450).
- MPET 6813f. TUTORIAL IN SYSTEMS PHARMACOLOGY (2 cr.; A-F; offered odd years; pre-req. MPET 6805/5808 encouraged.) H. Li, K. Robertson – Changes in biomedical research have greatly increased the opportunities for clinical impact. These new opportunities were born in large part through the emergence of large-scale genomics, transcriptomics, epigenomics, proteomics, and metabolomics research efforts that yielded huge databases from large patient cohorts and laboratory studies. This explosion of data necessitates the use of quantitative, machine learning and systems approaches more broadly than ever. This course will cover an introduction to computational techniques such as machine learning, systems biology and pharmacology as applied to various ‘omics’ datasets, network algorithms, and data science application methodology. We then discuss how these techniques are applied to large multi-layer datasets and more importantly, how they are integrated to yield new information on disease and drug response mechanisms, deregulated pathways, and biomarkers of disease and drug response. The class format is a combination of didactic lecture and computation laboratory-based study that is geared toward advanced graduate students and postdoctoral fellows learning how to generate and analyze ‘omics’ data, and what the pitfalls and limitations are in this field.

- MPET 6814w. CELLULAR PHARMACOLOGY OF AGENTS THAT TARGET CANCER. (2 cr.; A-F; offered even years) S. Kaufmann – This tutorial will examine the mechanisms of action of selected pharmacological agents of the cellular and subcellular level. Drug targets to be examined during the quarter will include plasma membrane receptors, enzymes involved in signal transduction, cell cycle regulation, chromatin modification and DNA repair, selected pathways in intermediary metabolism, and/or regulators of apoptosis. Emphasis will be placed on 1) understanding the variety of experimental approaches that are applicable to the study of drug action in different subcellular compartments and, 2) developing an ability to critically evaluate recent literature.
- MPET 6815f. NEUROBEHAVIORAL PHARMACOLOGY. (2 cr.; A-F; even years) D. Choi – This course will cover the most recent neuropharmacological aspects of behavior disorders. The emphasis will be on understanding the advancement of neurogenetics, neurobiology, neuroimaging, and human genomics, which are enabling us to decipher behavioral disorders in molecular levels, and thereby to develop more precise pharmacological treatment methods.
- MPET 6820w. REGENERATIVE MEDICINE. (2 cr.; A-F) A. Windebank – This course is designed to introduce students to principles of stem cell biology and provide an appreciation for applications in regenerative medicine and surgery. Presenters will stress fundamental principles. Particular emphasis is placed on state-of-the-art derivation of stem cell population lineages, analysis of respective genomic, proteomic, and metabolomic traits, and applications in therapy in diagnosis. The course will follow a discovery-translation-application curriculum. By course end, students should become proficient in the comprehension of fundamental concepts underlying stem cell platforms as well as obtain insight in new therapeutic/diagnostic opportunities. Proficiency in fundamental cell biology, genomics, and pharmacology is highly recommended. This is a shared course with the Clinical and Translational Sciences track

NEUROSCIENCE

- NSC 5600f. BEHAVIORAL NEUROLOGY. (2 cr.; S-N; Register in fall, course runs fall and winter terms; offered odd years) N. Taner – Students will learn about the neuropathological, genetic, and clinical characteristics of neurodegenerative diseases such as Alzheimer’s disease. The course will feature the most current knowledge about each disease, including therapies available or ongoing research on the causes of the disorder. The course features weekly lectures and will be assessed based on attendance and participation.
- NSC 6210sp,su. NEUROBIOLOGY OF DISEASE. (3 cr.; A-F; odd years; pre-req. consent of course director) A. Siddiqui – This course is designed for graduate students (Ph.D. and M.S.), residents, clinical fellows, and postdoctoral fellows in neuroscience/neurology and clinical translational science training programs. It is intended to confer a detailed mechanistic understanding of the genetic, pathological and cell biological basis of important neurological diseases and syndromes. The clinical and scientific background and context for each disease will also be provided and therapeutic rationales will be discussed along with current mechanisms and modeling (cellular or model organisms). The focus will be on research-oriented students, but this course will also provide a mechanistic understanding for clinically oriented students. Basic science and clinical experts from all three Mayo campuses will provide this didactic survey course. These 90-minute lectures will be on Tuesday afternoons, from 4:00pm-5:30pm EST. A two- page proposal on a student-selected disease entailing a brief background, importance, and two specific aims will be due at the end of each term. This course will span two quarters (January to June).

- NSC 6250f. SKILLS FOR EFFECTIVE PRESENTATIONS. (2 cr.; S-N) O. Ross – The purpose of this course is to instruct students on critical presentation skills that can be applied to journal club, works-in-progress presentations, and future speaker opportunities. In addition, students will discuss how to critically evaluate published manuscripts and effectively communicate the findings in ways that will keep a journal club audience engaged and encourage discussion. Target audience is first year NSC track students, although it is open to all students.
- NSC 6310sp,su. METHODS IN NEUROSCIENCE RESEARCH. (Register Spring term; 2 cr.; A-F) P. McLean – The purpose of this course is to give an overview of commonly used lab techniques in neuroscience research. Students should plan to register for the course in the spring quarter of Year 1 just after choosing a thesis mentor and when beginning to think about thesis projects. This is a 2-quarter course that will run through the end of summer quarter. This will be a team-taught course with a mid-term and final exam.
- NSC 6401sp. PRACTICAL NEUROANATOMY. (2 cr.; A-F; odd years; pre-req. first year MCGSBS student or consent of course director) M. Murray – This course is designed to provide a fundamental understanding of neuroanatomical nomenclature and the structure and function of the human nervous system. The emphasis is on practical application of neuroanatomical knowledge for research-oriented students. This course is appropriate for students in all tracks who want to increase their knowledge of Neuroanatomy.
Course detail:
- (1) The course is laboratory based. There will be ten 3-hour lecture/ laboratory sessions.
 - (2) Students will view at least one brain cutting session with a Mayo Neuropathologist and one Neuro Histopathology review.
 - (3) Students will write a mini review of an area of Neuroanatomical interest.
- NSC 6600f,w,sp,su. NEUROSCIENCE JOURNAL CLUB. (1 cr.; S-N) Da Mequita, W. Springer – This multifaceted course will address current topics in neuroscience and will emphasize dynamic interactions between students and faculty. Each quarter two to three focused topics will be covered in depth through a series literature reviews and presentations by the students. One credit will be given per year for years 1 and 2 and every student is required to present and participate each quarter in years 1 through 4. Register for this course fall quarter only of years 1-2 (1 cr. /yr.). Attendance required fall, winter, and spring all years.
- NSC 6650f,w,sp,su. NEUROSCIENCE WORK IN PROGRESS. (1 cr.; S-N) Da Mesquita, W. Springer – Presentation of ongoing research projects by graduate students in the Neuroscience Ph.D. Program. One credit will be given per year and every student is required to present a WIP each year in years 2 – 5. Register for this course fall quarter only of years 2-3 (1cr. /yr.). Attendance required fall, winter, and spring all years.
- NSC 6854w,sp. BASIC NEUROSCIENCE. (5 cr.; A-F) E. Benarroch – The Basic Neuroscience course consists of a series of didactic lectures and question and answer sessions covering basic molecular, cellular, neurochemical and physiological aspects of the organization of the nervous system, with an emphasis on clinical correlations. The course is intended to provide neurology and neurosurgery residents and neuroscience graduate students with basic information on the organization of the nervous system at the molecular, cellular, synaptic, and system levels. The course will also provide information that will allow clinical trainees to understand and critically analyze the increasing number of papers in the neurologic literature that address basic mechanisms of disease and therapeutic approaches. Finally, the course will provide an overview of the spectrum

of neurologic disease that will allow basic science trainees to put their specific research projects in the context of potential clinical relevance.

NSC 6857w. SYSTEMS NEUROSCIENCE AND BEHAVIOR. (3 cr.; A-F) (3 cr.; A-F; offered yearly) S. Lucio Boschen De Souza - The purpose of this course is to provide graduate students with a basic understanding of the neural basis of behavior. As virtually all behavior can be related to the functioning of the brain and nervous system, this course is essentially about these systems. Topics to be covered will include neuroanatomy, neurophysiology, neuropsychological methods, sensory systems, psychiatric disorders, motor disorders, and neurodegenerative diseases. This course is designed to provide a foundation of neuroscience understanding for graduate students. The course will have a strong research orientation but where appropriate, specific disease states and clinical perspectives will be highlighted.

NSC 6862f. MOLECULAR AND CELLULAR NEUROSCIENCE. (3 cr.; A-F; offered yearly) S. Lucio Boschen De Souza – This course will present didactic and literature-based training in molecular and cellular neuroscience. The aim of the course is to help students gain an understanding of the molecular basis of neuronal and glial function. Topics to be covered will include neuronal and glial cell biology, ion channels and the generation of membrane potential, the electrical properties of neurons, neurotransmitters, and neurotransmitter release, and second messenger signaling.

NSC 6900f,w,sp,su. NSC THESIS PROPOSAL. (2 cr.; S-N; prerequisite-must have completed and passed qualifying exams) O. Ross – Thesis proposal: The written thesis proposal matches the format of NIH F31 grants and, hence is limited to 7 pages, including figures but not references. In the student's own words, the proposal should outline the rationale for the proposed project and how it is to be executed. The proposal is subdivided into the following sections.

- Abstract: Summary of the project (1 page)
- Specific Aims: Briefly describe the aims and hypotheses of your project (1/2 page).
- Significance: Put your project into context with what is known about this area of neuroscience and demonstrate the significance of the questions you are asking (1 page)
- Innovation: How is the proposed project novel and groundbreaking (1/2 page)
- Approach: Describe what you plan to do and how you plan to do it. Include preliminary data for each aim that supports your question and hypothesis (4 pages). Register for credit the quarter AFTER you have presented your proposal and passed your qualifying oral exam.

OBSTETRICS AND GYNECOLOGY

Didactic

OBG 5803f,w,sp,su. INTRODUCTION TO SURGICAL GYNECOLOGY. (1 cr; A-F) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. C. Langstraat, J. Occhino - Didactic sessions presented weekly. Student preparation and participation is required. Students earn MCGSBS credits for participation in fellowship didactic activities, not a formal classroom setting. *Must register each of the four consecutive quarters. Begin summer quarter of first year of fellowship.*

OBG 5804f,w,sp,su. INTRODUCTION TO MATERNAL FETAL MEDICINE. (4 cr; A-F) Prerequisite: must be enrolled in Maternal Fetal Medicine Fellowship Program. C. Rose - Students earn MCGSBS credits for participation in fellowship didactic activities, not a formal classroom setting. Didactic

sessions presented weekly. Student preparation and participation is required. *Must register each of the four consecutive quarters. Begin summer quarter of first year of fellowship.*

OBG 5805f,w,sp,su. INTRODUCTION TO REPRODUCTIVE ENDOCRINOLOGY AND INFERTILITY. (5 cr; A-F; as prerequisite, must be enrolled in Reproductive Endocrinology & Infertility Fellowship Program) E. Stewart and TBA - Students earn MCGSBS credits for participation in fellowship didactic activities; not a formal classroom setting. Didactic sessions presented weekly. Student preparation and participation is required. *Must register each of the five consecutive quarters. Begin summer quarter of first year of fellowship.*

Research

OBG 6840f,w,sp,su. RESEARCH IN OBSTETRICS GYNECOLOGY. (6cr/qtr - 4 qtrs required; A-F; prerequisite: must be enrolled in one of the following programs:

- Gynecology Oncology Fellowship Program: Instructor C. Langstraat
- Female Pelvic Medicine and Reconstructive Surgery Fellowship Program: Instructor J. Occhino
- Maternal Fetal Medicine Fellowship Program: Instructor C. Rose
- Reproductive Endocrinology & Infertility Fellowship Program: Instructor J. Occhino Graduate thesis research under supervision of staff. Students earn MCGSBS credits for participation in fellowship research activities; not a formal classroom setting. Master's program application must be accepted by MCGSBS to enroll in this course.

Clinical

OBG 6857f,w,sp,su. GYNECOLOGIC ONCOLOGY. (6cr/qtr - 5 qtrs required; A-F; As prerequisite, satisfactory completion of an obstetrical and gynecologic residency training program at an accredited institution and maintenance of satisfactory status within the Gynecologic Oncology Fellowship Program) C. Langstraat and staff. Preoperative evaluation, surgical treatment, and postoperative management of benign and malignant gynecologic disease processes and the complications thereof arising within the female genitalia. In addition, the acquisition of theoretical and practical knowledge regarding the natural history, the diagnosis, alternatives to surgical management, prognosis, and the postoperative immediate and long-term disposition for each of the disease processes requiring surgery will be anticipated. Students earn MCGSBS credits for participation in fellowship clinical and surgical activities, not a formal classroom setting. *Must register for each of the five consecutive quarters. Begin summer quarter of second year of fellowship.*

OBG 6865f,w,sp,su. REPRODUCTIVE ENDOCRINOLOGY AND INFERTILITY. (6cr/qtr - 5qtrs required; A-F; prerequisite satisfactory completion of an obstetrics and gynecology residency training program at an accredited institution and maintenance of satisfactory status within the Reproductive Endocrinology and Infertility Fellowship Program) E. Stewart and TBA. Management of patient care under faculty supervision, developing clinical and surgical skills related to infertility, amenorrhea, abnormal uterine bleeding, neuroendocrine dysfunction, reproductive tract abnormalities (acquired and developmental), androgen disorders, recurrent abortion, and menopause. Review of patient care cases on a weekly basis to determine the best approach and plan of care. Daily discussion of the best management of patients undergoing ovulation induction or in vitro fertilization (IVF). Participation in IVF, gamete micromanipulation, assisted hatching, embryo cryopreservation, and oocyte donation. Preparation for clinical practice in reproductive endocrinology through extensive experience in sonography, sonohysterography, controlled ovarian hyperstimulation, transvaginal ultrasound-directed oocyte retrieval and embryo transfer. Application of medical and surgical treatments for male infertility, including epididymal aspiration, testicular biopsy and electroejaculation under the supervision of a urologist and medical endocrinologist. Students earn MCGSBS credits for participation in fellowship clinical

and surgical activities, not a formal classroom setting. *Must register for each of the five consecutive quarters. Begin summer quarter of first year of fellowship.*

OBG 6870f,w,sp,su. ADVANCED UROGYNECOLOGIC OPERATIVE SURGERY. (6cr/qtr-4 qtrs required; A-F; prerequisite is satisfactory completion of an obstetrics and gynecology or urology residency training program at an accredited institution and maintenance of satisfactory status within the Female Pelvic Medicine and Reconstructive Surgery Fellowship Program) J. Occhino and TBA. The preoperative, intra operative and postoperative management of gynecological patients. Students earn MCGSBS credits for participation in fellowship clinical and surgical activities, not a formal classroom setting. *Must register for each of the four consecutive quarters. Begin summer quarter of second year of fellowship.*

OBG 6875f,w,sp,su. MATERNAL FETAL MEDICINE. (6cr/qtr – 4 qtrs required; A-F; C. Rose and TBA; prerequisite is completion of an obstetrical and gynecologic residency training program at an accredited institution and maintenance of satisfactory status with the Maternal Fetal Medicine Fellowship Program.) Direct medical management of maternal and fetal conditions during pregnancy. Clinical experience in obstetrical, genetic, medical, and surgical complications of pregnancy and their effect on the mother and developing fetus through an intensive ambulatory and labor and delivery practice. Focus on the use of screening and diagnostic sonography and development of associated invasive procedural skills including chorionic villus sampling, genetic amniocentesis, in-utero stenting procedures, laser therapy for twin-twin transfusion syndrome, and percutaneous umbilical cord sampling/intrauterine blood transfusion. Students earn MCGSBS credits for participation in fellowship clinical and surgical activities, not a formal classroom setting. *Must register for each of the four consecutive quarters. Begin summer quarter of first year of fellowship.*

ORTHOPEDICS

Didactic

ORS 5803f,w,sp,su. PROSTHETICS FOR ORTHOPEDICS. (1 cr; A-F) N. Pulos - Lectures and discussions regarding upper and lower extremity Prosthetics for amputations at various levels, includes class participation in the application of immediate-type pylons.

ORS 6550f,w,sp,su. MICROVASCULAR SURGERY SKILLS. (2cr; S-N) W. Anding - Prerequisite is student must be involved in or have completed a training program in an approved surgical specialty or subspecialty or be involved as a research fellow, technician, etc.) Forty hours of instruction and practice, which includes the care and adjustment of the operating microscope, the basic techniques of microsurgical suture placement, and microvascular anastomosis of a rat femoral artery and rat femoral vein. Following successful completion of the above measures, the students will extend their application to end to side microvascular anastomosis, as well as epineural and fascicular nerve repair using the rat sciatic nerve model.

ORS 6860f,w,sp,su. BASIC KNOWLEDGE AND MOTOR SKILLS OF ORTHOPEDIC SPECIALTIES. (4 cr; A-F; consent of instructor is required) N. Pulos - This course will cover pertinent basic knowledge and motor skills as it applies to the subspecialties of Orthopedics, including adult reconstruction/ trauma, hand and upper extremity, pediatrics, spine, and sports medicine.

Clinical

ORS 6852f,w,sp,su. ADULT RECONSTRUCTION. (3 cr; A-F) J. Barlow and TBA - This course covers all areas of adult reconstructive surgery, including spine, hip, knee, shoulder, elbow, ankle, and foot.

Course will include personal teaching on patient assessment, surgical technique, pre- and postoperative care, as well as follow-up care.

- ORS 6853f,w,sp,su. SURGERY OF THE HAND. (3 cr; A-F) J. Barlow and TBA - Supervised exposure to clinical hand surgery with weekly teaching conference and monthly journal club.
- ORS 6854f,w,sp,su. PEDIATRIC ORTHOPEDICS. (3 cr; A-F) J. Barlow and TBA - Incidence, etiology, evaluation, and treatment of congenital developmental, metabolic, and post-traumatic orthopedic conditions from birth to physiologic maturity.
- ORS 6855f,w,sp,su. ORTHOPEDIC ONCOLOGY. (3 cr; A-F) J. Barlow and TBA - Orthopedic oncology residents participate in evaluation and management of patients with various musculoskeletal neoplasms. The surgical experience includes modern limb salvage procedures.
- ORS 6856f,w,sp,su. ORTHOPEDIC TRAUMA. (3 cr; A-F) J. Barlow and TBA. Instruction in patient assessment by history, physical examination, imaging modes, laboratory tests and other adjunctive special evaluation techniques in the investigation of the musculoskeletal system and its fractures and related injuries. Included are experiences in outpatient, inpatient and operating room settings. The didactic program includes clinical conferences, lectures, and journal clubs.

Research

- ORS 6890f,w,sp,su. RESEARCH IN ORTHOPEDICS. (6cr/qtr – 4 qtrs required; S-N) TBA - Graduate thesis research for Master's students under supervision of staff.

REGENERATIVE SCIENCES

- REGS 5200w. FUNDAMENTALS OF REGENERATIVE SCIENCES. (2 cr. A-F) S. Wyles, R. Hayden, A. Terzic – week course (approx. 6-8 hrs. per day) with no pre-requisites for enrolled PhD students, but employees and GREP/PREP/Postbac students must obtain permission to enroll from Dr. Wyles or Dr. Scarisbrick. Medical and graduate students are introduced to the fundamental principles, tools, and platforms of regenerative medicine. PhD students taking the course for credit must participate in all sessions and discussion. Learners will also be required to complete introductory online modules, Good Clinical Practice FDA CITI certification and multiple-choice written exam (70% pass rate with 2 attempts).
- REGS 5210sp. ADVANCED REGENERATIVE MEDICINE AND SURGERY. (2 cr. A-F) S. Wyles, R. Hayden, A. Terzic – 1 week course (approx. 6-8 hrs. per day) with a prerequisite of REGS 5200 for enrolled PhD students, but employees and GREP/PREP/Postbac students must obtain permission to enroll from Dr. Wyles or Dr. Scarisbrick. Medical and graduate students are introduced to regenerative strategies in clinical and biomedical training. PhD students taking the course for credit must participate in all sessions and discussion. Learners will be required to complete a small interdisciplinary group assignment, simulated patient encounter assignment and organ system-based clinical trial critical review for REGS: Advanced Regenerative Medicine and Surgery.
- REGS 5300f. STEM CELLS AND DEVELOPMENT. (3 cr. A-F) Q. Peterson, N. Kannan – This course will introduce stem cell and developmental biology in the context of regenerative sciences. Emphasis is placed on the fundamental concepts that govern development, regeneration and their application to study and treat disease. Topics covered include embryogenesis, organogenesis, pluripotency, differentiation, maturation, transdifferentiation, along with stem cell technologies and tissue engineering.

- REGS 5500f,w,sp. TOPICS IN REGENERATIVE SCIENCES AND MEDICINE. (3 cr S-N) Q. Peterson – Interdisciplinary course required for RSTP Postbac and PhD students; suitable also for all PhD students and others interested in regenerative science and medicine. Class meets regularly during the Fall/Winter/Spring Quarters. Journal club presentations of recent advances in regenerative sciences, research from one Mayo Clinic lab, and guest speakers on a variety of topics (including but not limited to quality control, quality assurance, regenerative regulatory science, manufacturing, and entrepreneurship). All meetings feature extensive discussion.
- REGS 5800sp. DEVELOPMENTAL BIOLOGY. (2 cr.; P/F) M. Fernandez-Zapico, J. Doles – Tutorials will be arranged on individual basis in selected advanced topics in developmental biology including cellular process of developing organisms, genetic analysis of development, early development: molecular basis of embryo polarity, maternal effect, patterning mechanisms and signal transduction cascades, molecular mechanisms of organogenesis: derivatives of the primary germ layers, molecular model of differential gene expression (e.g., Homeobox model), sex development pathways, teratogenesis and regeneration and aging. Students will determine a study topic with a member of the faculty. Knowledge of the topic will be assessed by oral presentation of the material at the end of the course. (Replaced BMB 5400 Independent Study of Developmental Biology)
- REGS 6300sp. EXPERIMENTAL METHODS IN REGENERATIVE SCIENCES. (1 cr.; A-F) R. Huebert, B. Druliner, H. Guerrero Cazares – This course is designed to teach state-of-the-art basic science technologies that can be applied to regenerative medicine through a series of interactive lectures and hand-on lab experiences. The focus of the course will be to provide exposure to the breadth and depth of techniques used in regenerative medicine research at Mayo Clinic and nationally. Emphasis will be on application to human disease including development of regenerative therapeutics.
- REGS 6400f,w. REGENERATIVE TISSUE ENGINEERING PRINCIPLES (RTEP). (4 cr.; A-F) L. Griffiths – The regenerative tissue engineering principles course employs a strongly student-centric teaching approach to assist learners to develop their understanding of tissue engineering principles, components and approaches; and apply this knowledge to solve unmet clinical needs. The course employs consists of ~50% student centered (e.g., problem based learning) teaching, allowing time for students to work with and master the course material. No prerequisites.
- REGS 6500f. INTRODUCTION TO TRANSLATIONAL BIOPRODUCT DEVELOPMENT. (2 cr.; A-F) D. Lott – This course will cover the fundamentals and concepts needed to understand the development process of complex regenerative bioproducts. Activities will consist of lectures, interactive group discussions, and a pitch presentation. This course is focused on translational capabilities. Students will partner with a Mayo Clinic clinician of their choosing to understand their clinical bioproduct needs. No specific course prerequisites exist.

VIROLOGY AND GENE THERAPY

- VGT 5300w. MOLECULAR THERAPY LECTURE COURSE. (1 cr.; A-F) P. Devaux – After attending this course the student will have gained an appreciation of the broad potential scope of molecular therapies and should understand how to develop a DNA, RNA, virus, or cell-based therapeutic from an idea to a validated product. Various molecular and cellular therapeutic strategies will be considered in relation to a broad spectrum of human diseases illustrating how they can be used for gene replacement, tissue engineering, destruction of unwanted tissues, or immune stimulation.

Stages in the development of these drugs will be studied from vector design through preclinical proof of efficacy, clinical protocol development, product manufacture, pharmacology and toxicology testing, analysis of clinical trial outcomes, regulatory affairs, patenting and partnering with industry.

- VGT 5500w. FROM VIRUSES TO VECTORS LECTURE COURSE. (1 cr.; A-F) M. Barry – This course will introduce non-viral and physical methods for gene or RNA delivery as a prelude to a deeper dive into viral vectors. The course will discuss how different types of viruses are converted into nucleic acid delivery vectors. The course will discuss promising applications of the vectors as well as current challenges making safe, efficient, targeted vectors for gene therapy vaccines and oncolytic virotherapy.
- VGT 5600w. MOLECULAR VIROLOGY LECTURE COURSE. (1 cr.; A-F) K. Mohni – We highlight unifying principles emerging from the study of animal viruses. Using selected examples, we illustrate virus structure, cell entry and receptors, replication of retroviruses, DNA viruses and riboviruses, transcription and RNA processing, translation and intracellular transport, particle assembly and cell escape. We discuss which questions are still outstanding and introduce emerging viruses.
- VGT 5650su. EMERGING PATHOGENS AND VACCINES JOURNAL CLUB. (1 cr.; S-N) M. Barry – The emergence persistence of pathogens that cause human and animal diseases have continued to surge despite technological and medical advances in the past century. COVID-19 is the most recent example. This journal club will survey emerging and emerged pathogens in a journal club format.
- VGT 6740f. VIRUSES AND VECTORS JOURNAL CLUB. (1 cr.; S-N) R. Cattaneo – Discussion of recent advances in the fields of virology and gene therapy. Students, postdocs, and staff will present recently published papers that are of general interest to the fields. Emphasis will be on the development of new vectors for gene delivery and on cytoreductive therapy. From 2nd year on: Register in fall quarter only (1 cr./yr.). Attendance is required by all students. Presentations are required by all students in the 2nd year and beyond.
- VGT 6745f. CURRENT TOPICS IN VIROLOGY AND GENE THERAPY. (1 cr.; S-N) M. Barry – This is a weekly seminar course in which visiting seminar speakers alternate with Mayo investigators. The format is a one-hour seminar in which the presenter gives a detailed account of their own virology or gene therapy research followed by a lively question and answer session. From 2nd year on: Register in fall quarter only (1 cr./yr.). Attendance is required by all students.
- VGT 6884sp. VIRAL DISEASE TUTORIAL. (2 cr.; offered odd years; A-F, Structure: 12 sessions with 2 sessions per week) M. Barry – Virus pathology and disease tutorial. Major viruses and their molecular biology, pathogenesis and clinical features, emerging pathogens, therapeutic strategies. Important viral infections will be covered; emphasis will also be placed on emerging viruses of strong topical or emerging interest. Structure: 11-12 sessions, meeting weekly for about two hours. Discussion will center on important papers after introduction to topic by faculty.
- VGT 6886sp. MOLECULAR VIROLOGY TUTORIAL. (2 cr.; offered odd years; A-F, Structure: 12 sessions with 2 sessions per week) R. Cattaneo – This tutorial is a companion to the Molecular Virology course. It deepens the subjects illustrated in the lectures. Publications that have contributed in shaping the field or have identified new principles will be introduced by staff members and presented by the students.

VGT 6888sp. MOLECULAR THERAPY TUTORIAL. (2 cr.; offered even years; A-F, Structure: 12 sessions with 2 sessions per week) P. Devaux – The major goal of this tutorial is to develop a broad understanding of the field of clinical gene transfer and therapy. Tutorials will range from the scientific and biological aspects of gene vectors and safety to the conduct and regulatory issues of clinical gene transfer trials. A variety of instructors will discuss pertinent questions involving the development and practice of ongoing clinical trials. These trials will include those that address infectious disease, malignancies, and cardiovascular disease.

Student Services

Office of Student Financial Aid & Registrar

The Office of Student Financial Aid & Registrar seeks to attract the very best students to Mayo Clinic Graduate School of Biomedical Sciences by assisting with financial aid needs. Their support allows students to choose a career based primarily on their interest, skill, and aptitude rather than financial considerations imposed by indebtedness. The office assists students with financial aid processing, grant and scholarship opportunities, loan programs and consolidation counseling, loan deferment processing, *etc.* More information about the Office of Student Financial Aid & Registrar is available within this catalog in the section marked Student Financial Aid.

Coaching and Academic Success

Academic Success

The primary objective for the Academic Success Coach is to partner with the student to empower success; so the student is able to identify and work through challenges with ownership. The coach may support the student's academic success by providing individual, small group or workshop sessions, offer resources for emotional issues or learning differences, or provide individualized coaching for:

- Time management
 - Creating and maintaining effective Study Groups
 - Calendar Preparation
- Wellness
 - Stress Management
 - Work-life Integration
- Learning and reading strategies
- Study skills and test preparation
 - Assessing and Optimizing Learning Skills
 - Peer tutoring
- Residency Preparation
 - CV & PS Preparation and Proofing
 - Interview Skills
- Learning differences
- Job search assistance, including creating and editing resumes, CVs, personal statements, and cover letters, as well as developing interview skills

Tutoring Resources

Peer tutors are available in a variety of content areas. Students must complete the online form to request a tutor. Guidelines for requesting a tutor:

- Student must obtain course leader/director approval for a tutor prior to requesting.
- Requests will be filled in the order they are received, with an attempt made to respond within 24 hours.
- Arrangements such as time and location of tutoring will be made between tutors and tutees.
- Tutor costs are covered by Mayo Clinic Graduate School of Biomedical Sciences.

Life and Wellness

Life and Wellness

Student Life and Wellness resources are available to promote the well-being of students; foster an educational environment that nourishes students' mental, physical, social, and spiritual aspects; and help equip students with the skills to promote personal well-being.

Resources include the following components:

- Physical Wellness
 - Discounts toward workout facilities
 - Mayo Clinic Healthy Weight Program
 - Medical Benefits Plan
 - Primary Care through Mayo Clinic's Employee Occupational Health Services
 - Health & Wellness Tips and Presentations
 - Presentations address common problems, provide practical tips, and allow ample time for discussion.
- Social Wellness
 - A variety of student organizations and specialty interest groups to choose from
 - A number of Mayo Clinic Graduate Student Association sponsored events.
- Emotional/Mental Wellness
 - Stress Management and Resilience Training Program (SMART)
 - Mayo Clinic Department of Psychiatry and Psychology
 - Ask Mayo Clinic (RN Triage Line)
 - Student Counseling Services
- Spiritual Wellness
 - Chaplain Services
 - Meditation

Disability and Accommodations

Students can get **student-specific services** from the Department of Preventative, Occupational and Aerospace Medicine if they:

- Have a health issue that is impacting the ability to participate fully in training
- Need accommodations for testing and other activities
- Have been out of class/rotations due to health reasons
- Need a medical leave of absence
- Have been referred by a Dean or faculty member for consultation

Counseling and Testing Performance

Students receive services from a licensed clinical social worker in the following areas:

- Evaluation and counseling for test taking anxiety
- "Drop in" hours to meet about various concerns, that you may have in the dimension of mental health, and collaborate to define a plan
- All records confidential
 - Confidential therapy: all Electronic Medical Records will be noted as 'confidential' (only access to record is through use of password)
 - Remains strictly confidential and has no academic consequence or academic oversight
- Can provide ongoing intervention to address anxiety, depression, *etc.*



POLICIES & PROCEDURES

Absence and Leave Policy

Scope

Applies to Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) PhD students and MD-PhD students in the graduate school phase of training when seeking an absence from training.

Purpose

To define options and set expectations for students seeking an absence from their educational programs while maintaining good standing in their MCGSBS appointments.

Policy

Attendance

- Students are expected to attend and be on time for all required learning activities, including in the classroom, laboratory, or other learning environments.
- Students who are absent, tardy or depart early from their required learning activities, are considered an unexcused absence, unless approved for one of the excused absences listed below.
- Unexcused absences and tardiness will be addressed through the Mayo Clinic College of Medicine and Science Warning, Probation, Dismissal and Appeal [Policy](#) and [Procedure](#).

Excused Absences

Vacation

- Students are allowed 15 days of vacation per year beginning on the date of commencement of their appointment.
- Weekends and holidays are not charged as vacation time. MCGSBS observes federal holidays as defined in the Mayo Clinic [Holidays Policy](#).
- Vacation cannot be carried over from one 12 month period to another;
- Approval of when to take vacation is obtained from the graduate school program director until a mentor has been identified.
- Students will not be paid for unused vacation.
- If a student is denied the ability to use vacation days this must be reported to the graduate school.

Leave of Absence

- MCGSBS allows students to take an approved Leave of Absence (LOA) when [significant extenuating personal circumstances](#) impact their ability for continuation in the program.

- An LOA must be approved by the MCGSBS Academic Affairs Committee and communicated to the program director and mentor (if assigned).
- An LOA must be requested in accordance with the [Absence and Leave Procedure](#).
- Lack of communication or failure to provide required documentation for an LOA will result in student being placed in an unpaid personal leave until documentation is provided, disciplinary action or both.
- Failure to return from a leave of absence on the expected return date without an approved extension is considered voluntary resignation.
- In order to allow equal training time for PhD students, an LOA will result in an automatic extension of training end date, e.g. a three month LOA pushes out training end date three additional months. This change will be made in the student record after completion of the LOA.
 - This change of end date does not apply to MD-PhD students due to the impact on return to MD training; however LOA time is considered if an extension of training is requested.
- A student on LOA must be allowed for responsibilities associated with their training to be suspended throughout the leave period. MCGSBS can provide assistance as needed to negotiate these expectations with the student's mentor, including any required assignments, courses, meetings, or research-related responsibilities. A student is not eligible to take qualifying exams while on LOA.

Leave Types

Medical Leave of Absence (Medical Leave)

- Medical Leave can be used for a qualifying [serious health condition](#) of the student or of an immediate family member who requires the student's direct care.
- To qualify for a Medical Leave the student must submit medical documentation to Student Services from their health care provider supporting their condition that results in their inability to perform the essential functions of their training with or without accommodations. (See Confirmation of Leave in Definitions below and the [Provider Instructions Medical LOA](#) for guidance.)
 - Documentation from the student's health care provider must be submitted to Student Services within 15 calendar days of the start of the LOA. (See exceptions below for International Students which must be completed prior to start of LOA.)
 - If a letter cannot be obtained within 15 calendar days, the student must contact Student Services within this timeline to discuss expected date of receipt; else the absence will be considered unpaid personal leave until documentation is provided.
 - If communication or documentation is not received by Student Services within 30 calendar days of the start of LOA, the absence will be considered unexcused absence and will be addressed through the Mayo Clinic College of Medicine and Science Warning, Probation, Dismissal and Appeal [Policy](#) and [Procedure](#).

- In the absence of such documentation, the student must use vacation or be placed on unpaid Personal LOA (see below).
 - Final approval for the use of Medical Leave is made by the College Disability Officer, not the graduate school.
- To be eligible for return to training following a Medical LOA, supporting documentation from the student's health care provider must be submitted to and approved by Student Services. See Clearance to Return to Training in Definitions below.
- Medical Leave (13 weeks at full stipend) is available to students at the time of appointment to the PhD or MD-PhD program.
 - The 13-week balance is renewed annually on the anniversary date of the student's matriculation into their current program. Exception: If on LOA at time of anniversary date, renewal would be deferred until student returns from LOA for duration of two weeks.
- If an LOA needs to be extended beyond 13 weeks, the student must be placed on unpaid Personal LOA (unless [Long-Term Disability](#) benefits are applicable).
 - If cleared to return to training on part-time basis, stipend will be adjusted accordingly.
 - If Personal LOA used after Medical LOA is exhausted, medical clearance to return to training is still required.
 - Long-Term Disability eligibility is dependent on a student's benefit package.
 - Medical Leave applies for the period after childbirth, typically six weeks (see [Parental LOA](#) below). Medical considerations may extend STD or require it to begin prior to delivery.
- Other employment not permitted if currently on formal Medical Leave of Absence from MCGSBS.

Parental Leave of Absence

- MCGSBS allows the student, a parent or primary adoptive parent regardless of gender, a Parental LOA of up to 12 weeks duration for childbirth or adoption, including six weeks with stipend.
 - In the event of childbirth, [Medical](#) for medical recovery (paid with stipend) is provided for six weeks beginning on the date of birth. (This six weeks is included in the yearly 13-week allotment.)
 - A student who does not qualify for [Medical Leave](#), but has a qualifying birth or adoption, is eligible for a total of six weeks of parental leave annually paid with stipend.
 - If both parents are MCGSBS students, each are eligible for six weeks of paid leave.
 - Additional absence would involve vacation, [Personal LOA](#) (without stipend), or a combination of the two.
- A Parental LOA must be communicated to the student's mentor and program director as early as possible. The student and mentor must discuss and clarify expectations for the planned leave period.

- The student who is a childbearing parent will work closely with their respective lab supervisors to determine if any accommodations are needed to assigned lab tasks, e.g. liquid nitrogen filling, moving lab inventory, etc.
 - The student will review laboratory and chemical safety for expectant mothers applicable to their environment. See Mayo Clinic [Biosafety](#) resources.
 - If assistance is needed to help negotiate accommodations the student can contact Student Services or MCGSBS leadership.

Personal Leave of Absence

- Personal LOA can be requested when the circumstance does not qualify under another leave type.
- Personal LOA must be requested and approved; ongoing absence without communication with the school is considered voluntary resignation.
- Personal LOA is without stipend and limited to six months duration.
- Mayo Student Health Insurance eligibility continues throughout the leave.
- Students are allowed to use a Personal LOA to extend [Parental Leave](#).

Bereavement Leave of Absence

- The student is responsible for notifying their mentor and/or program director of a death as soon as possible, so any appropriate coverage arrangements can be made.
- MCGSBS allows for a paid absence of three to five days when a student has a death in the family; see defined days in the Allied Health Staff [Bereavement Absence Policy](#).

Military Leave of Absence

- MCGSBS allows for Military LOA for military duty or for medical treatment of a service-related medical condition.
- Except under emergency or short-notice situations, the mentor and program director must be notified well in advance of pending military service.
- For short-term military leave (2-4 weeks) a student can use available vacation days, leave without pay, or a combination of the two.
 - Benefit eligibility continues throughout the leave.
- For long-term military leave (greater than 4 weeks), the entire absence must be a LOA without stipend.
 - Benefit eligibility continues for up to 6 months.
- Refer to the Mayo Clinic College of Medicine and Science (MCCMS) [Military Leave Policy](#) for consideration of course and/or program withdrawal, impact to financial aid, etc.

Jury Duty/Court Appearances Leave of Absence

- Student stipend and benefit eligibility continues throughout the absence.
- If jury duty will seriously disrupt training, a student can ask the court to reschedule or to be excused from serving.

International Students

- If in F or J status, contact visahelp@mayo.edu prior to the start of a leave.
- Students in F-1 status must follow requirements as defined by Student and Exchange Visitor Program (SEVP), which include but are not limited to:
 - Definition of maximum aggregate period of leave.

- Specific requirements for the licensed provider documentation to substantiate a medical leave, e.g. must be from licensed medical doctor, clinical psychologist or doctor of osteopathy and cannot be a nurse practitioner).
- Submission of required documentation to substantiate medical leave to the Designated School Official (DSO) prior to start of leave.

External Requirement

- When student stipends are supported by NIH federal grant funding, e.g. Kirschstein-NRSA, any relevant paid leave requirements of the grant must supersede school policy.
- MCGSBS Education Committee must approve these exceptions.

Grievance

Any student who believes that he or she has not been treated equitably under the provisions of this policy can file a grievance per the [Grievance Procedure](#) or directly with Mayo Clinic's Title IX Coordinator.

Academic Progress and Graduation Requirements Policy

Scope

Applies to all Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) students in the pre-doctoral and M.D. - Ph.D. programs in pursuit of a pre-doctoral (Ph.D.) degree.

Purpose

To provide students in the pre-doctoral and M.D. - Ph.D. programs criteria for satisfactory academic progress and to define graduation requirements for the Ph.D. degree.

To define criteria to obtain a master's degree for students unable to complete all requirements for the Ph.D. degree.

Policy

Satisfactory Academic Progress

- Students are expected to make continuous and successful academic and professional progress toward graduation requirements for the Ph.D. degree. The concept of satisfactory progress mandates monitoring of a students' academic and professional performance through items including, but not limited to:
 - Register for at least one course all terms throughout training
 - Written Qualifying Exam
 - Oral Qualifying Exam Committee Selection
 - Oral Qualifying Exam
 - Submit Thesis Proposal (Data to be included in the Ph.D. thesis must be generated after admission to the Ph.D. program)
 - Mentor Selection
 - Thesis Advisory Committee (TAC) Selection
 - Submit application for extramural fellowship award or equivalent.
 - All Ph.D. students must submit a fellowship application, preferably during their 2nd year of study (Applies to students who matriculated in 2020 or after.) See Policy Notes below for exceptions for international students.

- All M.D.-Ph.D. students must submit an NIH F30 fellowship application (or equivalent) by the end of their 2nd PhD year.
- Routine TAC meetings and Progress Reports, minimum every six months.
 - Completed final Progress Report reflecting TAC approval for defense must be received by the graduate school to be eligible for graduation.
- Individualized Development Plan completed and maintained throughout training
- Minimum of one peer-reviewed first-authored original paper accepted for publication (unless exception approved- see Publication Exception Request Procedure)
- Submit thesis per MCGSBS Thesis Guidelines for Ph.D.
- Final Oral Exam/Thesis Defense
- Meet any [program specific competencies](#) as defined by track
- The goal of MCGSBS is for students to successfully complete training leading to the Ph.D. degree within 4-6 traditional academic years (M.D.-Ph.D. 4 years, Ph.D. 5-6 years).
- Consequences for unsatisfactory performance and/or behavior are defined in the [Deficiencies and Unsatisfactory Progress Policy](#).

Residence Requirement

- Regardless of how many transfer credits are awarded, candidates for graduate degrees from MCGSBS must complete a minimum period in residence after admission to their degree program. For Ph.D. degree candidates, the minimum period of residence will be two years (start date to end date), and for Master's degree candidates the period is one year.

Graduation Requirements

- In order to graduate, students must meet the following requirements:
 - Pass all required courses and complete required credits as defined by the specific program
 - Successfully pass Written Qualifying Exam
 - Successfully pass Oral Qualifying Exam
 - Successful pass Final Oral Exam- defense and final thesis corrections
 - Complete all graduation clearance and check-out requirements
 - Final GPA of 3.0 or greater

Graduation deadlines

- Students must complete all requirements with these defined timelines:
 - Ph.D. students: within 8 years of matriculation.
 - M.D. - Ph.D. students: within 10 years of matriculation.
- Students are granted degrees four times a year: February, May, August, and November and must meet the deadlines for requirements listed in the table below.
 - The May date involves a formal ceremony as part of the Mayo Clinic commencement in conjunction with the Mayo Clinic School of Medicine. No ceremony is held in February, August, and November, but students who graduate at one of these times are eligible to participate in the May ceremony.
- Ph.D. appointments must end a maximum 30 days after the thesis defense date.
 - Students are allowed the 30 days to complete any outstanding Ph.D. degree requirements and make final thesis corrections.

- If a student does not meet the final thesis correction deadline, he/she will be required to re-defend their thesis within six months.
 - Following the re-defense, a student will have four weeks to submit the final copy of their thesis. If this thesis submission deadline is not met, the degree will not be awarded and there will be no further opportunities to receive the degree from MCGSBS.
- If a student does not defend by defined training end date, and the Thesis Advisory Committee is not supportive of an extension, the student will be dismissed from the program effective on their training end date.

For degree conferral in:	Defend by:	All Post-Defense Requirements completed by:
February	January 1	February 1
May	April 1	May 1
August	July 1	August 1
November	October 1	November 1

Optional Master's Degree

- When a student is unable to complete Ph.D. requirements, eligibility for an optional master's degree in biomedical sciences will be considered.
- To be eligible for an optional master's degree, the student must meet the following minimum MCGSBS requirements:
 - Completed all the core and track courses required by the graduate program in which the student is enrolled
 - Final GPA of 3.0 or greater
 - Passed the written qualifying examination of their graduate program within allowed maximum of two attempts
 - Has not previously received an MCGSBS Master in Science degree withing the same track
 - Any exceptions to the above require both program and school approval
- The optional master's request is initiated by submission of the Program Withdrawal Request Form.
- Students receiving optional Master's degree must complete MCGSBS checkout requirements, including return of Mayo laptop if applicable. Diploma will be withheld until completed.

Policy Notes

International students are not eligible to apply for federal funding, but are eligible to apply to some select extramural fellowships. They must either submit an application for an eligible extramural fellowship or submit a F31 templated grant application to the graduate school for continued intramural support. See [Fellowship Application and Award Policy](#) for more information.

Appointment Eligibility Policy

Scope

Applies to Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) leaders and faculty at all sites involved in the student admissions and recruitment process.

Applies to students when accepted to, appointed to, or enrolled in an MCGSBS program.

Purpose

To establish eligibility requirements for appointment to an MCGSBS degree or certificate program, define requirements to maintain eligibility, and define funding eligibility when applicable.

Policy

- MCGSBS offers training programs with various appointment and eligibility criteria. The programs awarding a formal degree or certificate must comply with the following:
 - **Masters and Certificate**
 - The Masters and Certificate programs are eligible only to active Mayo Clinic employees. Prospective applicants who do not plan to remain employed for the required duration of the training program should not apply. If Mayo Clinic employment terminates prior to completion of these programs, the MCGSBS appointment must also end. If program completion requirements are not satisfied before the Mayo Clinic employment ends, the student will be withdrawn from the program effective on last date of employment.
 - Medical students enrolled within the Mayo Clinic Alix School of Medicine (MCASOM) are eligible only if approved by MCASOM for an academic leave of absence. If program completion requirements are not satisfied before the MCASOM appointment ends, the student will be withdrawn from the program effective on the MCASOM program end date.
 - **Ph.D. and M.D.- Ph.D.**
 - Candidates must meet eligibility requirements, technical standards and selection criteria as described on the [PhD Admissions](#) and [MD-PhD Admissions](#) websites.
 - International students must also comply with respective immigration requirements.
 - Once an appointment is accepted, continuation of the appointment is based on the student's ability to continuously meet the qualifications, standards and requirements of the respective program/track.
 - MCGSBS programs do not accept transfer students; however transfer credits for graduate courses taken at another institution can be considered after matriculation.
 - Training in the PhD and MD-PhD training programs is a full-time commitment; part-time training is not allowed.

- Any plagiarism discovered as part of a prospective student's application will result in disqualification from consideration.
- Letters of recommendation must be submitted to MCGSBS by the letter writer, not by the prospective student.
- **Ph.D.**
 - Ph.D. candidates are selected for appointment by the respective track/program's admissions committees, then endorsed by the MCGSBS Education Committee (MGSEC).
 - The application, interview, and selection of PhD candidates are managed within each respective program/track.
 - Selected candidates will receive an offer for admission from the track and a formal letter of appointment from MCGSBS.
- **M.D.-Ph.D.**
 - M.D.-Ph.D. candidates are selected for appointment by the M.D.-Ph.D. Admissions Committee, then endorsed by MGSEC and the Mayo Clinic Alix School of Medicine (MCASOM) Admissions Executive Committee.
 - The application, interview and selection of MD-PhD candidates are managed by the MD-PhD Admissions Committee in coordination with MCGSBS and MCASOM).
 - Selected candidates will receive an offer for admission and formal letter of appointment from the M.D.-Ph.D Program.

Stipend Funding

- Every MCGSBS student must have approved funding before formal MCGSBS appointment.
 - MCGSBS offers a unique, centralized funding model which provides financial support for the entire 5-year PhD appointment (4 years for MD- PhD). The funding model is subject to review and amendment.
 - MCGSBS provides funding for a defined number of student slots per track, assessed and determined annually. Requests to appoint beyond the pre-determined funded slots must be approved and must be requested and approved per the Appointment Funding Exceptions Procedure.
 - Students who enter MCGSBS with pre-awarded Mayo department/division funding will continue under the terms of any such arrangements throughout the duration of their PhD training.
 - If a Ph.D. appointment is made contingent on financial support from a concurrent Mayo Clinic employment role and that employment role terminated prior to completion of the program, the MCGSBS appointment must also end.
 - To eliminate the risk of a student losing financial support before training is completed, no individual mentor, principal investigator, etc. may directly fund a student.
- If required training exceeds the appointment length, a request for extension may be made for consideration by MCGSBS Academic Affairs Committee (AAC). If extensions are warranted, it is expected that the cost of the student stipend and benefits are incurred by the respective mentor, unless otherwise determined by AAC. Unique

requests or challenges in funding decisions will be reviewed and determined by the MCGSBS Executive Committee.

Previous Research Activities

- MCGSBS does not recognize research, publications and abstracts generated during employment prior to MCGSBS admission as part of the PhD thesis work, though it may constitute preliminary data for a thesis research project. Data to be included in the PhD thesis must be generated after admission to the PhD program. Therefore; a Ph.D. degree candidate must complete a minimum residence of at least two years within the program (start date to end date).
- Regardless of past research experience, students must complete all required coursework and accomplish all other MCGSBS and track required milestones, including laboratory rotations, written and oral qualifying exams, regular thesis advisory committee meetings, etc.

Deferral of Start Date

- Requests for deferral of admissions start date into a degree program are considered by program and MCGSBS leadership on a case-by-case basis.
 - If deferral is approved:
 - Program start date may be deferred for maximum of one year.
 - Exception: MD-PhD program does not allow a one year deferral.
 - If PhD, track must appoint one less slot the following academic year.
 - If deferral is denied:
 - Candidate has option to either accept offer with original program start date or decline offer.

Rescinding an Offer

- MCGSBS expects all students accepted to, appointed to, or enrolled in a graduate school program to uphold professional conduct expectations as outlined in the [Learner Professional Conduct Policy](#).
- MCGSBS may rescind an offer of admission or appointment when a student is not in compliance with the [Learner Professional Conduct Policy](#). This includes any behaviors or actions prior to program start date. Examples include, but are not limited to:
 - Student is found to have presented misleading or fraudulent information during the application process.
 - Student fails to complete all admissions and onboarding requirements by confirmed start date of program. This includes the original start date or approved deferred start date.

Attendance, Absences, and Tardiness Policy

Scope

Applies to all students when enrolled in Mayo Clinic College of Medicine and Science (MCCMS) programs.

Purpose

To set expectations for student attendance.

To establish criteria for monitoring and addressing student attendance.

Policy

- Students are expected to attend and be on time for all required learning activities.
- MCCMS programs will inform students of specific rules regarding attendance, absence, and tardiness during program orientation and will apply consistent, fair, and equitable enforcement of those rules.
- MCCMS programs will provide students with clear instructions for requesting an excused absence.
 - This may include completing a request form or other notification procedure specific to the program and area.
- Unexcused absences and tardiness will be addressed through the Mayo Clinic College of Medicine and Science Warning, Probation, Dismissal and Appeal [Policy](#) and [Procedure](#).

Course Management Policy

Scope

Applies to Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) faculty involved in course development and/or course delivery.

Purpose

To provide expectations and requirements for MCGSBS courses

Policy

Course Design

- Courses must have clear, measurable learning objectives.
- At a minimum, learning objectives must be included in the course syllabus. Ideally, learning objectives are associated with units or modules in the course.
- The current version of the syllabus must be available through the Learning Management System (LMS) by the first day of class. See the [Syllabus Policy](#) for further details.
- Faculty must utilize available, relevant educational technologies.
- All courses must have a presence in the LMS.
- To prevent student access issues, all files must be posted in the learning management system.
 - All course files must be posted to the LMS. Materials must not be posted to internal departmental servers or alternative platforms. Faculty may not rely on email or chat rooms to distribute course files.

- Courses in the LMS should be released at least 24 hours in advance of the official start of the quarter.
- A virtual attendance option must be provided to accommodate remote learners. Strategies may include, but are not limited to Zoom connection, Kaltura Classroom, and/or access to lecture recordings.
- Content must be appropriately organized in distinct units or modules.
- Content must flow in a logical progression.
- Supplemental resources are provided, such as journal articles, e-textbooks, etc.
- When applicable, sources are appropriately cited.

Interaction and Collaboration

- Confidentiality must be respected when faculty return a student's work or discuss a student's performance.
- Course activities and assignments must promote learner engagement.
- Course activities must achieve a balance of group and individual activities. Group activities should foster a sense of community and collaboration.
- There must be a blend of synchronous and asynchronous interactions.
- Course content must be presented in an engaging way, such as enhancing visual and auditory elements. A wide variety of mediums are used to deliver content.
- Activities must connect course concepts with application in authentic environments ("real-world").
- Required technologies are clearly stated and made available to students, when applicable.
- Guidelines are provided regarding levels of participation, such as the quality of communication. Ideally, this is presented in the form of a rubric.
- Feedback is provided to students in a timely manner.
- Course Director(s) must be internal to Mayo Clinic. Faculty and teaching assistants who have access to student grades must complete FERPA training.
- Faculty uses reliable and consistent communications tools, such as course announcements in the LMS.
- For in-class discussions, alternative options must be available for learners connecting remotely. Strategies include, but are not limited to the Zoom chat feature, Slido, and/or Mural.

Assessment

- The purpose of assessments are clearly communicated to students.
- Grading policies and rubrics are available to students. When appropriate, example submissions are provided to students.
- Assessments are appropriately aligned to the learning objectives.
- Assessments are offered throughout the course. For example, weekly quizzes, unit exams, etc.
- Course assessments, such as assignments, quizzes, exams, and asynchronous discussions, are submitted to the LMS.
- Faculty and/or teaching assistants will provide timely and valuable feedback to learners.
- Opportunities for self-assessment are provided.
- Take home exams are not allowed.

- Exam and homework questions must not be reused from prior years. Questions and prompts must be updated each year.
- Final grade entry into Banner must be completed by the primary course director(s).

Learner Support

- Orientation to the course is provided.
- Required technologies are stated. Students are directed to links for installation, when applicable.
- Questions directed to instructors are addressed in a timely manner.
- Links to applicable IT support are provided within the course.
- Links to institutional services, policies, procedures, materials, and forms are provided.
- Course materials adhere to applicable accessibility standards.
- Closed captions and transcripts are provided in required course videos.
- Consideration is given to time zones and geographic location when setting course deadlines.
- Students are given the opportunity to provide feedback to instructors and should be encouraged to complete the standard course evaluation. See the [Course Evaluation Procedure](#) for details.

Credit Transfer Policy

Scope

Applies to students within Mayo Clinic College of Medicine and Science (MCCMS) when they wish to transfer credits.

Purpose

To define if and how credits obtained at other accredited institutions of higher education are evaluated for fulfillment of degree or certificate requirements in MCCMS educational programs.

Policy

Mayo Clinic Alix School of Medicine

- Mayo Clinic Alix School of Medicine does not accept transfer students.

Mayo Clinic School of Health Sciences

- Mayo Clinic School of Health Sciences (MCSHS) does not accept transfer of credits, except on a limited basis for the following programs:
 - Nurse Anesthesia
 - Respiratory Care
- MCSHS program directors evaluate course work and make the final determination regarding credit transfer.

Mayo Clinic School of Graduate Medical Education

- Transfer of credits is not applicable to the Mayo Clinic School of Graduate Medical Education.

Mayo Clinic Graduate School of Biomedical Sciences

- Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) students who wish to transfer graduate credits to substitute for a Mayo elective, core, or track-required

- course must obtain approval from both the Mayo course director and their Graduate Program Director.
- To substitute or to waive core or track-required course credits, the student may be required to prove competence by taking an exam as dictated by the course director on the subject.
 - If the course director and the Graduate Program Director determine that a student has the knowledge equivalent to satisfactory performance in the Mayo course, written approval from the course director and the Graduate Program Director must be sent to MCGSBS to document the student's academic record accordingly.
 - If a student wishes to count credits earned in a Mayo graduate course towards the program's required elective credits, but the Mayo course is not listed as an option for elective credit, the Graduate Program Director may approve at their discretion based on the student's career objectives. If approved, the Graduate Program Director must provide written approval to MCGSBS to document the student's academic record accordingly.

External Courses

- MCGSBS programs do not accept transfer students; however, transfer credits for graduate courses taken at another institution can be considered per the [Transfer Credit Request Form](#).
- Students who wish to transfer credits for graduate courses taken at another institution must have earned a grade of A or B to request credit and provide a transcript. The student must also provide a course description or syllabus and grading scale from the institution to the Graduate Program Director for approval.
- The time interval since the credits were earned must be within five years unless exception approved by the Graduate Program Director.

Total Credits Allowed

- A total of 21 credits may be transferred into the Ph.D. Program.
- A total of 9 didactic credits may be transferred into the Employee Master's Program.
- A total of 6 didactic credits may be transferred into the Clinical Master's Program.
- A total of 6 didactic credits may be transferred into the Postdoctoral Master's Program.

Definitions

Student: Non-resident/non-fellow individual enrolled in the Mayo Clinic College of Medicine and Science.

Policy Notes:

Veterans: MCCMS will request and evaluate all prior transcripts for those receiving veteran's educational benefits, including military training, and credit will be granted as appropriate.

Deficiencies and Unsatisfactory Progress Policy

Scope

Applies to Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) students, leadership, and faculty when students enrolled in an MCGSBS degree program are not meeting academic performance expectations.

Purpose

To define the criteria for student disciplinary action and requirements in addressing MCGSBS student unsatisfactory academic performance.

Policy

- Disciplinary action for student deficiencies of an academic or non-academic are described in the Mayo Clinic College of Medicine and Science (MCCMS) [Learner Professional Conduct Policy](#). These disciplinary actions may include formal written warning of deficiency, probation or dismissal, and are further defined and explained in the MCCMS [Warning, Probation, Dismissal and Appeal Policy](#) and [Procedure](#).
- This policy defines academic deficiencies specific to MCGSBS students in the PhD and master's programs and how each align with levels of disciplinary action.
- Escalation between disciplinary actions below may occur at any given time during the disciplinary period if warranted by student's lack of progress or if additional deficiencies are identified.

Formal Warning Criteria

- Criteria for issuing a formal written warning of deficiency may include, but are not limited to the following:
 - Failure to maintain a minimum grade point average (GPA) of 3.0 in didactic course work (if 2.50 - 2.99 GPA).
 - A student's academic standing is evaluated at the end of each term.
 - New matriculants are assessed after first two terms.
 - Pattern of failure to register for a course within the defined open registration period.
 - Pattern of failure to follow-through on required administrative tasks related to student milestones.

Probation Criteria

- Criteria for issuing probation specific to MCGSBS students may include, but are not limited to the following:
 - Failure to maintain a minimum grade point average (GPA) of 3.0 in didactic course work (if GPA less than 2.50).
 - New matriculants are assessed after first two terms.
 - Accumulation of two or more "C," "F," or "N" grades.
 - Failure of qualifying written or oral exam on first attempt.
 - Exam must be retaken by the end of the term following the term in which the exam was first taken.
 - Unsatisfactory performance in research; such a recommendation is largely the responsibility of the adviser.

Dismissal Criteria

- Criteria for dismissal may include, but are not limited to the following:
 - Failure to identify a thesis research laboratory after five rotations.
 - A maximum of five rotations (minimum of three required) will be allowed to find a thesis research laboratory.
 - Failure to have feasible course remediation plan to obtain 3.0 GPA by expected completion date.
 - Three research grades of "N" (no credit).
 - Based on student performance in rotations, courses and on the examination(s), the program will decide if an optional master's degree is appropriate.
 - Failure of qualifying written or oral examination in second attempt.
 - Students will be given five business days to resign before the dismissal is implemented.
 - Based on student performance in rotations, courses and on the examinations(s), the program will decide if an optional master's degree is appropriate.
 - Failure of Final Oral Examination (Final Defense).
 - Failure to meet degree completion timeline standards.
 - PhD students are required to complete all requirements within 8 years of matriculation.
 - MD-PhD students are required to complete all total requirements within 10 years of matriculation.

A student who has been dismissed will not be readmitted to MCGSBS, unless the dismissal was overturned through the appeal process.

Grievance Procedure

Scope

Applies to Learners in the in the Mayo Clinic College of Medicine and Science (MCCMS) when raising a grievance within a school or program.

Purpose

To provide a mechanism to facilitate resolution of conflicts, problems, or disagreements raised by individuals enrolled in Mayo Clinic education programs, with the exception of disciplinary actions.

Procedure Statements

Every effort will be made to resolve complaints in the most expedient and confidential manner possible. Retaliation against individuals who bring forward complaints or assist in investigating complaints is prohibited.

- For issues relating to Sexual Misconduct, follow [Title IX Sexual Misconduct Policy](#) and [Title IX Sexual Misconduct Procedure](#).
- For issues relating to Faculty Misconduct, follow [Faculty Misconduct Policy](#) and [Faculty Misconduct Investigation and Appeal Procedure](#).

Procedure

Learner	<ol style="list-style-type: none"> 1. Address conflicts or problems in direct communication with the individual with whom they have a problem or complaint, if possible. 2. Discuss any conflicts or problems with the program director/course leader. <ol style="list-style-type: none"> a. In instances where an individual is uncomfortable taking a complaint to the program director/course leader, they should contact one of the individuals in Table A below, who will consider the situation and act to address the concern. <p>If the conflict is not resolved</p> <ol style="list-style-type: none"> 3. Contact the next appropriate person in Table A to discuss problem or complaint. 4. May file a grievance in writing within 30 calendar days of the event in question.
Program Director/Course Leader	<ol style="list-style-type: none"> 5. If student provides written grievance, inform appropriate school operations manager of the grievance and discuss planned response. 6. Respond in writing within 30 calendar days to answer questions or resolve complaints. <ol style="list-style-type: none"> a. If appropriate, form panel to resolve complaint.
Learner	<p>If satisfactory resolution is not reached</p> <ol style="list-style-type: none"> 7. Appeal in writing within 14 calendar days to the Dean of the School. <ol style="list-style-type: none"> b. The written request must be limited to three pages and address why the learner feels the action taken was unsatisfactory.
Dean/Designee	<ol style="list-style-type: none"> 8. Judge the merits of this appeal within 30 calendar days. <ol style="list-style-type: none"> c. In certain situations and at the Dean's discretion, form a panel to consider the submitted information.
Panel	<p>If panel is convened</p> <ol style="list-style-type: none"> 9. Request additional information or appearance before the panel of the individuals involved, if necessary. 10. Judge the merits of the appeal within 15 days. 11. Report recommendations to the Dean.
Dean/Designee	<ol style="list-style-type: none"> 12. Respond to the learner in writing. <ol style="list-style-type: none"> d. The decision of the Dean is final, without further appeal.

<p>Learner (excluding MCSGME)</p>	<p>For Arizona Only</p> <p>13. If complaint cannot be resolved after exhausting the institution's grievance procedure the student may file a complaint with the Arizona State Board for Private Post-Secondary Education. Contact the State Board for further details at:</p> <p style="padding-left: 40px;">Arizona State Board for Private Post-Secondary Education 1740 W. Adams, Ste 3008 Phoenix, AZ 85007 Phone: (602) 542-5709 Website: https://ppse.az.gov</p> <p>For Florida Only</p> <p>14. Students enrolled in programs licensed by the Commission for Independent Education in the state of Florida may contact them for assistance with grievances. The State Commission address is:</p> <p style="padding-left: 40px;">Florida Commission for Independent Education 325 W Gaines St Tallahassee, FL 32399 Phone: (850) 245-3200 Website: http://www.fldoe.org/policy/cie</p> <p>For Minnesota Complaints</p> <p>15. If complaint cannot be resolved after exhausting internal grievance procedures the student may file a complaint with:</p> <p style="padding-left: 40px;">Registration & Licensing Office of Higher Education 1450 Energy Park Drive, Suite 350 St. Paul, MN 55108 Phone: (651) 259-3975 or (800) 657-3866 Email: info.ohe@state.mn.us Website: http://www.ohe.state.mn.us/mPg.cfm?pageID=1078</p> <p>For Wisconsin Only</p> <p>16. If complaint cannot be resolved after exhausting internal grievance procedures, the student may file a complaint with:</p> <p style="padding-left: 40px;">Wisconsin Department of Safety and Professional Services Division of Legal Services and Compliance P.O. Box 7190 Madison, WI 53707-7190 Fax: (608) 266-2264 Email: dsps@wisconsin.gov Website: https://dsps.wi.gov/Pages/SelfService/FileAComplaint.aspx</p>
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If a Learner is uncomfortable taking a complaint to their program director/course leader, they should contact one of the individuals below, in the recommended but not required order.

Mayo Clinic School of Graduate Medical Education (MCSGME)	Mayo Clinic School of Health Sciences (MCSHS)
Division/Department: <ul style="list-style-type: none"> • Education Chair • Administrator • Chair 	<ul style="list-style-type: none"> • Operations Manager • Administrator • Associate Dean
MCSGME	Mayo Clinic Alix School of Medicine (MCASOM)
<ul style="list-style-type: none"> • Ombudsperson • Operations Manager • Administrator • Associate Dean • Minority Affairs Director 	<ul style="list-style-type: none"> • Operations Manager • Administrator • Associate Dean
Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS)	Mayo Clinic School of Continuing Professional Development (MCSCPD)
<ul style="list-style-type: none"> • Operations Manager • Administrator • Assistant Dean • Associate Dean 	<ul style="list-style-type: none"> • Operations Manager • Administrator • Associate Dean

Definitions

Grievance: A conflict, problem, or disagreement that does not involve sexual misconduct (covered by Title IX Sexual Misconduct Policy and Procedure) or faculty misconduct (covered by Faculty Misconduct Policy and Faculty Misconduct Investigation and Appeal Procedure).

Learner: Individual enrolled in the Mayo Clinic College of Medicine and Science (collectively includes residents, fellows and students)

Title IX: Federal Act that protects people from discrimination based on sex in education programs or activities that receive Federal financial assistance. Title IX states that: No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance.

Satisfactory Academic Progress (SAP) for Financial Aid Recipients Policy

Scope

Applies to all Mayo Clinic College of Medicine and Science (MCCMS) students who receive Federal or Institutional financial assistance and used when determining satisfactory academic progress (SAP).

Purpose

To comply with federal regulations requiring the Office of Student Financial Aid to monitor the academic progress of students.

To establish the financial aid (FA) SAP standards that apply to undergraduate certificate students, graduate students, and professional students (medical students) who wish to maintain financial aid eligibility.

Policy

- The standards in this Policy apply to a student's entire academic record at MCCMS (including all credits transferred to MCCMS from another school), whether or not financial aid was received for prior terms of enrollment.
- The FA SAP standards may differ from the academic standards administered by MCCMS schools and/or programs.
- FA SAP standards are cumulative and include all periods of enrollment, whether or not the students received financial aid.

Graduate Students

The below standards apply to all students enrolled in the following graduate degree programs at MCCMS: Doctor of Physical Therapy (D.P.T.), Doctor of Nurse Anesthesia Practice (D.N.A.P.), Doctor of Philosophy (Ph.D.), and the joint Doctor of Medicine and Doctor of Philosophy (M.D./Ph.D.).

- Minimum GPA
 - Students must maintain a minimum cumulative GPA of 3.0 to remain eligible for financial aid.
 - Academic records are reviewed at the completion of every term of enrollment (fall, spring, summer) to determine FA SAP.
 - Students who earn a GPA of less than 3.0 for any given term will be automatically placed on financial aid warning for one term.
 - If the cumulative GPA is less than 3.0 following the warning term, the student will be placed in financial aid suspension.

Grading System:

A = 4.0	C = 2.0	P = Pass	X = Multi-term course (placeholder)
A- = 3.7	C- = 1.7	S = Satisfactory	W = Withdrawal (student withdraws or resigns)
B+ = 3.3	D+ = 1.3	F = Fail	
B- = 2.7	D = 1.0	I = Incomplete	
C+ = 2.3	F = 0.0	NP = Non-passing	

- Maximum Time Frame
 - Graduate students are eligible to receive financial aid for 150% of the

published degree credits required to complete the program.

- For example, if a degree program requires 30 credits, the student is eligible to receive financial aid for up to 45 attempted credits.
- Financial Aid Suspension
 - Students can be put on FA SAP suspension for the reasons listed below and are not eligible for financial aid while on FA SAP suspension. Students on FA SAP suspension may appeal for reinstatement of their financial aid. Approval of the appeal is not guaranteed.
 - Reasons for FA SAP suspension:
 - Does not meet the FA SAP requirements as outlined above.
 - Does not meet the academic expectations while on Financial Aid Warning (see Appeals).
 - Meets or exceeds the Maximum Time Frame requirement to complete program.
 - Withdrawal from ALL semester credit hours.
 - Receives a non-passing grade or incomplete in ALL semester credit hours.
- Appeals
 - If a student does not successfully obtain a minimum 3.0 GPA, the student will be placed on financial aid suspension. The student may appeal this determination if there are extenuating circumstances such as a death in the family, student injury, illness, or other special circumstances. Student must submit the appeal, including explanation as to why MCCMS standards were not met, in writing to MCCMS Director of Financial Aid. After the appeal is vetted by the FA Appeals Committee, the student will be notified of decision by email. The email will be sent to the Mayo Clinic and personal email address on record in Banner student record system.
 - If an appeal is approved, the student will be placed in a financial aid warning status and must complete all coursework (100%) with a GPA of at least 3.0 by the end of the next subsequent semester. Academic advisor support is continuously available to assist student in academic success.

Policy Notes

Mayo Clinic College of Medicine and Science does not offer remedial coursework.

Student Records and the Family Education Rights and Privacy Act (FERPA)

Scope

Applies to students within the Mayo Clinic College of Medicine and Science (MCCMS) when their educational records are accessed, released, or used.

Purpose

To protect the privacy of educational records in compliance with the [Family Educational Rights and Privacy Act of 1974 \(20 U.S.C., Section 1232-g\) \(FERPA\)](#).

Policy

Use of Records

- MCCMS faculty, administration, and staff are responsible for the careful protection of student records.
- Student educational records will only be used for appropriate MCCMS educational, administrative, and internal research functions.

Release of Records

- MCCMS reserves the right to deny the release of any information unless required by law.
- MCCMS has designated the following data as directory/public information which may be released at the discretion of the School administrator without student permission unless mandated by Federal law (Solomon Amendment requests):
 - Academic degree, certificates, and/or awards/honors
 - Date and Place of birth
 - Dates of attendance
 - Degree/Certificates awarded
 - Name
 - Enrollment status (full-time/part-time)
 - E-mail address
 - General Mayo mailing address (site specific)
 - Grade level
 - Major field of study
 - NRMP residency match results
 - Participation in officially recognized activities
 - Photograph
 - Telephone listing
- Directory/public information will not be released to organizations or institutions making large scale requests unless specifically directed by law.
- Unless MCCMS has been notified by the student that directory information is not to be released, MCCMS may release such information at its discretion and without further permission.
- Students may request to prohibit the release of directory (public) information by submitting a completed and signed Request to Prevent Disclosure of Directory Information form.
- Students have the right to provide written consent before MCCMS discloses personally identifiable information from the student's education record, except to the extent that FERPA authorizes disclosure without consent.
- FERPA allows disclosure of education records, other than directory information, including , but not limited to: transcripts, test scores, college advising records, disciplinary files, financial aid information, housing records and records of educational

services that are provided to the following parties without prior written consent of the student:

- Persons within the College who have a legitimate interest in the information for educational, administrative or research purposes;
 - Other educational institutions in which the student seeks to enroll or Mayo affiliated educational institutions, provided the disclosure is limited to official copies of student transcripts or test scores for the appropriate College office;
 - Other organizations conducting educational research studies, provided the studies are conducted in a manner which will not permit identification of students, and the information will be destroyed when no longer needed for the purpose for which the study was conducted;
 - Persons in compliance with a court order or lawfully issued subpoena; provided that a reasonable attempt is made to notify the student in advance of compliance thereof, except when required by law;
 - Appropriate persons in connection with an emergency if the information is necessary to protect the health or safety of the student or other individuals;
 - Accrediting organizations and state or federal education authorities when the information is needed for auditing, evaluating or enforcing legal requirements of educational programs; provided the accrediting organizations and authorities protect the data in a manner which will not permit the personal identification of students, and personally identifiable information is destroyed when no longer needed;
 - Appropriate persons or agencies in connection with a student's application or receipt of financial aid to determine eligibility, amount or conditions of financial aid; or
 - Parents of a dependent student as defined under the Internal Revenue Code.
- MCCMS will maintain a record of external requests for information from student education records other than directory information and the disposition of the requests.

Access to Records

- Students have the right to access and inspect all information in the student educational record except:
 - Financial information submitted by parents; and
 - Confidential letters and recommendations collected under established policies of confidentiality or to which the student has waived in writing the right of inspection.
- Access must be granted no later than forty-five days after the request is made.

Amendments to Records

- Students have the right to:
 - request amendment of the contents of their education records,
 - have a hearing if the result of the request for amendment is unsatisfactory,
 - provide a statement for inclusion in the record if the decision resulting from the hearing is unacceptable to the student.

Student Complaints

- Students have the right to file a complaint with the U.S. Department of Education concerning alleged failure by the college to comply with the requirements of FERPA. The name and address of the office that administers FERPA is:
 - Family Policy Compliance Office
U.S. Department of Education
400 Maryland Avenue Southwest
Washington, DC 20202-4605

Privacy Rights Notification

- MCCMS will notify students annually of their privacy rights and their right to file complaints concerning the failure of MCCMS to comply with the requirements of FERPA.
- This notice is sent to all students no later than October 1st of each year per Federal regulations.

Definitions

Directory Information: Information contained in the education records of a student that would not generally be considered harmful or an invasion of privacy if disclosed. Directory information could include information such as the student's name, address, e-mail address, telephone listing, date and place of birth, major field of study, participation in officially recognized activities and sports, weight and height of members of athletic teams, dates of attendance, degrees and awards received, the most recent previous educational agency or institution attended, photograph, grade level and enrollment status (full-time or part-time).

Education Records: Records that contain information directly related to a student and which are maintained by an educational agency or institution or by a party acting for the agency or institution.

Family Educational Rights and Privacy Act of 1974 (FERPA): A federal privacy law designed to protect the privacy of education records and afford students certain rights related to the review, release of and accessibility to their education records. The law also provides guidelines for the correction of inaccurate and misleading data through informal and formal hearings.

Legitimate Educational Interest: In accordance with FERPA, Persons within the College have a legitimate educational interest if the Persons need to review an educational record to fulfill their professional responsibility. Persons within the College is defined as MCCMS faculty, administration, and staff. Further, these Persons within the College act in the student's educational interest on a legitimate "need-to-know" basis.

If Persons within the College require information located in a student's educational record to fulfill MCCMS related responsibilities, those Persons within the College have legitimate educational interest. This includes such purposes as:

- performing appropriate tasks that are specified in their position description or by a contract agreement;
- performing a task related to a student's education;
- performing a task related to the discipline of a student;
- providing services for the student or the student's family, such as health care, counseling, job placement, or financial aid.

Solomon Amendment: Solomon Amendment is a federal law that allows military recruiters to access some address, biographical and academic program information on students age 17 and

older who have not filed any FERPA restrictions. The Department of Education has determined the Solomon Amendment supersedes most elements of FERPA.

Timely Complaint: A timely complaint is defined as one that is submitted to the Family Policy Compliance Office within 180 days of the date that the complainant knew or reasonably should have known of the alleged violation. Complaints that do not meet FERPA's threshold requirement for timeliness are not investigated. The Family Policy Compliance Office may investigate those timely complaints that contain specific allegations of fact giving reasonable cause to believe that a school has violated FERPA.

Warning, Probation, Dismissal and Appeal Policy

Scope

Applies to Mayo Clinic College of Medicine and Science (MCCMS) administration and faculty when a [learner](#)'s performance or behavior is unsatisfactory.

Applies to [learners](#) when experiencing disciplinary action at MCCMS.

Purpose

To provide MCCMS with a framework for working with learners whose performance does not meet [academic](#) and [non-academic](#) standards.

Policy

- When a learner's performance or behavior does not meet minimum academic and non-academic standards, MCCMS faculty and administration will take one or more of the following actions:
 - issue the learner a formal warning of academic or non-academic deficiency,
 - place the learner on probation, or
 - dismiss the learner.
- MCCMS will follow the [Warning, Probation, Dismissal and Appeal Procedure](#) in investigating failures to meet academic and/or non-academic standards.
- In the case of severe non-academic deficiencies, MCCMS reserves the right to dismiss the learner without formal warning or probation.
- MCCMS will provide an [ombudsperson](#) upon the learner's request.
- A learner has the right to appeal either probation or dismissal.
- A learner who appeals a dismissal forfeits the option to resign.
- A learner who appeals a dismissal must meet with the Appeal Committee in person.
- Attorneys, representing either learners or Mayo Clinic, will not attend appeal committee meetings.
- A learner may request to have an Ombudsperson, or one non-attorney support person attend the appeal meeting.
 - Any support person will observe but not directly participate in the meeting.

Warning, Probation, Dismissal & Appeal Procedure

Scope

Applies to Mayo Clinic College of Medicine and Science (MCCMS) [education leaders](#) and [administrators](#) when a [learner](#) warrants disciplinary action. Applies to [learners](#) when experiencing disciplinary action at MCCMS or for those learners who are seeking to appeal a determination under the Title IX Sexual Misconduct Policy.

Purpose

To provide MCCMS staff with instructions for working with learners whose performance or behavior does not meet [academic](#) and/or [non-academic](#) standards or who are seeking to appeal a determination under the Title IX Sexual Misconduct Policy.

Procedure

Education Leader	17. Contact the administrator when a learner exhibits academic or non-academic deficiencies, to determine and initiate the proper response and/or action.
Administrator	18. Determine the appropriate action, with input from the Education Leader, based on the severity of academic or non-academic deficiency: warning, probation, or dismissal. <ul style="list-style-type: none"> e. For academic and non-academic deficiencies for which probation or dismissal are being considered, consult with site HR liaison and/or, the legal department (as needed), and the executive dean of MCCMS or site Medical Director of Education, in accordance with the Notification of Leadership Regarding Extraordinary Events.

Formal Written Warning

Education Leader	19. Determine remediation plan to address deficiencies with the learner; include metrics to measure success when applicable. <ul style="list-style-type: none"> a. MCCMS reserves the right to dismiss the learner without formal warning or probation in certain non-academic deficiency cases. <ul style="list-style-type: none"> i. Consult with Human Resources and Legal in cases of dismissal without formal warning or probation.
Administrator / Education Leader	20. Approve remediation plan. 21. Generate and sign a formal written warning . 22. Issue the formal written warning to the learner.
Learner	23. Follow the remediation plan included in the written warning.
Administrator / Education Leader	24. Determine, in collaboration and at the end of the written warning period, and take action on one of the following: <ul style="list-style-type: none"> a. Remove the learner from formal warning status and return to good standing b. Extend the formal warning period, if applicable c. Place in probationary status

	<p>25. Meet with learner at the end of the timeframe established in the formal written warning to communicate and document if remediation is sufficient or if additional disciplinary action is required.</p> <p>26. Determine, with input from Education Leader and appropriate dean, whether the formal written warning should be removed immediately after remediation or if it should remain in the school record until the learner completes the Mayo Clinic educational program.</p>
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Probation

Education Leader	<p>27. Determine remediation plan to address deficiencies with the learner; include metrics to measure success when applicable.</p> <p>a. MCCMS reserves the right to dismiss the learner without formal warning or probation in certain non-academic deficiency cases.</p> <p>i. Consult with Human Resources and Legal in cases of dismissal without formal warning or probation.</p>
Administrator and/or Program Director	<p>28. Approve the remediation plan.</p> <p>29. Generate and sign the probation document.</p> <p>30. Issue the probation document to the learner.</p>
Learner	<p>31. Choose, within five business days, one of the following actions:</p> <p>a. Accept the probation.</p> <p>b. Appeal the probation.</p> <p>c. Resign from the program if option is offered.</p> <p>32. Follow the remediation plan included in the probation document.</p>
Administrator	<p>33. Determine, with input from the Education Leader and appropriate dean, at any time during and at the end of the probationary period, one of the following actions:</p> <p>a. Remove the learner from probationary status.</p> <p>b. Extend the probationary period, if applicable.</p> <p>c. Dismiss the learner.</p> <p>d. Accept learner's resignation.</p>

Dismissal

Administrator / Program Director	<p>34. Notify the learner of the decision of dismissal, and whether or not resignation is an option.</p> <p>35. Provide both a dismissal document and any relevant policies to the learner.</p>
Learner	<p>36. Choose, within five business days, one of the following actions:</p> <p>e. Accept the dismissal.</p> <p>f. Submit a resignation, if permitted, effective at a mutually acceptable date (resignation forfeits option to appeal).</p> <p>g. Appeal the dismissal (forfeits option to resign).</p>
Administrator or Designee	<p>37. Initiate school's check out process, if dismissed.</p> <p>a. Notify appropriate departments, e.g. Human Resources, Payroll, etc.</p>

	b. Notify the Director of Financial Aid, Payroll or Student Services, as applicable, of the dismissal.
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Appeal

Learner	38. Submit a letter of appeal to the School Dean within five business days of notification of probation, dismissal, or determination. a. In the case of Mayo Clinic Alix School of Medicine (MCASOM), this letter is submitted to the vice dean.
Administrator	39. Provide acknowledgement in writing of receipt of appeal to learner within 48 hours. 40. Verify Dean received receipt of appeal.
Dean of School	41. Notify the Executive Dean of MCCMS that a learner has submitted an appeal. 42. Determine if the site Chief Executive Officer needs to be notified, in accordance with the Notification of Leadership Regarding Extraordinary Events .
Administrator	43. Identify Appeal Committee members and set date for meeting within 14 business days of receiving appeal. a. Appeal Committee meeting date to occur within 30 business days of receiving an appeal. Exceptions to this timeframe must be explained to the learner. 44. Provide details of Appeal Committee in writing to learner, e.g. date, time, location, etc., when meeting date is confirmed. 45. Advise learner to provide an appropriate written reason for appeal with any supporting documentation.
Learner	46. Submit written reason for appeal with any supporting documentation to the Administrator at least ten business days before the Appeals Committee meets.
Appeal Committee	47. Review relevant information. 48. For appeals against probation, determine if the appeal can be resolved based on the submitted written record or if the learner must appear before the Appeal Committee. 49. For appeal against Title IX determination, determine if the appeal can be resolved on the submitted written record or if the learner must appear before the Appeal Committee. 50. Meet with learner on scheduled Appeal Committee date to hear their summary of basis for appeal. 51. Hear any needed stakeholder and/or witness accounts at the Appeal Committee meeting. 52. Choose one of the following options: a. Probation: i. Uphold the probation. ii. Remove probation from the learner's record; reduce to Formal Written Warning with remediation plan. b. Dismissal:

	<ul style="list-style-type: none"> i. Uphold the dismissal. ii. Overturn dismissal, place in probationary status with remediation plan. <p>c. Appeal against negative Title IX determination:</p> <ul style="list-style-type: none"> i. Reject the findings of the investigatory report and request further investigation. ii. Reject the sanctions issued by the sanctioning official(s) based on evidence of the investigatory report and other relevant evidence; or iii. Deny the appeal in whole or in part. <p>53. Provide learner with written documentation of decision within 5 business days after the Appeal Committee meeting date.</p> <p>54. Provide a written determination of any Title IX appeal, summarizing the reasoning behind the determination, to the Title IX Coordinator.</p>
Administrator	55. Initiate school's check out process if dismissal is upheld.

Procedural Notes

N/A

Definitions

Academic Deficiency: failure to maintain a satisfactory academic record. Examples of academic deficiencies include, but are not limited to the following:

- Inability to master the technical skills required to competently practice in the specialty.
- Inability to apply knowledge appropriately to the situation.
- Unsatisfactory interpersonal and/or communication skills with patients, colleagues, and other personnel.
- Unacceptable academic commitment, such as, not fulfilling all responsibilities, not participating in all required educational activities, and not completing all required documentation and assignments.
- Unsatisfactory recognition of own limits, such as failing to seek appropriate help when indicated.
- Failure to meet program or school specific academic requirements.
- Disregard for patient safety.

Administrator: Refers to the administrator, associate dean, or operations manager of the appropriate school. With respect to dismissals, includes the dean of the appropriate school.

Appeal Committee: must have at least three members, including a committee chairperson. The executive dean may serve on and lead the committee except in the case of the MCASOM, for which the vice dean may serve on and lead the committee.

Dismissal Document:

- A clear description of the reason(s) for dismissal, citing examples of academic or non-academic deficiencies.
- References to previous discussions and documentation of the problems, if any.
- Effective date of dismissal.

Education Leader: Includes, but is not limited to, the physician, scientist, or allied health leader, program director, block leader, faculty, or clerkship director of the educational program to which the learner is appointed.

Formal Written Warning:

- A clear description of the deficiencies, citing examples of academic or non-academic deficiencies.
- References to previous discussions and documentation of the problems, if any.
- A remedial plan with suggestions to improve performance and/or behavior.
- Expectations (metrics) and timeframes for the learner, which can be monitored for compliance.

Learner: an individual enrolled in the Mayo Clinic School of Health Sciences (MCSHS), Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS), Mayo Clinic School of Graduate Medical Education (MCSGME), or Mayo Clinic Alix School of Medicine (MCASOM).

Non-Academic Deficiency: behavior judged to be illegal, unethical, or objectionable and violation of school or institutional policies or rules, civil or criminal law. Examples of non-academic deficiencies include, but are not limited to, the following:

- Violations of mutual respect.
- Threatening, intimidating, harassing, or coercing patients, learners, employees, volunteers, or visitors on Mayo Clinic's premises at any time for any reason.
- Lying or cheating, misrepresentation, plagiarism.
- Distribution, possession or use of alcoholic beverages, non-prescribed drugs, or illegal/controlled substances on Mayo Clinic property.
- Reporting with the odor of alcohol on one's breath or appearing to be under the influence of alcoholic beverages or any drug that impairs judgment or work performance.
- Theft, misuse, misallocation or inappropriate removal or disposal of property belonging to Mayo Clinic, patients, learners, employees, or visitors.
- Breach of ethics concerning confidentiality of employee, patient, or institutional information.
- Engaging in criminal behavior.
- Engaging in sexual misconduct (see [Title IX Sexual Misconduct Policy](#)).
- Any deliberate or negligent act which jeopardizes the health or safety of a patient, employee, learner, volunteer, or visitor.
- Fighting, agitating a fight, or attempting bodily harm or injury to anyone on Mayo Clinic property.
- Bringing a firearm or weapon onto Mayo Clinic property without authorization.
- Failure to report for expected assignments without notification.
- Disruptive behaviors which compromise the learning environment of colleagues.
- Conscious and reckless disregard for safety rules or Mayo Clinic's safety practices.

Probation Document:

- A clear description of the deficiencies, citing examples of academic or non-academic deficiencies,
- References to previous discussions and documentation of the problems, if any (modeled after the elements in the formal written warning, if the warning preceded probation).
- A remedial plan with suggestions to improve performance and/or behavior.
- Probation length, which begins with the date of the learner's notification.
 - The recommended minimum probationary period is three months for programs of more than twelve months' duration,

- Exceptions for less than three months can be determined by the program and school.

Stakeholder: an individual with an invested interest in the success of the learner.

Witness: an individual who was present at the time of the occurrence warranting discipline or can provide information related to the occurrence that is of value in considering the appeal.

Withdrawal and Tuition Refund Policy

Scope

Applies to employees of the Mayo Clinic College of Medicine and Science (MCCMS) Financial Aid Department and MCCMS students when a student withdraws from a course or program.

Purpose

To define the circumstances under which students may discontinue their enrollment in a MCCMS educational course or program.

To comply with state and federal laws that regulate financial aid and tuition funds.

Policy

- Students who choose to terminate their enrollment before the completion of their course, term or payment period must officially withdraw from their classes and notify appropriate MCCMS staff/departments.
 - Students must withdraw prior to the 80th percentile of the term, course, or payment period to receive a grade of W (withdraw).
- Failure to properly withdraw may impact readmission and may result in financial liabilities for the student and/or MCCMS.

Withdrawal

- Students who withdraw from MCCMS must initiate the process with their respective school or program director.
- A formal withdrawal from MCCMS requires that:
 - The student discusses the matter with the appropriate operations manager, administrator, program director and/or associate dean.
 - The student provides written notice of withdrawal to the program director and/or other appropriate school official. Email is an acceptable form of written communication.
 - An appropriate school official notifies the Student Financial Aid/Registrar's Office that the student has withdrawn from the program.
 - The Student Financial Aid/Registrar's Office and the Bursar's Office determine the appropriate refund of tuition (if applicable) and whether or not the learner has any financial liability from the calculation of the Return of Title IV policy.
 - The student will be notified if additional financial obligations are incurred.

Tuition/Fee Refund

- MCCMS adheres to the following regarding tuition/fee refunds:

- Withdrawals made within 7 calendar days following the start of the course, term or payment period will receive a 100% refund.
 - A prorated refund is available for students who withdraw from all courses after the 7th calendar day but before the 60th percentile of the course term or payment period. There is no refund for students who withdraw after the 60th percentile of the term or payment period.
 - Students who receive a full MCCMS school or Mayo departmental tuition scholarship or waiver are not eligible for a refund.
 - Students who have signed an employment contract with a specific department and have their tuition paid for should review their contract for implications of withdrawal.
 - Federal Financial Aid recipients who withdraw from all classes/courses prior to the 60th percentile of the term may be required to return a portion of the Federal Title IV aid they received. Please see the [Return of Title IV \(R2T4\) Funds Policy](#).
 - MCCMS reserves the right to cancel or postpone any course or program due to unforeseen circumstances. In the unlikely event a course or program is canceled or postponed, the registration fee is refunded in full.
-

Veteran Benefits Educational Assistance Policy

Scope

Applies to learners when enrolled in Mayo Clinic College of Medicine and Science (MCCMS) and identified as Covered Individuals as defined by the U.S. Department of Veterans Affairs (VA).

Purpose

To ensure compliance with the Veterans Benefits and Transition Act of 2018, which requires the protection of Covered Individual's enrollment and attendance while waiting for the disbursement of educational assistance under U.S. Department of Veterans Affairs, Chapter 31, Vocational Rehabilitation and Employment, or Chapter 33, Post-9/11 GI Bill® benefits.

Policy

- A Covered Individual, as identified by the U.S. Department of Veterans Affairs (VA), shall be permitted to participate in appointed Mayo Clinic College of Medicine and Science (MCCMS) program upon submission of a certificate of eligibility for entitlement to Veterans Administration educational assistance to MCCMS Financial Aid Office.
 - The certificate of eligibility may include a Statement of Benefits obtained from the VA website (eBenefits) or a VAF 28-1905 form for authorization purposes.
- Covered Individual shall be permitted to participate in MCCMS program from date of submission of certificate of eligibility and end on the earlier of the following dates:
 - The date on which payment from VA is made to MCCMS, or
 - Ninety (90) days after the date MCCMS certified tuition and fees following receipt of the certificate of eligibility.

- MCCMS shall not impose assessment of late fees, denial of access to MCCMS facilities, or require Covered Individual to borrow additional funds to meet MCCMS financial obligations due to delayed disbursement funding from the VA.
- A Covered Individual must submit a certificate of eligibility for entitlement to educational assistance no later than first day of MCCMS program.
- The difference between MCCMS program tuition and expected amount of VA education benefit shall be the responsibility of Covered Individual and paid in accordance with MCCMS Tuition Payment Policy.

Definitions

Covered Individual is any individual who is entitled to educational assistance under U.S. Department of Veterans Affairs Chapter 31, Vocational Rehabilitation and Employment, or Chapter 33, Post-9/11 GI Bill® benefits.

Acknowledgements

Within 10-days from the date Mayo Clinic College of Medicine and Science, a licensed institution, revises this catalog or publishes a new catalog, the institution shall submit a written or electronic copy of the catalog to the Arizona State Board for Private Postsecondary Education.

This catalog shall be available to students and prospective students in written or electronic format

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