Mayo Clinic Graduate School of Biomedical Sciences

Ph.D., Master's and Certificate Programs

2024-2025

Course and Program Catalog

https://college.mayo.edu

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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.

Mayo Clinic College of Medicine and Science and MCGSBS Leadership

Mayo Clinic College of Medicine and Science

Fredric B. Meyer, M.D.
Juanita Kious Waugh Executive Dean for Education

John D. Poe
Chair, Department of Education Administration

Shannon K. Laughlin-Tommaso, M.D.
Associate Dean for Education Diversity, Equity and Inclusion

Mayo Clinic Graduate School of Biomedical Sciences

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Dean

Bruce F. Horazdovsky, Ph.D.
Associate Dean, Academic Affairs

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Christopher K. Pierret, Ph.D.
Assistant Dean, Academic Affairs

Karen S. Nation, MBA/HCM
Administrator

Rachel L. Halsrud, M.B.A.
Operations Manager

Kristen J. Krueger, M.A.
Operations Manager, Mayo Clinic in Arizona

Caitlyn J. Gillen
Operations Manager, Mayo Clinic in Florida

Introduction

Mayo Clinic Graduate School of Biomedical Sciences

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 330 Ph.D. and M.D.-Ph.D. candidates, and 110 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 Brightspace, a learning management system designed for use in online teaching, in addition to Microsoft Teams, 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 students enrolled in the MCGSBS Ph.D. and MD-PhD programs. Its purpose is to facilitate interaction between graduate students and gradute school administration. It provides a means for students to share input or bring forward any concerns on behalf of the student body.

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

2025-2026 Academic Calendar

Summer Quarter (Term 202610)

Registration for summer quarter courses opens – June 2, 2025
Registration for summer quarter courses due – June 20, 2025
Summer quarter begins – July 7, 2025
Independence Day Holiday (observed) – July 4, 2025
Last date to register or withdraw – Before one-half of the course is completed
Labor Day Holiday – September 1, 2025
Last day of quarter – September 26, 2025

Fall Quarter (Term 202620)

Registration for fall quarter courses opens – September 1, 2025
Registration for fall quarter courses due – September 19, 2025
Fall quarter begins – September 29, 2025
Last date to register or withdraw – Before one-half of the course is completed
Thanksgiving Holiday – Thursday, November 27, 2025
Last day of quarter – December 19, 2025

Winter Quarter (Term 202630)

Registration for winter quarter courses opens – December 1, 2025
Registration for winter quarter courses due – December 19, 2025
Winter quarter begins – January 5, 2026
Last date to register or withdraw – Before one-half of the course is completed
Last day of quarter – March 27, 2026

Spring Quarter (Term 202640)

Registration for spring quarter courses opens – March 2, 2026
Registration for spring quarter courses due – March 20, 2026
Spring quarter begins – April 6, 2026
Last date to register or withdraw – Before one-half of the course is completed
Memorial Day Holiday – May 25, 2026
Last day of quarter – June 26, 2026

Curriculum

MCGSBS curriculum consists of a combination of instructional practices, learning experiences, and educational technologies, in addition to the content itself. MCGSBS curriculum is designed to provide everyone in the learning environment (faculty, students, leaders, staff, other stakeholders) with structure and expected outcomes.

At Mayo Clinic, there are institutional domains that help to guide educational programs and inform the curriculum. These domains are Knowledge, Research, Professionalism, Patient Care, Systems Based Practice Approach, Interpersonal & Communication Skills, Practice Based Learning & Improvement, Interprofessional Collaboration, Personal & Professional Development, Leadership, IDARE.

The Graduate School further interprets these domains into school-level competencies. The components are further distilled down to be more specific and detailed. The school-level competencies include:

- Core Science Knowledge
- Specialty Science Knowledge
- Critical Thinking
- Scientific Method
- Experimental Design
- Data Interpretation and Analytics
- Ethical Conduct of Research
- Diversity, Equity, and Inclusion
- Implementation of Your Research
- Discovery to Health (Translational Spectrum)
- Written Communication Skills
- Oral Communication Skills
- Proficiency in Research
- Team Science
- Mentorship
- Lifelong Learning
- Professional Development
- Leadership and Management

Registration

Mayo courses are 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 may be very limited and degree candidates are given preference for these courses. 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.*

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.

Minimum Grade Requirements

Students in degree programs 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.

Definition of Credit Hour

Credit hours are determined by the number of contact hours in a course. A contact hour is instructional time with the subject matter expert (instructor). For example, a one credit, didactic course will have 12 contact hours in a given quarter.

Per the U.S. Department of Education, an amount of work represented in intended learning outcomes and verified by evidence of student achievement that is an institutionally established equivalency that reasonably approximates not less than:

- One hour of classroom or direct faculty instruction and a minimum of two hours of out of class student work each week for approximately fifteen weeks for one semester or trimester hour of credit, or ten to twelve weeks for one quarter hour of credit, or the equivalent amount of work over a different amount of time; or
- At least an equivalent amount of work as required in paragraph (1) of this definition for other academic activities as established by the institution including laboratory work, internships, practica, studio work, and other academic work leading to the award of credit hours.

MCGSBS 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.

Graduation

Students are granted degrees four times a year: 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. MD-PhD students are awarded their Ph.D. diploma concurrently with the M.D. diploma. The student is invited to participate in a commencement ceremony in May of their last year of medical school training, held jointly between MCGSBS and MCASOM.

Students are allowed no more than 30 days to complete all requirements after a successful thesis defense/final project presentation. Students should consider this 30 days within their program end date when scheduling the thesis defense.

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

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)

Overview

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.

Transfer Credits

A total of 21 credits may be transferred into the Ph.D. Program.
For more details, see the Credit Transfer and Waiver Policy on the MCGSBS Policies and Procedures intranet site.

Admissions

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

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Admissions/Financial Support

- PhD students are fully supported through a guaranteed internal fellowship for five years, eliminating the need to identify a faculty member to provide financial support. The annual base stipend for PhD students funded by Mayo Clinic for the 2024-2025 academic year is $38,434, deposited electronically bi-monthly in the student's bank of choice. The annual tuition fee is waived in full ($27,000).
- Appointment and funding are conditional on remaining actively enrolled in the program, continuously meeting the qualifications, standards and requirements of the program and track.
- Funding may consist of graduate school, external fellowships and/or internal scholarships.
- Students are appointed for five years with designated program start and end dates.
- If required training exceeds the appointment length, a request for extension may be made for consideration. All extension requests require graduate school approval and funding to cover all student costs during the extension period are typically paid by the student's mentor.
- Training must be completed within a maximum of seven years, regardless of funding availability.
- 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.

MGS Curriculum

The MGS curriculum has been designed to provide a common fundamental knowledge base and technical language supporting multiple discipline-specific, advanced fields.

Summer – 1st Year

*MGS 6000	Responsible Conduct of Research	1 cr.
MGS 5010	Rigor, Reproducibility, and Experimental Design	1 cr.
MGS 5020	Statistics for Biomedical Research	1 cr.
MGS 5030	Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology	3 cr.
MGS 5000	Fundamental Skills	1 cr.

Summer – 2nd Year

MGS 5050	Critical Thinking and Scientific Writing	2 cr.
MGS 5051	Scientific Writing II	1 cr.

*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. Students who are enrolling in the refresher course will register for MGS 6001.

MGS Laboratory Rotations

PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, one-month full time rotations.

MGS 5102	PhD Laboratory Rotation	2 cr.
MGS 5107	PhD Laboratory Rotation	2 cr.
MGS 5108	PhD Laboratory Rotation	2 cr.

Career Development Internships

Career Development Internships (CDIs) are MCGSBS opportunities for upper-level PhD students to spend 80 or more hours as interns in the areas described in our professional development Brightspace resource. CDIs 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 learners with hands-on experiences in diverse career environments both internally and externally to assist with making informed career path decisions.

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. The DPT must 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 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.

Milestones

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
- Complete Degree Planning Tool (DPT)
- Pass Written Qualifying Exam
- Submit Oral Qualifying Exam Committee Selection
- Pass 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 o Submit application for a fellowship award (or equivalent) as defined in the Fellowship Application and Award Policy.
- 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

Full details are included in the Academic Progress and Graduation Requirements for PhD Policy on the MCGSBS Policies and Procedures intranet site.

Mentor Selection: Completion of lab rotations is required in order to allow students a variety of experiences to help decide on selecting an mentor and home laboratory for completion of their thesis research work during the remainder of their training. A Ph.D. student's mentor must have full graduate faculty privileges and must be selected timely after all required laboratory rotations have been completed. For more details see the Mentor Selection, Withdrawal and Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Once a mentor is selected, the student must register for MGS 6890 Predoctoral Research every term for which they will be given a grade of Satisfactory or Not Satisfactory by the mentor.

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.
>
> 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. All members must have graduate faculty privileges. For more details, see the Oral Qualifying Exam Committee Selection and Procedure on the MCGSBS Policies and Procedures intranet site.

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 via the Thesis Advisory Committee Section eForm. The TAC composition is determined collaboratively between student and student's mentor and requires approval of the program director and the school. For more details, see the TAC Member Selection and Documentation for PhD/MD-PhD Programs Procedure on the MCGSBS Policies and Procedures intranet site.

Progress Meetings: The 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 submitted to MCGSBS administration. The report form template can be found on the PhD Program Forms web page.

Thesis Proposal

A written thesis proposal, including presentation and thesis committee discussion of the proposal, is a requirement that 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. 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.

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.
- 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, 2) MCGSBS has completed a graduation clearance audit confirming that all course and non-course requirements have been met, and 3) a a TAC Progress Report is submitted to MCGSBS reflecting TAC approval that student is ready to defend. 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 from the defense date to complete all post-defense requirements, including final thesis corrections. The chair of the Thesis Advisory Committee must sign a form verifying the final corrections to the thesis have been made. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted. If a student does not meet the thesis corrections deadline, they will be required to re-defend their thesis.

The final thesis is uploaded 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.

M.D. – Ph.D. Program

Overview

The M.D.-Ph.D. program is a highly competitive dual degree 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.

Admissions/Financial Support

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.

- Appointment and funding are conditional on remaining actively enrolled in the program, continuously meeting the qualifications, standards and requirements of the program and track.
- Funding may consist of graduate school, medical school, external fellowships and/or internal scholarships.
- If required training exceeds the appointment length, a request for extension may be made for consideration. All extension requests require graduate school approval and funding to cover all student costs during the extension period are typically paid by the student's mentor.
- The PhD and MD training must be completed within a maximum of ten years, regardless of funding availability.

Requirements

Students follow the Mayo Clinic Alix School of Medicine (MCASOM) curriculum for 18 months. The United States Medical Licensing Examination (USMLE) Step 1 exam must be taken by the end of 24 months (within 6 months of the end of M1/M2) and a passing score documented before entry into the Ph.D. phase of the program, unless granted an exception. Students then begin Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) training. The advanced course work in the track and thesis research are undertaken and usually completed in 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 and track electives. M.D.-Ph.D. students are required to take the following courses:

MGS Courses

MGS	6000	Responsible Conduct of Research
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
MPET	6450	Molecular Pharmacology and Receptor Signaling
CTSC	5400	Introduction to Bioinformatics Concepts and Core Technologies for Individualized

Medicine Approaches
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
CTSC 5650 Advanced Statistics in Clinical and Translational Research: Survival Analysis with Statistical Software
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

Clinical Experience Elective Course. For MD-PhD students in the research years to maintain focused clinical training.
MDPH 6100 MD-PhD Clinical Experience

Post Graduate MD-PhD Research Experience. For MD-PhD students who have completed all PhD coursework and thesis research, successfully defended, and completed the post-defense requirements 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. Duration is up to 16 weeks.
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 fewer than the standard 68 credits.

- All track electives are fulfilled by preclerkship medical school coursework.
- Laboratory rotations are satisfied by completing 2 one-month, full-time rotations.
  MDPH 5000 Laboratory Rotation 1 for M.D.-Ph.D. Students (4 weeks)
  MDPH 5001 Laboratory Rotation 2 for M.D.-Ph.D. Students (4 weeks)
  MDPH 5002 Laboratory Rotation 3 for M.D.-Ph.D. Students (4 weeks if needed)

Waived Courses

MGS 5050 Critical Thinking & Scientific Writing – waived for M.D.-Ph.D. whohave taken MDPH 5150 (Grant Writing for M.D.-Ph.D. Students)

IMM 5100 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.

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

NSC 6401 Practical Neuroanatomy – waived for M.D.-Ph.D. students in the NSC Track (and students with existing MD if pass WQE).

Milestones

Students in the MD-PhD program 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
- Pass Written Qualifying Exam
- Submit Oral Qualifying Exam Committee Selection
- Pass 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
- Complete Degree Program Form
- Submit application for a fellowship award (or equivalent) as defined in the Fellowship Application and Award Policy.
- 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 for thesis defense and return to medical school.
- 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 MD-Ph.D.
- Final Oral Exam/Thesis Defense
- Meet any program specific competencies as defined by track

Full details are included in the Academic Progress and Graduation Requirements for PhD Policy on the MCGSBS Policies and Procedures intranet site.

Mentor Selection: Completion of lab rotations is required in order to allow students a variety of experiences to help decide on selecting an advisor/mentor and home laboratory for completion of their thesis research work during the remainder of their training. An MD-PhD student's mentor must have full graduate faculty privileges and must be selected timely after all required laboratory rotations have been completed. For more details see the Mentor Selection, Withdrawal and Transfer Policy on the MCGSBS Policies and Procedures intranet site.

Once a mentor is selected, the student must register for MGS 6890 Predoctoral Research every term for which they will be given a grade of Satisfactory or Not Satisfactory.

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.
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. All members must have graduate faculty privileges. For more details, see the Oral Qualifying Exam Committee Selection and Procedure on the MCGSBS Policies and Procedures intranet site.

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 via the Thesis Advisory Committee Section eForm. The TAC composition is determined collaboratively between student and student's mentor and requires approval of the program director and the school. The TAC must include a member of the M.D.-Ph.D. Executive Committee, either as a voting member or an ex-officio member.
For more details, see the TAC Member Selection and Documentation for PhD/MD-PhD Programs Procedure on the MCGSBS Policies and Procedures intranet site.

Progress Meetings: The 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 submitted to MCGSBS administration. The report form template can be found on the PhD Program Forms web page.

Thesis Proposal: A written thesis proposal, including presentation and thesis committee discussion of the proposal, is a requirement that 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. 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.

Fellowship Award Submission: MD-PhD students must submit an application for extramural fellowship award or equivalent during their training. Students should be aware that F30 grants must be submitted before their 48th month in the program and that F31 grants must be submitted before their 36th month in the PhD phase per NIH rules. Students not eligible for submission through NIH should consider other options (AHA, American Epilepsy Society, MCGSBS Intramural Application, etc.) Submission of a fellowship application is a program 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, 2) MCGSBS has completed a graduation clearance audit confirming that all course and non-course requirements have been met, and 3) a a TAC Progress Report is submitted to MCGSBS reflecting TAC approval that student is ready to defend. 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 from the defense date to complete all post-defense requirements, including final thesis corrections. The chair of the Thesis Advisory Committee must sign a form verifying the final corrections to the thesis have been made. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted. If a student does not meet the thesis corrections deadline, they will be required to re-defend their thesis.
The final thesis is uploaded 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.

CARE PhD Program

Clinician-scientist Academic Research Excellence PhD Degree

Leigh G. Griffiths, M.R.C.V.S., Ph.D., *Program Director*

The Clinical-scientist Academic Research Excellence (CARE) PhD program is an innovative pathway to a PhD degree for students in existing residencies or fellowships. The program is designed to empower motivated individuals to pursue advanced research endeavors while leveraging their existing medical training. Students are able to complete the degree program in an accelerated timeline of approximately three years through the acceptance of credit transfers for previous medical school training and coursework. As a result, advanced coursework and thesis research are undertaken almost immediately.

The elements of the training for students enrolled in the CARE Ph.D. program are generally the same as those for non-CARE Ph.D. candidates, except for laboratory rotations and requirements satisfied by transferred credits.

Lab Rotations

Each CARE PhD student must complete two four-week lab rotations in two different laboratories (one credit each) for a total of two credits. A third rotation may be completed but is considered optional.

MGS 5105	CARE Laboratory Rotation #1
MGS 5106	CARE Laboratory Rotation #2

Transfer Credits

A key benefit of the CARE PhD program is the accelerated timeline. To accomplish this goal, CARE PhD students may transfer up to 21 credits for previous education and training as part of the program nomination and acceptance process. The estimated time to completion is three years.

The use of a track-specific CARE PhD Degree Planning Tool (DPT) is required to list the coursework to fulfill degree requirements, including transfer credits. CARE PhD DPTs outline the specific MCGSBS courses that have been satisfied by transferred credits.

Credit transfer evaluation will be conducted automatically after full nomination to the program. A personalized degree planning tool will be provided.

Track Requirements

CARE Ph.D. students must complete all track-required courses, journal clubs and seminars; however, there are exceptions allowed for CARE laboratory rotations and requirements satisfied by transferred credits. CARE Ph.D. students are still expected to complete the required number of credits for the track-specific degree program.

Mentor Selection

Upon completion of lab rotations, CARE PhD students are expected to select a PhD degree mentor and the laboratory for their thesis studies. Mentor selection should be completed by the end of the first quarter.

Thesis Advisory Committee
CARE Ph.D. candidates are expected to submit to the MCGSBS office the composition of their Thesis Advisory Committee (TAC) by the end of the second quarter of the program. It is recommended that students include at least one clinical member in their Thesis Advisory Committee.

Qualifying Exams and Thesis Research
Upon completion of lab rotations, CARE PhD students are expected to select a PhD degree mentor and the laboratory for their thesis studies. Mentor selection should be completed by the end of the first quarter.
Written Qualifying Exams will be facilitated by the track. See specific track program page for details. To continue on the accelerated timeline, students should complete the WQE by the end of the 4th quarter of their first year.
Oral Qualifying Exams will be facilitated by the track. See specific track program page for details. To continue on the accelerated timeline, students should complete the OQE by the end of the 6th quarter.

Submission of a Fellowship Application
All CARE PhD students will work with their Mentors to prepare and submit an application for an NIH F or equivalent fellowship. Students should be aware that F30 grants must be submitted before their 48th month in the program and that F31 grants must be submitted before their 36th month in the PhD phase per NIH rules. Students not eligible for submission through NIH should consider other options (AHA, American Epilepsy Society, MCGSBS Intramural Application, etc.) Submission of a fellowship application is a program requirement.

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.)

MGS Courses (10 credits required)

MGS 6000	Responsible Conduct of Research	1 cr.
MGS 5010	Rigor, Reproducibility, and Experimental Design	1 cr.
MGS 5020	Statistics for Biomedical Research	1 cr.
MGS 5030	Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology	3 cr.
MGS 5000	Fundamental Skills	1 cr.
MGS 5050	Critical Thinking and Scientific Writing	2 cr.
MGS 5051	Scientific Writing II	1 cr.

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

MGS 5102	PhD Laboratory Rotation	2 cr.
MGS 5107	PhD Laboratory Rotation	2 cr.
MGS 5108	PhD Laboratory Rotation	2 cr.

PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, one-month full time rotations.

Track Requirements (12 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.
BMB 5100	Chemical Principles of Biological Systems	2 cr.
BMB 5250	Molecular Cell Biology	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.

Advanced Elective Courses (16 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 MGS 5030, BMB 5100, and BMB 5150 as well as the elective courses, BMB 5400 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*
Matthew W. Urban, Ph.D., *Associate Program Director*

Course Work

The curriculum for the Predoctoral degree consists of **73 credits**, which can include a maximum of 24 Research credits.

MGS Courses (10 credits required)

MGS 6000 Responsible Conduct of Research ..... 1 cr.
MGS 5010 Rigor, Reproducibility, and Experimental Design ..... 1 cr.
MGS 5020 Statistics for Biomedical Research ..... 1 cr.
MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology .... 3 cr.
MGS 5000 Fundamental Skills *(required for 2021 matriculants and forward)* ..... 1 cr.
MGS 5050* Critical Thinking and Scientific Writing ..... 2 cr.
MGS 5051 Scientific Writing II ..... 1 cr.
*M.D.-Ph.D. students may exclude these in accordance with M.D.-Ph.D. requirements.

Track Requirements (27 credits required)

BMEP 5010 Integrative Physiology of Health and Disease ..... 6 cr.
BMEP 5020 Quantitative Biomedical Imaging and Signal Processing ..... 6 cr.
BMEP 5030 Biomedical Applications of Engineering Principles ..... 6 cr.
BMEP 6600 Biomedical Engineering and Physiology Seminars (1cr./qtr) ..... 3 cr.
BMEP 6650 BMEP Journal Club (1cr./qtr) ..... 3 cr.
CTSC 5600 Introduction to Statistics in Clinical and Translational Research ..... 3 cr.

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

MGS 5102 PhD Laboratory Rotation ..... 2 cr.
MGS 5107 PhD Laboratory Rotation ..... 2 cr.
MGS 5108 PhD Laboratory Rotation ..... 2 cr.
PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, one-month full time rotations.

Research (minimum 24 credits required)

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

Advanced Coursework Requirements (6 credits required)

In addition to the core and track requirements, courses should be selected after consultation between the student, their advisor, and the Program Director/Associate Program Director. Depending on the student's area of study additional courses will be selected from BMEP track advanced courses. Courses from other tracks, schools or institutions may be substituted for BMEP track advanced courses with approval from the track chair, however even if approved a majority of the 6 required advanced course credits must be completed from BMEP advanced course work.

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. All students must take and satisfactorily pass a written comprehensive qualifying exam preparing an NIH style F award. The oral qualifying exam will include a presentation of proposed research and tests the synthesis of course work and research interests.

By January the second year of the program, it is expected that all students will have selected their thesis mentor. A Thesis Advisory Committee proposal must be submitted to the education committee for approval by February of the 2nd year. The Thesis Advisory Committee must be approved by the Biomedical Engineering & Physiology Education Committee. Students must have their first thesis committee meeting by August 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.

Thesis Advisory Committee Guidelines

Thesis Advisory Committee (TAC) – must consist of five members with any additional members serving as ex-officio. Three committee members must have full faculty (FF) privileges in BMEP track and minimum of two members must be Experienced Examiners (EE) in BMEP track. Two committee members must have mentored a student to degree. The committee for MD-PhD students must include a member of MD-PhD Executive Committee either as voting member or ex-officio.

Proposed TAC membership must be approved by the BMEP Education Committee prior to submitting to the graduate school via the Ph.D. Thesis Advisory Committee eForm on the intranet. Please note any external TAC members require temporary MCGSBS faculty privileges: see the Graduate Faculty Privileges Request Procedure on the MCGSBS Policies and Procedures intranet site.

Written Qualifying Exam Guidelines

The purpose of the Written Qualifying Exam (WQE) is to evaluate the student's ability to apply the knowledge of key principles acquired during graduate study (i.e., MCGSBS and BMEP core coursework) toward generation and exploration of new testable hypotheses in an important area of BMEP research. The format of the WQE will be an NIH F31 proposal (i.e., 6 pages, plus 1 Specific Aim page) or similar grant proposal (Contact Education Committee if you intend to write a grant other than an F-award). The grant proposal will be evaluated to determine the student's understanding of and ability to integrate the principles of biomedical engineering and physiology, ability to establish a rigorous research plan to address the proposed question and ability for independent thought.

Expectations of Independent Work:

During the preparation of the proposal, it is expected that students will seek the advice and input of their mentor, members of their thesis advisory committee, laboratory members and others. Those providing input should not be involved in drafting, writing or directly editing the proposal but should provide generalized comments, suggestions and direction. The work product should be completed entirely by the student. It is acceptable for a mentor or other consulting individual to provide broad opinions and direction, review drafts and provide general comments, advise students on structure and content, provide topically unrelated grants as examples and be actively engaged in the conceptualization of the broad direction of the project. It is not acceptable for the mentor or another consulting individual to write portions of the proposal, provide direct edits to the proposal (such as proposing new wording, correcting grammar, or adding new or clarifying sentences), solely conceptualize, formulate or dictate the hypotheses and/or aims of the study, or provide closely related grant applications to the student as a

guide. If students have closely related grant text prior to initiating the exam, they should not use the text in the preparation of their proposals.

Format and Topic:

WQE topics should be directly related to the student's proposed thesis research and must be related to Biomedical Engineering and/or Physiology. Students should discuss their proposed WQE topic with their mentor. After agreeing on the topic of the WQE proposal, the topic should be submitted to the BMEP Education Coordinator for approval (see timeline below). The preferred format of the proposal will be modeled on the NIH pre-doctoral F31 application. However, proposals that reflect a design applicable to other pre-doctoral grant applications (e.g., AHA) may also be acceptable. If a student would like to prepare the proposal in a different grant format with the aim of a future submission to that granting agency, a request must be approved by the BMEP Education Committee for the non-NIH grant format at the time of topic approval.

Oral Qualifying Exams:

This exam is scheduled to take place in September/October, following the successful completion of the written qualifying exam. The Oral Qualifying Committee is comprised of 4 members appointed by the BMEP education committee and the student's advisor. Attempts are made to populate the committee with one faculty member from each of the sub-tracks in BMEP.

Within the second year, all students must take and satisfactorily pass an oral qualifying exam. The oral qualifying exam will include a presentation of a proposed research project and tests the student's synthesis of BMEP course work and their proposed research interests.

Goal of the exam:

Our goal is to evaluate the student's ability to formulate a scientific approach to a complex research problem, present it clearly and succinctly, defend their scientific and subject-matter choices for the study design, and answer questions that challenge the student's ability to answer direct or peripheral questions in a logical, scientific and responsive manner.

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

Felicity T. Enders, Ph.D., *Program Director*
Marina Walther Antonio, 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.)

MGS Courses (10 credits required)

MGS 6000	Responsible Conduct of Research	1 cr.
MGS 5010	Rigor, Reproducibility, and Experimental Design	1 cr.
MGS 5020	Statistics for Biomedical Research	1 cr.
MGS 5030	Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology	3 cr.
MGS 5000	Fundamental Skills *(required for 2021 matriculants and forward)*	1 cr.
MGS 5050	Critical Thinking and Scientific Writing*	2 cr.
MGS 5051	Scientific Writing II	1 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	PhD Laboratory Rotation	2 cr.
MGS 5107	PhD Laboratory Rotation	2 cr.
MGS 5108	PhD Laboratory Rotation	2 cr.

PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, 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 5100	Academic Publishing	1 cr.
CTSC 5300	Fundamentals of Epidemiology**	1 cr.
CTSC 5600	Introduction to Statistics in Clinical and Translational Research	3 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* (max 1 cr)	1 cr.
CTSC 6120	Case Studies in Translation	2 cr.
CTSC 6130	CTS Journal Club* (max 1 cr)	1 cr.

*Students gain credit only for quarters in which they present. Minimum one credit required.
** Students focusing on patient or community-based research will be encouraged to take CTSC 5370 – Introduction to Epidemiology (2 credit) instead of CTSC 5300 – Fundamentals of Epidemiology.

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 (11 credits required)

Sixty-eight 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:

- MGS 6000 Responsible Conduct of Research
- MGS 5050 Critical Thinking and Writing
- MGS 5051 Scientific Writing Part II
- CTSC 5020 Regulatory Issues in Clinical Research
- CTSC 5300 Fundamentals of Clinical Epidemiology (or CTSC 5370)
- CTSC 5600 Introduction to Statistics in Clinical and Translational Research
- 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*
Kathryn Knoop., 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.)

MGS Course (13 credits required)

MGS 6000 Responsible Conduct of Research ..... 1 cr.
MGS 5010 Rigor, Reproducibility, and Experimental Design ..... 1 cr.
MGS 5020 Statistics for Biomedical Research ..... 1 cr.
MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology .... 3 cr.
MGS 5000 Fundamental Skills *(required for 2021 matriculants and forward)* ..... 1 cr.
MGS 5050 Critical Thinking and Scientific Writing ..... 2 cr.
MGS 5051 Scientific Writing II ..... 1 cr.
*IMM 5100 Basic Graduate Immunology ..... 3 cr.
* 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 PhD Laboratory Rotation ..... 2 cr.
MGS 5107 PhD Laboratory Rotation ..... 2 cr.
MGS 5108 PhD Laboratory Rotation ..... 2 cr.
PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, 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 ..... 2 cr.
IMM 6879 Tutorial in Adaptive Immunity Concepts ..... 2 cr.

IMM 6880 Tutorial in Tissue Immunity ..... 2 cr.
IMM 6882 Tutorial in Bridiing Innate and Adaptive Immunity ..... 2 cr.
IMM 6884 Tutorial in Generation and Function of T Cells ..... 2 cr.
IMM 6885 Tutorial in the Generation and Function of B Cells ..... 2 cr.

Electives/ Other Required CORE & Upper-Level Courses (9 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 students 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 MGS 5050 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*
Taro Hitosugi, 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.)

MGS Courses (10 credits required)

MGS 6000	Responsible Conduct of Research	1 cr.
MGS 5010	Rigor, Reproducibility, and Experimental Design	1 cr.
MGS 5020	Statistics for Biomedical Research	1 cr.
MGS 5030	Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology	3 cr.
MGS 5000	Fundamental Skills *(required for 2021 matriculants and forward)*	1 cr.
MGS 5050	Critical Thinking and Scientific Writing	2 cr.
MGS 5051	Scientific Writing II	1 cr.

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

MGS 5102	PhD Laboratory Rotation	2 cr.
MGS 5107	PhD Laboratory Rotation	2 cr.
MGS 5108	PhD Laboratory Rotation	2 cr.

PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, one-month full time rotations.

Track Requirements (16 credits required)

MPET 5808*	Introduction to Molecular Pharmacology	4 cr.
MPET 5900	Molecular Pharmacology and Receptor Signaling	3 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	3 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 6700	Cell Death Journal Club	1 cr.
MPET 6811	Tutorial in Cardiovascular Pharmacology	2 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.

Advanced Elective Coursework (6 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 (WQE):
MPET learners from all degree programs can take WQE in July during their 1st or 2nd year.

At a minimum, the following courses should be completed before attempting the Written Qualifying Exam:

MGS 5010 Rigor, Reproducibility, and Experimental Design 1 cr.
MGS 5020 Statistics for Biomedical Research 1 cr.
MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology 3 cr.
MPET 5900 Molecular Pharmacology and Receptor Signaling 3 cr.
MPET 5808 Introduction to Molecular Pharmacology 4 cr.

In addition, at least one of the following courses is strongly recommended. (These courses are only offered every other year):
MPET 6805 Drug Metabolism and Pharmacogenomics 2 cr.
MPET 6655 Mechanisms of Cell Growth and Death 2 cr.
MPET 6450 Applied Data Science and Artificial Intelligence in Pharmacology
MPET 6814 Cellular Pharmacology of Agents that Target Cancer 2 cr.

WQE format
The Written Qualifying Exam consists of demonstrating critical evaluation and understanding of 1 to 2 published papers. Six to 8 papers reflecting the key areas of emphasis of the track will be available 3 days prior to the exam. On exam day, learners are provided a set of questions for each of the papers, and the learner will select any paper for which to answer the questions on exam day. Concepts stemming from core coursework will also be investigated as relevant to the research articles. The exam is prepared and graded by the faculty and a grade of 70% is required for successful completion of the exam.

Oral Qualifying Exam: Please review the prior oral qualifying exam information noted on PhD Program page.

Thesis proposal: A written thesis proposal in the format of an NIH F31 grant must be presented to your

Thesis Advisory Committee within two months of completing the oral qualifying exam. See also the Fellowship Application and Award Policy on the MCGSBS Policies and Procedures intranet site.

Neuroscience (NSC) – Ph.D. Degree

Owen A. Ross, Ph.D., *Program Director*
Long-Jun Wu, Ph.D., *Associate Program Director, MN*
Wolfdieter Springer, Ph.D., *Associate Program Director, FL*
John D. Fryer, 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.)

MGS Courses (10 credits required)

MGS 6000 Responsible Conduct of Research ..... 1 cr.
MGS 5010 Rigor, Reproducibility, and Experimental Design ..... 1 cr.
MGS 5020 Statistics for Biomedical Research ..... 1 cr.
MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology .... 3 cr.
MGS 5000 Fundamental Skills *(required for 2021 matriculants and forward)* ..... 1 cr.
MGS 5050* Critical Thinking and Scientific Writing ..... 2 cr.
MGS 5051 Scientific Writing II ..... 1 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 PhD Laboratory Rotation ..... 2 cr.
MGS 5107 PhD Laboratory Rotation ..... 2 cr.
MGS 5108 PhD Laboratory Rotation ..... 2 cr.
PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, 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. *NSC 6401 is waived for M.D.-Ph.D. students in the NSC Track (and PhD students with existing MD if pass WQE).*
**Two credits maximum.

Advanced Elective Courses (7 credits required)

NSC 5600 Behavioral Neurology ..... 2 cr.
BMEP 6300 Tutorial in Neurophysiology ..... 3 cr.
MPET 6820 Regenerative Medicine ..... 2 cr.
IMM 5100 Basic Graduate Immunology ..... 3 cr.

BMB 5400 Molecular Genetics..... 3 cr.
MPET 5900 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, MN*
Clifford D. Folmes, Ph.D., *Associate Program Director, AZ*
Tsuneya Ikezu, M.D., Ph.D., *Associate Program Director, FL*

Course Work

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

MGS Courses (10 credits required)

MGS 6000 Responsible Conduct of Research ..... 1 cr.
MGS 5010 Rigor, Reproducibility, and Experimental Design ..... 1 cr.
MGS 5020 Statistics for Biomedical Research ..... 1 cr.
MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology .... 3 cr.
MGS 5000 Fundamental Skills *(required for 2021 matriculants and forward)* ..... 1 cr.
MGS 5050* Critical Thinking and Scientific Writing ..... 2 cr.
MGS 5051 Scientific Writing II ..... 1 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 PhD Laboratory Rotation ..... 2 cr.
MGS 5107 PhD Laboratory Rotation ..... 2 cr.
MGS 5108 PhD Laboratory Rotation ..... 2 cr.
PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, one-month full time rotations.

Track Requirements (15 credits required)

REGS 5300 Stem Cells and Development ..... 3 cr.
REGS 5800 Developmental Biology ..... 2 cr.
REGS 5230 Ethics and Regenerative Medicine ..... 1 cr.
REGS 6300 Experimental Methods in Regenerative Sciences ..... 1 cr.
REGS 6400 Regenerative Tissue Engineering Principals ..... 4 cr.
REGS 6500 Introduction to Translational Bioproduct Development ..... 2 cr.
REGS 6820 Regenerative Medicine Principles to Practice ..... 2 cr.

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.

Advanced Elective Courses (13 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

REGS 5200	Fundamentals of Regenerative Sciences	2 cr.
REGS 5210	Advanced Regenerative Medicine and Surgery	2 cr.
REGS 5500	Topics in Regenerative Sciences and Medicine	1 cr.
REGS 6700	Genomic and Epigenomic Data Integration	1 cr.
IMM 6865	Regenerative T Cell Immunotherapy and Cellular Engineering	3 cr.
IMM 5100	Basic Graduate Immunology	2 cr.
BMB 5100	Advanced Chemical Principles	2 cr.
BMB 5150	Advanced Molecular Cellular Biology	2 cr.
BMB 5400	Molecular Genetics	3 cr.
BMB 6150	Epigenomics Journal Club	1 cr.
CTSC 5020	Regulatory Issues in Clinical Research	1 cr.
CTSC 5025	Introduction to Regulatory Science	1 cr.
CTSC 6100	Molecular Mechanisms of Human Disease	3 cr.
CTSC 6120	Case Studies in Translation	3 cr.
VGT 5700	Virology and Gene Therapy	3 cr.
MPET 5900	Molecular Pharmacology and Receptor Signaling	3 cr.
MPET 6813	Tutorial in Systems Pharmacology	2 cr.
NSC 6210	Neurobiology of Disease	3 cr.
NSC 6857	Systems Neuroscience and Behavior	3 cr.
NSC 6862	Molecular and Cellular Neuroscience	3 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.

Regulatory Science in Regenerative Medicine Emphasis

CTSC 5020 Regulatory Issues in Clinical Research
CSTC 5025 Introcution to Regulatory Science
CTSC 6120 Case Studies in Translation

Data Science in Regeneration Emphasis

MPET 6813 Tutorial in Systems Pharmacology
REGS 6700 Genomic and Epigenomic Data Integration
BMB 6150 Epigenomics Journal Club

Regenerative Genetic Engineering and Immunology Emphasis

IMM 5100 Basic Graduate Immunology
VGT 5700 Virology and Gene Therapy
IMM 6865 Regenerative T Cell Immunotherapy

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:

- MGS 5010 Rigor, Reproducibility, and Experimental Design
- MGS 5020 Statistics for Biomedical Research
- MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology
- REGS 5300 Stem Cells and Development
- REGS 5800 Developmental Biology
- REGS 6100 Ethics and Regenerative Medicine
- REGS 6400 Regenerative Tissue Engineering Principles
- REGS 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

Autumn J. Schulze, Ph.D., *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.)

MGS Courses (10 credits required)

MGS 6000 Responsible Conduct of Research ..... 1 cr.
MGS 5010 Rigor, Reproducibility, and Experimental Design ..... 1 cr.
MGS 5020 Statistics for Biomedical Research ..... 1 cr.
MGS 5030 Core Concepts in Genome Dynamics, Biochemistry, and Cellular Biology .... 3 cr.
MGS 5000 Fundamental Skills *(required for 2021 matriculants and forward)* ..... 1 cr.
MGS 5050 Critical Thinking and Scientific Writing ..... 2 cr.
MGS 5051 Scientific Writing II ..... 1 cr.

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

MGS 5102 PhD Laboratory Rotation ..... 2 cr.
MGS 5107 PhD Laboratory Rotation ..... 2 cr.
MGS 5108 PhD Laboratory Rotation ..... 2 cr.

PhD student should have complete 6 credits of lab rotations. Students should enroll and successfully complete MGS 5102, MGS 5107, MGS 5108. MGS 5101 and MGS 5104 may also be used to satisfy the rotation requirement. M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations. CARE Ph.D. students satisfy this requirement with two, one-month full time rotations.

Track Requirements (12 credits required)

IMM 5100* Basic Graduate Immunology ..... 3 cr.
VGT 5700 Intro to Virology and Gene Therapy ..... 3 cr.
VGT 6740 Viruses and Vectors Journal Club (1 cr. /yr.) ..... 3 cr.
VGT 6745 Current Topics in VGT (1 cr. /yr.) ..... 3 cr.

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

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 Molecular Therapy Tutorial (even years) ..... 2 cr.

Advanced Elective Courses (8 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.

Master of Science (M.S.) Degree Programs

Overview

The Mayo Clinic Graduate School of Biomedical Sciences provides an important mechanism by which current Mayo Clinic residents, fellows and employees can advance their training by obtaining a Master of Science Degree (MS) in Biomedical Sciences.

The opportunity to take graduate school courses and pursue a MS degree is a benefit and privilege for qualified employees, but not a guarantee. Permission to take courses may be restricted and/or forfeited at a program director or supervisor's discretion if expectations of the learner's employment role are not being met.

Scholars must have a Mayo Clinic appointment of sufficient length to allow for completion of all requirements of the program. If an enrolled master's student ends their employment with Mayo Clinic before graduation requirements are satisfied, the student will be withdrawn from the program effective on last date of employment.

There are three types of MS programs as follows:

- Postdoctoral Basic Science Master's Degree Program (thesis based)
- Employee-Professional Master's Degree Program (non-thesis/final project-capstone)
- Clinical Master's Degree Program (for select Mayo Clinic clinical residency programs)

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)

Overview

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.

Admissions

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. Tracks may have more defined eligibility criteria. More details on eligibility for the CTS track can be found here.

Time to completion can vary by program specialty 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.

Admissions/Financial Support

Mayo Clinic employees accepted into the Master's program continue to receive the salary from their primary appointment and do not receive a stipend from MCGSBS.

Program Fees are charged for many Master's programs to cover administrative costs, due upon admission. The cost is covered by Mayo Clinic funds, either by the candidate's home department, lab, or Mayo Clinic's Career Investment Program (CIP) if eligible and selected by CIP.

Candidates must complete a formal application. 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.

More details are available on the MCGSBS Master's Programs intranet site.

Milestones

Students are expected to make continuous and successful academic and professional progress toward graduation requirements for the M.S. 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
- Complete Degree Planning Tool (DPT)
- Mentor Selection (required within 6 months of program start)
- Pass Written Qualifying Exam
- Submit Research Proposal (Data to be included in the M.S. thesis must be generated after admission to the M.S. program)
- Thesis Advisory Committee (TAC) Selection
- Routine TAC meetings and Progress Reports, minimum every six months
- Final Oral Exam/Thesis Defense
- Meet any program specific competencies as defined by track

Full details are included in the Academic Progress and Graduation Requirements for Masters Programs Policy on the MCGSBS Policies and Procedures intranet site.

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.

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. The DPT must 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 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/Masters Forms.

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 Selection: A Master's degree mentor must be chosen from within Mayo Clinic and must have MCGSBS Full or Master's graduate faculty privileges. (Identifying a mentor is pre-determined for CTSC students in application phase, required within six months of start date for non-CTSC students.)A list of Faculty with Privileges can be found on the MCGSBS intranet site.

Once a mentor is selected, the student must register for MGS 6840 Master's Research every term for which they will be given a grade of Satisfactory or Not Satisfactory.

Examinations

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 examination must be passed before the final oral examination may be scheduled.
For more details, see the Written Qualifying Exam Procedure on the MCGSBS Policies and Procedures intranet site.

Final Oral Examination: The final oral examination may be scheduled after 1) the written qualifying examination has been passed, 2) MCGSBS has completed a graduation clearance audit confirming that all course and non-course requirements have been met, and 3) the thesis is reviewed and deemed ready to defend by the TAC.
Candidates for the Master's degree are expected to pass the final oral examination before completion of the Mayo residency or fellowship training program.
For more details, see the Final Oral Examination-Thesis Defense Procedure on the MCGSBS Policies and Procedures intranet site.

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.

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: The composition of the Thesis Advisory Committee (TAC) is determined collaboratively between student and student's mentor and requires approval of the program director and the school. 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 submitted to MCGSBS administration. 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 student has no more than 30 days from the defense date to complete all post-defense requirements, including final thesis corrections. The chair of the Thesis Advisory Committee must sign a form verifying the final corrections to the thesis have been made. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted. If a student does not meet the thesis corrections deadline, they will be required to re-defend their thesis.

The final thesis is uploaded 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.

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
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.
AIHC 5200 Mathematical Foundations for AI (1st 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.

Advanced 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
<u>Signals & Systems</u> (6 credits required)
BMEP 6720 Deep Learning for Medical Imaging……3 cr.
BMEP 5704 Bio-instrumentation & Signal Processing……3 cr.

<u>Discovery Science</u> (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.

<u>Discovery Science – Molecular Genetics</u> (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.

<u>Applied Clinical Informatics</u> (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 *(future offering)*……1 cr.
AIHC 5963 Health Information Security *(future offering)*……1 cr.
AIHC 5964 AI&HIT Implementation……1 cr.

<u>Translational & Regulatory (6 credits required)</u>

AIHC 5045 FDA & ISO Software Verification & Validation *(future offering)*……...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 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.
It is expected that a minimum of one year will be devoted to research.

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 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.

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

Biomedical Science Requirements (5 credits required)
MGS 6000 Responsible Conduct of Research.....1 cr.
BMB 5100 Chemical Principles of Biological Systems .....2 cr.
BMB 5150 Molecular Cell Biology .....2 cr.

Advanced Elective Courses (17 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.

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 BMB 5100 and BMB 5150. 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:

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)……..…16 cr.
It is expected that a minimum of one year will be devoted to research.

Track Requirements (18 credits required)

MGS 6000 Responsible Conduct of Research……1 cr.
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 .....3 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 (8 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 – MGS courses are also acceptable. However, other courses listed in the MCGSBS catalog may be taken with/without prior approval from the CCaTS Postdoctoral Executive Committee. Consult with your CCaTS Education Coordinator/Specialist for further information. 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. CTSC 5601 will only count as an elective if the scholar started in the program before July 2021 and were also required to take CTSC 5602 to meet a course prerequisite. CTSC 5611 will not count as an elective as content duplicates CTSC 5610 which is required for all master's students.

Concentration Requirements

Biomedical Ethics (BET) (5 credits required)

CTSC 5261 Theoretical and Historical Foundations of Biomedical Ethics.....2 cr.
CTSC 5262 Health Policy and Biomedical Ethics.....1 cr.

Select 2 credits from:

CTSC 5210 Ethical Issues in Regenerative Medicine…….1 cr.
CTSC 5263 Ethical Issues in Population Health Science.....1 cr.
CTSC 5340 Ethical Issues in Individualized Medicine……..1 cr.
CTSC 5350 Ethical Issues in Artificial Intelligence and Information Technologies……..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 Advanced Statistics in Clinical and Translational Research: Logistic Regression with Statistical Software ……..……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 cr.). 1 cr.

Individualized Medicine (IDVM) (6 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.....2 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.
CTSC 5900 Introduction to Health Services Research and Policy……..…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 Genomic Analysis of Complex Traits..……...…..……....1 cr.
CTSC 5641 Observational Studies and Causal Inference ……..….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 Proposal
Students develop their research proposals in CTSC 5010: Clinical Research Proposal Development and submit their proposal to the CCaTS Masters and Certificate 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

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 Masters and Certificate 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. A minimum of one first or last author

journal ready or published paper will be required before being approved to defend thesis. A co-first author paper may be approved if a supplemental statement from your mentor is received that indicates you served as a significant contributor. The paper(s) should be derived from your thesis and must be linked to your master's thesis topic. In other words, papers not related to the thesis topic do not meet the publication requirement.

Immunology (IMM) – Postdoctoral Masters

Kay L. Medina, Ph.D., *Program Director*
Kathryn Knoop., Ph.D., *Associate Program Director, MN*
Henrique Borges da Silva, Ph.D. *Associate Program Director, AZ*

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

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

MGS Courses (12 credits required)
Students are expected to complete 12 credits of course work selected from the Biomedical Sciences core curriculum. MGS 6000 and IMM 5100 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.
MGS 6000 Responsible Conduct of Research..... 1 cr.
MGS 5050 Critical Thinking and Scientific Writing ..... 2 cr.
IMM 5100 Basic Graduate Immunology..... 3 cr.
CTSC 6100 Molecular Mechanicism of Human Disease ..... 3 cr.
VGT 5700 Virology nd Gene Therapy..... 3 cr.
BMB 5100 Advanced Chemical Principles of Biological Systems ..... 2 cr.
BMB 5150 Advanced Molecular Cell Biology ..... 2 cr.
BMB 5400 Molecular Genetics ..... 3 cr.
MPET 5900 Molecular Pharmacology and Receptor Signaling..... 2 cr.

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 Barrier Immunology …….……..... 1 cr.
*IMM 6867 may be taken twice for credit

Track Tutorials (8 credits required)
IMM 6878 Tutorial in Innate Immunity…… 2 cr.
IMM 6879 Tutorial in Adaptive Immunity Concepts ……..2 cr.
IMM 6880 Tutorial in Tissue Immunity……..2 cr.
IMM 6882 Tutorial in Briding Innante and Adaptive Immunity……2 cr.
IMM 6884 Tutorial in Generation and Function of T Cells…… 2 cr.
IMM 6885 Tutorial in 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.

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

Molecular Pharmacology and Experimental Therapeutics (MPET) – Postdoctoral Masters

Martin E. Fernandez-Zapico, M.D., *Program Director*
Taro Hitosugi, Ph.D., *Associate Program Director*

Course Requirements

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

Research 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.

MGS Courses (12 credits required)

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

Track Requirements (9 credits required)

MPET 5900 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 6700 Cell Death Journal Club……...……1 cr.
MPET 6811 Tutorial in Cardiovascular Pharmacology……2 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.

MGS Courses (7credits required)

MGS 6000 Responsible Conduct of Research ..... 1 cr.
MGS 5050 Critical Thinking and Scientific Writing ..... 2 cr.
BMB 5100 Chemical Principles of Biological Systems ..... 2 cr.
BMB 5150 Molecular Cell Biology ..... 2 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 Ethical Issues in Regenerative Medicine ..... 2 cr.
MPET 6820 Regenerative Medicine Principles to Practice ..... 2 cr.

Elective Courses (7 credits required)

In addition to the core and track requirements, 7 credits of electives are required.
Recommended Elective courses include:

IMM 5100 Basic Graduate Immunology ..... 2 cr.
CTSC 6100 Molecular Mechanisms of Human Disease ..... 3 cr.
VGT 5700 Virology and Gene Therapy ..... 3 cr.
CTSC 6120 Case Studies in Translation ..... 3 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 ..... 2 cr.
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

Autumn J. Schulze, Ph.D., *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.

MGS Courses (8 credits required)

MGS 6000	Responsible Conduct of Research	1 cr.
MGS 5050	Critical Thinking & Scientific Writing	2 cr.
BMB 5100	Chemical Principles of Biological Systems	2 cr.
VGT 5700	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 Required Courses (7 or 5, depending 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 5040	Intro to the Principles of Current Good Manufacturing Practices (cGMP)	1 cr.
CTSC 5300	Introduction to Clinical Epidemiology	1 cr.
CTSC 5600	Statistics in Clinical & Translational Research	3 cr.

Research Pathway (5 credits required)

IMM 5100 Basic Graduate Immunology ..... 3 cr.
VGT 6888 Molecular Therapy Tutorial ..... 2 cr.

<u>Advanced Electives (9 or 11 credits required based on chosen pathway)</u>

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

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.

Employee-Professional Master's Degree Program Description 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)

Overview

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.

Admissions

Applicants must have a current Mayo Clinic appointment. Although more common for allied health staff, it is open to all employees. Visiting clinicians and research trainees are not eligible.

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.

Time to completion can vary by student, but 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.

Admissions/Financial Support

Mayo Clinic employees accepted into the Master's program continue to receive the salary from their primary appointment and do not receive a stipend from MCGSBS.

Program Fees are charged for many Master's programs to cover administrative costs, due upon admission. The cost is covered by Mayo Clinic funds, either by the candidate's home department or lab.

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.

Milestones

Students are expected to make continuous and successful academic and professional progress toward graduation requirements for the M.S. 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
- Complete Degree Planning Tool (DPT)
- Mentor Selection (required within 6 months of program start)
- Pass Written Qualifying Exam
- Advisory Committee Selection
- Final Oral Exam/Thesis Defense
- Meet any program specific competencies as defined by track

Full details are included in the Academic Progress and Graduation Requirements for Masters Programs Policy on the MCGSBS Policies and Procedures intranet site.

Minimum Credit Requirements

Students must complete a minimum of 45 credits, including MGS 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.

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. The DPT must 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 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/Masters Forms.

Transfer Credits

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

Mentor Selection: A Master's degree mentor must be chosen from within Mayo Clinic and must have MCGSBS Full or Master's graduate faculty privileges. This must be completed within six months of start date. A list of Faculty with Privileges can be found on the MCGSBS intranet site.

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 must be passed before the Master's final project review may be scheduled.
For more details, see the Written Qualifying Exam Procedure on the MCGSBS Policies and Procedures intranet site

Employee Master's Advisory Committee

The composition of the Master's Advisory Committee is determined collaboratively between student and student's mentor and requires approval of the program director and the school. The requested

committee membership is submitted on the Employee Master's Advisory Committee form available on the MCGSBS intranet site. All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. The committee must consist of:

- Four members, including the student's mentor
- Mentor serves as the chair of the committee
- Any additional members beyond four will be designated as ex-officio and will have voting rights
- No more than two members may have Teaching/Examining Privileges (TE).

Some tracks may define more specific criteria.

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.

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.

Final Project Corrections: After the student has completed the final project presentation the student has no more than 30 days from the presentation date to complete all graduation requirements, including any requested corrections to the final project.

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.

MGS Courses (11 credits required)

MGS	6000	Responsible Conduct of Research	1 cr.
BMB	5100	Advanced Chemical Principles of Biological Syst	2 cr.
BMB	5150	Advanced Molecular Cell Biology	2 cr.
MGS	6400	Master's Scholarly Review Article (Final Project)	6 cr.

Journal Clubs (1 credits required)

BMB	6500	BMB Journal Club (1 cr./yr.)*	1 cr.

*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.

Advanced Elective Courses (33 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 BMB 5100 and BMB 5150. 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*
Matthew W. Urban, 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.

MGS Courses (10 credits required)

MGS	6000	Responsible Conduct of Research	1 cr.
MGS	6050	Critical Thinking and Scientific Writing	2 cr.
MGS	6051	Critical Thinking and Scientific Writing II	1 cr.
MGS	6400	Master's Scholarly Review Article (Final Project)	6 cr.

Track Requirements (20 credits required)

BMEP 5010	Integrative Physiology of Health and Disease	6 cr.
BMEP 5020	Quantitative Biomedical Imaging and Signal Processing	6 cr.
BMEP 5030	Biomedical Applications of Engineering Principles	6 cr.
BMEP 6600	Biomedical Engineering and Physiology Seminars	1 cr.
BMEP 6650	BMEP Journal Club	1 cr.

Advanced Coursework (15 credits)
15 total credits are required to complete the program. In addition to the core and track requirements, 15 advanced course work credits (at least 9 of which should be taken from BMEP course offerings) should be selected after consultation between student and program director. Minimum GPA of 3.0 will be required for combined coursework.

Written Qualifying Exam (WQE)
The written qualifying examination (WQE) for the Employee Master's Degree in Biomedical Engineering and Physiology is comprised of a significance section (as in an F-award application) covering the topics of clinical need, normal physiology and disease pathophysiology, current clinical deficiencies, prior research successes and failures and future directions. The topic of the proposed WQE is due on November 1st for review and approval by the BMEP Track Education Committee. Final submission of the full WQE is due by March 1st the following year. 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*
Kathryn Knoop., Ph.D., *Associate Program Director, MN*
Henrique Borges da Silva, Ph.D. *Associate Program Director, AZ*

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

MGS Courses (7 credit minimum)

MGS	6000	Responsible Conduct of Research (required)	1 cr.
MGS	6400	Master's Scholarly Review Article (Final Project)	6 cr

Track Requirements (16 credit minimum).

IMM	5100	Basic Graduate Immunology	3 cr.
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	2 cr.
IMM	6879	Tutorial in Adaptive Immunity Concepts	2 cr.
IMM	6880	Tutorial in Tissue Immunity	2 cr.
IMM	6882	Tutorial in Briding Innate and Adaptive Immunity	2 cr.
IMM	6884	Tutorial in Generation and Function of T Cells	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.

Advanced 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*
Taro Hitosugi, Ph.D., *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.

MGS Courses (14 credits required)

MGS	6000	Responsible Conduct of Research	1 cr.
MGS	6400	Master's Scholarly Review Article (Final Project)	6 cr.

Track Requirements (7 credits required)

BMB	5100	Chemical Principles of Biological Systems	2 cr.
BMB	5150	Molecular Cell Biology	2 cr.
MPET	5900	Molecular Pharmacology and Receptor Signaling	3 cr.
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	6700	Cell Death Journal Club	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.

Advanced Electives (19 credits required)
Any courses approved for graduate credit; select in consultation with your project mentor.

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.

MGS Courses (14 credits required)

MGS	6000	Responsible Conduct of Research	1 cr.
BMB	5100	Chemical Principles of Biological Systems	2 cr.
BMB	5150	Molecular Cell Biology	2 cr.
CTSC	6100	Molecular Mechanisms of Human Disease	2 cr.
MGS	6400	Master's Scholarly Review	6 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 (11 credits required)

NSC	5600	Behavioral Neurology	2 cr.
BMEP	6300	Tutorial in Neurophysiology	3 cr.
MPET	6820	Regenerative Medicine	2 cr.
IMM	5100	Basic Graduate Immunology	3 cr.
BMB	5400	Molecular Genetics	3 cr.
MPET	5900	Molecular Pharmacology and Receptor Signaling	3 cr.
REGS	5300	Stem Cells and Development	3 cr.

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

Autumn J. Schulze, Ph.D., *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.

MGS Courses (14 credits required)

MGS 6000	Responsible Conduct of Research	1 cr.
MGS 5050	Critical Thinking & Scientific Writing	2 cr.
BMB 5100	Chemical Principles of Biological Systems	2 cr.
VGT 5700	Intro to Virology and Gene Therapy	3 cr.
MGS 6400	Master's Scholarly Review Article (Final Project)	6 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 5300	Introduction to Clinical Epidemiology	1 cr.
CTSC 5600	Statistics in Clinical & Translational Research	3 cr.
CTSC 5040	Intro to the Principles of Current Good Manufacturing Practices (cGMP)	1 cr.

Research Pathway (5 credits required)

IMM 5100 Basic Graduate Immunology ..... 3 cr.
VGT 6888 Molecular Therapy Tutorial ..... 2 cr.

Advanced Electives (22 or 24 credits required based on chosen pathway)

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

Clinical Master's Degree Program Description and Track Requirements

- Dentistry *(no longer accepting new applications)*
  - 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)

Overview

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.

Admissions

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.

Admissions/Financial Support

Students in the Clinical Master's program continue to receive the salary from their residency/fellowship and do not receive a stipend from MCGSBS.

Program Fees may be charged to cover administrative costs, due upon admission. The cost is covered by Mayo Clinic funds, either by the candidate's home department or program.

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.

Milestones

Students are expected to make continuous and successful academic and professional progress toward graduation requirements for the M.S. 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
- Complete Degree Planning Tool (DPT)
- Mentor Selection (required within 6 months of program start)
- Pass Written Qualifying Exam
- Submit Research Proposal (Data to be included in the M.S. thesis must be generated after admission to the M.S. program)
- Thesis Advisory Committee (TAC) Selection
- Routine TAC meetings and Progress Reports, minimum every six months
- Final Oral Exam/Thesis Defense
- Meet any program specific competencies as defined by track

Full details are included in the Academic Progress and Graduation Requirements for Masters Programs Policy on the MCGSBS Policies and Procedures intranet site.

Minimum Requirements

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.

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. The DPT must 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 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/Masters Forms.

Transfer Credits

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

Mentor Selection

A Master's degree mentor must be chosen from within Mayo Clinic and must have MCGSBS Full or Master's graduate faculty privileges. This must be completed within six months of start date. A list of Faculty with Privileges can be found on the MCGSBS intranet site.

Examinations

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 examination must be passed before the final oral examination may be scheduled.
For more details, see the Written Qualifying Exam Procedure on the MCGSBS Policies and Procedures intranet site.

Final Oral Examination

The final oral examination may be scheduled after 1) the written qualifying examination has been passed, 2) MCGSBS has completed a graduation clearance audit confirming that all course and non-course requirements have been met, and 3) the thesis is reviewed and deemed ready to defend by the TAC. Candidates for the Master's degree are expected to pass the final oral examination before completion of the Mayo residency or fellowship training program.
For more details, see the Final Oral Examination-Thesis Defense Procedure on the MCGSBS Policies and Procedures intranet site.

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: The composition of the Thesis Advisory Committee (TAC) is determined collaboratively between student and student's mentor and requires approval of the program director and the school. 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.

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 submitted to MCGSBS administration. 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 at For Students/General Forms/Resources.

Final Thesis Corrections: After the student has passed the final oral examination, the student has no more than 30 days from the defense date to complete all post-defense requirements, including final thesis corrections. The chair of the Thesis Advisory Committee must sign a form verifying the final corrections to the thesis have been made. MCGSBS will not certify completion of degree requirements until the final thesis has been submitted. If a student does not meet the thesis corrections deadline, they will be required to re-defend their thesis.

The final thesis is uploaded 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.

Dentistry Specialities (DENT) – Clinical Master's Degree*

Ji Hyun Ahn, D.D.S., M.S., *Program Director (Orthodontics)*
Miao Xian (Cindy) Zhou, D.M.D., M.S., *Program Director (Periodontics)*
Sarah K. Lee, D.D.S., M.S., *Program Director (Prosthodontics)*

The Dental Specialities Program is no longer accepting applications. Please contact mgsmastersprogram@mayo.edu for questions.

Clinical Master's Degree
In addition to the following courses, successful completion of the requirements for the Certificate in Orthodontics, Periodontics, or Prosthodontics is required.

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

Biomedical Sciences Courses (all 6 credits required)

MGS	6000	Responsible Conduct of Research	1 cr.
CTSC	5600	Introduction to Statistics in Clinical and Translational Research	3 cr.
CTSC	5100	Academic Publishing	1 cr.
CTSC	5300	Fundamentals to Epidemiology	1 cr.

Dental Didactic Courses (all 17 credits required)

DENT	5300	Professional Skills in Dentistry (0.25 cr./qtr, total 3 cr.)	3 cr.
DENT	5500	Scientific Writing for Dental Specialties (0.25 cr./qtr, total 1 cr.)	1 cr.
DENT	5600	Scholarly Presentation (1cr./qtr, total 3 cr.)	3 cr.
DENT	5200	Dental Specialties Literature Review (0.25 cr./qt, total 6cr.)	6 cr.
DERM	6870	Mucous Membrane Course	1 cr.
DENT	6852	Applied Anatomy for Dental Residents	3 cr.

Dental Research Courses (all 22 credits required)

DENT	5900	Dental Specialties Master's Thesis Proposal, Development, and Defense (0.5 cr./qtr, total 4 cr.)	4 cr.
DENT	5000	Research in Selected Problems (2cr./qtr, total 18 cr.)	18 cr.

Obstetrics & Gynecology (OBG) - Clinical Master's Degree

Carl H. Rose, M.D., *Program Director, Maternal Fetal Medicine (MFM)*
Carrie L. Langstraat, M.D., *Program Director, Gynecologic Oncology (GYNO)*
Elizabeth A. Stewart, M.D., *Program Director, Reproductive Endocrinology and Infertility (REPR)*
Isobel C. Green, M.D., *Program Director, Minimally Invasive Gynecologic Surgery (MIGS)*
John A. Occhino, M.D., *Program Director, Female Pelvic Medicine/Reconstructive Surgery (GYNP)*
Laura L. Elliot, M.D., *Program Director, Hospital Obstetrics (HOSP)*

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

OBG Core Courses (minimum 9 credits required)

ANAT	6000	Anatomy of the Pelvis-Perineum	2 cr.
MGS	6000	Responsible Conduct of Research	1 cr.
CTSC	5600	Introduction to Statistics in Clinical and Translational Research	3 cr.
CTSC	5602	Introduction to Utilizing Statistics in Clinical Research	1 cr.
CTSC	5100	Academic Publishing	1 cr.

Select one of the following:

CTSC	5300	Fundamentals of Epidemiology	1 cr.
CTSC	5370	Introduction to Epidemiology	2 cr.

OBG Journal Clubs (minimum 2 credits required)
A minimum of 2 journal club credits are required. A maximum of 4 journal club credits may be applied towards degree requirements. Journal clubs may be taken more than once. Journal clubs outside of OBG may be taken, with approval from the fellowship director.

OBG	5000	Sentinel Articles in Gynecologic Oncology	1 cr.
OBG	5002	Journal Club in Benign Pelvic Surgery	1 cr.
OBG	5003	Minimally Invasive Gynecology Journal Club	1 cr.
OBG	5004	Reproductive Endocrinology and Infertility Journal Club	1 cr.
OBG	5005	Journal Club for Professionals in MFM & HOSP	1 cr.
OBG	5006	Simulation Journal Club	1 cr.
BMB	6510	Cancer Biology Journal Club	1 cr.

OBG Professional Courses (2 credits required)
A maximum of 2 credits may be applied towards degree requirements. Courses may be taken more than once.

OBG	5802	Professional Skills in Gynecological Oncology	1 cr.
OBG	5803	Professional Skills in Gynecologic Surgery	1 cr.
OBG	5804	Case Studies in Maternal Fetal Medicine	1 cr.
OBG	5805	Professional Skills in Reproductive Endocrinology and Infertility	1 cr.
OBG	5806	Case Studies in Minimally Invasive Gynecological Surgery	1 cr.
OBG	5807	Case Studies in Hospital Obstetrics	1 cr.
OBG	5808	Professional Skills in Minimally Invasive Gynecological Surgery	1 cr.
OBG	5809	Professional Skills in Hospital Obstetrics	1 cr.

Research Courses (23 credits required)

OBG 6840 Research in Obstetrics-Gynecology .....24 cr.
(5 cr./qtr. – 4 qtrs. required)
MGS 6100 Master's Thesis Proposal .....3 cr.

Concentrations and Electives

All concentration and elective credits must total a minimum of 9 credits. Each concentration To receive a concentration, all requirements must be completed. Completing a concentration is not required. Students may take other Graduate School courses as an elective, with approval from their fellowship director. Students are responsible for meeting course prerequisite requirements. See the Graduate School Course Catalog or contact MCGSBSCurr@mayo.edu.

Gynecologic Oncology Concentration (GYNO) (5 credits required)

BMB 5000 Cancer Biology I .....3 cr.
BMB 5350 Hormones and Cancer .....1 cr.
OBG 5500 Case Studies in Gynecological Oncology .....1 cr.

Endocrinology and Infertility Concentration (REPR) (5 credits required)

Select one of the options below. Review course descriptions before enrollment.

BMB 6660 Transcription, Chromatin, and Epigenetics .....3 cr.
BMB 6860 Tutorial in Endocrine Physiology.....1 cr.

Select one of the options below. Review course descriptions before enrollment.

BMB 5150 Molecular Cell Biology …….....2 cr.
BMB 5400 Molecular Genetics …….....3 cr.

Biomedical Ethics (BET) (5 credits required)

CTSC 5261 Theoretical and Historical Foundations of Biomedical Ethics.....2 cr.
CTSC 5262 Health Policy and Biomedical Ethics.....1 cr.

Select 2 credits from the options below.

CTSC 5210 Ethical Issues in Regenerative Medicine…….1 cr.
CTSC 5263 Ethical Issues in Population Health Science.....1 cr.
CTSC 5340 Ethical Issues in Individualized Medicine……..1 cr.
CTSC 5350 Ethical Issues in Artificial Intelligence and Information Technologies……..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 5720 Clinical Trials: Design and Conduct……..…1 cr.
CTSC 5710 Practical Data Collection ……..……..…1 cr.
CTSC 5820 Introduction to Survey Research ……..……..…1 cr.
CTSC 5390 Advanced Applied Epidemiologic Methods ……..……..…2 cr.
CTSC 5010 Research Proposal Development ……..……..…2 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 for Individualized Medicine Approaches.....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.
CTSC 5900 Introduction to Health Services Research and Policy……..…1 cr.

Quantitative Research Methods (QUAN) (5 credits required)

CTSC 5610 Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software ……3 cr.
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.

Orthopedics (OR) - Clinical Master's Degree

Cody C. Wyles, 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)	
MGS	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)
- Cancer Discovery and Translational Science (CDTS)
- 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 (8 credits)

AIHC	5020	Introduction to Data	3 cr.
AIHC	5030	Introduction to Deployment, Adoption and Maintenance	2 cr.
AIHC	5615	Fundamentals of Statistics for AI	2 cr.
CTSC	5300	Fundamentals of Epidemiology	1 cr.
CTSC	5350	Ethical Issues in Artificial Intelligence and Information Technologies	1 cr.
AIHC	6000	Independent Study in AIHC	1 cr.

Elective Courses (4 credits)
Choose from one of the following:

AIHC	5010	Introduction to Machine Learning	3 cr.
MPET	6450	Applied Data Science & Artificial Intelligenc in Pharmacology	2 cr.
BMEP	6720	Deep Learning for Mecial Imaging	3 cr.
AIHC	XXXX	Survey of Machine Learning Methods (*future offering*)	2 cr.

Independent Study
The independent study is an opportunity to demonstrate the integration of knowledge from the concentration courses. Through the independent study with one of the faculty of the AIHC track, the learning will complete a project or writeup related to the use of AI in their scientific domain. The faculty and learner will meet at the beginning of the term to define the specific learning objectives and academic output from the Independent Study.

Cancer Discovery & Translational Science (CDTS) – Certificate

Bruce Horazdovsky, Ph.D, *Program Director*

Certificate – 12 credits required
The Certificate program in Cancer Discovery & Translational Science is available to Mayo Clinic professionals who working in cancer related discuplines. 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

- None

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

Course Requirements (7 credits required)
BMB 5000 Cancer Biology I: Introduction to Cancer Biology; Molecular, Cellular and Genetic Basis of Cancer.....3 cr.
BMB 6070 Cancer Biology II: Molecular Mechanisms of Cancer: Signal Transduction Pathways and Networks.....3 cr.
BMB 6510 Cancer Biology Journal Club.....1 cr.

Elective Courses (5 credits required)
Students have the option to complete these courses within a given degree plan. A minimum of 4 credits are required.
BMB 5350 Hormones and Cancer.....1 cr.
CTSC 5300 Fundamentals of Epidemiology.....1 cr.
CTSC 5400 Introduction to Bioinformatics Concepts and Core Technologies for Individualized Medicine Approaches.....1 cr.
CTSC 5720 Clinical Trials: Design and Conduct.....1 cr.
IMM 6865 Regenerative T Cell Immunotherapy and Cellular Engineering. .....3 cr.
IMM 6884 Tutorial in Tumor Immunology.....2 cr.
MPET 6814 Cellular Pharmacology of Agents That Target Cancer.....1 cr.

Clinical and Translational Science (CTS) – Certificate

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

CTS Basic Science Certificate

The Certificate Program in Clinical and Translational Science is open to Mayo Clinic employees who have a doctoral degree in a discipline applicable to clinical research. 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 (14 credits for those pursuing a concentration)**. The student must complete all of the required courses listed below:

MGS Course Requirements (1 credit required)

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

Track Requirements (7 credits required)

CTSC 5010 Clinical Research Proposal Development.....2 cr.
CTSC 5100 Academic Publishing .....1 cr.
CTSC 5370 Introduction to Epidemiology.....2 cr.
CTSC 5600 Introduction to Statistics in Clinical and Translational Research .....3 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 – MGS 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 5261 Theoretical and Historical Foundations of Biomedical Ethics.....2 cr.
CTSC 5262 Health Policy and Biomedical Ethics.....1 cr.

Select 2 credits from:

CTSC 5210 Ethical Issues in Regenerative Medicine……1 cr.
CTSC 5263 Ethical Issues in Population Health Science.....1 cr.
CTSC 5340 Ethical Issues in Individualized Medicine……..1 cr.
CTSC 5350 Ethical Issues in Artificial Intelligence and Information Technologies……..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.

Individualized Medicine (IDVM) (5 credits required)

CTSC 5340 Ethical Issues in Individualized Medicine.....1 cr.

CTSC 5400 Introduction to Bioinformatics Concepts and Core Technologies for Individualized Medicine Approaches.....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.

CTSC 5900 Introduction to Health Services Research and Policy……..…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.

Concentration Program Description and Requirements

- Applied Biostatistics (ABIOT)
- Applied Mixed Methods (AMM)
- Artificial Intelligence in Healthcare (AIHC)
- Cancer Biology and Therapeutics (CBT)

Applied Biostatistics (ABIOT) – Concentration

Felicity T. Enders, Ph.D., *Program Director*

Concentration – 13 credits required

The Concentration in Applied Biostatistics is open to all PhD and MD-PhD students from all MCGSBS training programs to provide the opportunity to integrate coursework into their degree plan and inform their thesis research.

Pre-Requisite Course Work

None

Course Work

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

Course Requirements (10 credits required)

CTSC 5600 Statistics in Clinical and Translational Research .....3 cr.
CTSC 5602 Utilizing Statistics in Clinical Research ..... 1 cr.
CTSC 5610 Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software .....3 cr.
CTSC 5640 Advanced Statistics in Clinical and Translational Research: Survival Analysis with Statistical Software ……..……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.

Elective Courses (3 credits required)

Students have the option to complete these courses within a given degree plan. A minimum of 3 credits are required.

CTSC 5500 Genomic Analysis of Complex Traits..……...…..…….....1 cr.
CTSC 5710 Practical Data Collection ……..……..……..…1 cr.
CTSC 5715 Publication Quality Tables and Figures ……..…....1 cr.
CTSC 5740 Systematic Reviews and Meta-Analysis …….……..…2 cr.
CTSC 5940 Secondary Data Analysis ……...……...…1 cr.

Applied Mixed Methods (AMM) – Concentration

Felicity T. Enders, Ph.D., *Program Director*

Concentration – 12 credits required

The Concentration in Applied Mixed Methods is open to all PhD and MD-PhD students from all MCGSBS training programs to provide the opportunity to integrate coursework into their degree plan and inform their thesis research.

Pre-Requisite Course Work

None

Course Work

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

Course Requirements (11 credits required)

CTSC 5600 Statistics in Clinical and Translational Research .....3 cr.
CTSC 5602 Utilizing Statistics in Clinical Research ..... 1 cr.
CTSC 5610 Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software .....3 cr.
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.

Elective Courses (1 credit required)

Students have the option to complete these courses within a given degree plan. A minimum of 1 credit is required.

CTSC 5710 Practical Data Collection ……..……..……1 cr.
CTSC 5715 Publication Quality Tables and Figures ……..…....1 cr.
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.
CTSC 5720 Clinical Trials: Design and Conduct ……..……1 cr.
CTSC 5900 Introduction to Health Services Research and Policy ..……..…1 cr.
CTSC 5940 Secondary Data Analysis ……...…….1 cr.

Artificial Intelligence in Healthcare (AIHC) – Concentration

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

Concentration – 12 credits required

The Concentration in Artificial Intelligence in Healthcare is open to all PhD and MD-PhD students from all MCGSBS training programs to provide the opportunity to integrate Cancer coursework into their degree plan and inform their thesis research.

Pre-Requisite Course Work

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 Concentration consists of **12-14 credits**. The student must complete all of the required courses listed below:

Course Requirements (8 credits required)

CTSC 5300 Fundamentals of Epidemiology..... ....1 cr.
AIHC 5020 Introduction to Data……3 cr.
AIHC 5030 Introduction to Deployment, Adoption and Maintenance……...2 cr.
CTSC 5350 Ethics Issues in Artificial Intelligence and Information Technologies……1 cr.
AIHC 6000 Independent Study in AIHC ....1 cr.

Elective Courses (4 credits required)

Students have the option to complete these courses within a given degree plan. A minimum of 2 credits from each category are required.

Category One:

AIHC 5010 Introduction to Machine Learning……3 cr.
BMEP 6720 Deep Learning for Medical Imaging…….3 cr.
MPET 6450 Applied Data Science & Artificial Intelligence in Pharmacology.....2 cr.
AIHC XXXX Survey of Machine Learning Methods (*Future Offering*) .....2 cr.

Category Two:

AIHC 5615 Fundamentals of Statistics for Artificial Intelligence..……..2 cr.
CTSC 5610 Statistics in Clinical and Translational Research: Linear Regression Concepts, Interpretation, and Statistical Software .....3 cr.

Independent Study: The independent study is an opportunity to demonstrate the integration of knowledge from the concentration courses. Through the independent study with one of the faculty of the AIHC track, the learning will complete a project or writeup related to the use of AI in their scientific domain. The faculty and learner will meet at the beginning of the term to define the specific learning objectives and academic output from the Independent Study.

Cancer (CAN) – Concentration

Bruce F. Horazdovsky, Ph.D., *Program Director*

Concentration – 12 credits required

The Concentration in Cancer is open to all PhD and MD-PhD students from all MCGSBS training programs to provide the opportunity to integrate Cancer coursework into their degree plan and inform their thesis research.

Pre-Requisite Course Work

None

Course Work

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

Course Requirements (7 credits required)

BMB 5000 Cancer Biology I: Introduction to Cancer Biology; Molecular, Cellular and Genetic Basis of Cancer.....3 cr.
BMB 6070 Cancer Biology II: Molecular Mechanisms of Cancer: Signal Transduction Pathways and Networks.....3 cr.
BMB 6510 Cancer Biology Journal Club.....1 cr.

Elective Courses (5 credits required)

Students have the option to complete these courses within a given degree plan. A minimum of 5 credits are required.

BMB 5350 Hormones and Cancer.....1 cr.
CTSC 5300 Fundamentals of Epidemiology.....1 cr.
CTSC 5400 Introduction to Bioinformatics Concepts and Core Technologies for Individualized Medicine Approaches.....1 cr.
CTSC 5720 Clinical Trials: Design and Conduct.....1 cr.
IMM 6865 Regenerative T Cell Immunotherapy and Cellular Engineering. .....3 cr.
IMM 6884 Tutorial in Tumor Immunology.....2 cr.
MPET 6814 Cellular Pharmacology of Agents That Target Cancer.....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 of 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 of 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 5045sp. FDA & ISO SOFTWARE VERIFICATION AND VALIDATION. (1cr.; A-F;) M. Lifson, D. 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 5200f. AI MATH FOUNDATIONS. (2cr.; A-F;) D. Holmes, N. Hugenberg – This course will provide a mathematical foundation for the study of machine learning and artificial intelligence applications, with examples emphasizing best practices for biomedical and clinical research. Primary topics are calculus, linear algebra, probability and statistics, and computer programming in MATLAB. Students are expected to have some background in these topics already, but this course will establish a common ground for all AIHC students to work from.

AIHC 5300f,w,sp,su. INTRODUCTION TO MAYO CLINIC CLOUD. (1cr.; S-N;) D. Holmes, K. Schultz – This course will provide an overview of the Mayo Clinic Cloud (MCC) environment, enabling learners to get started in MCC and use AI Factory 2.0 and Cloud App Factory.

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;) N. Hugenberg – 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.

AIHC 6000f,w,sp,su. INDEPENDENT STUDY IN ARTIFICIAL INTELLIGENCE IN HEALTHCARE (1cr.; S-N) D. Holmes – Independent studies are arranged on an individual basis in selected advanced topics in artificial intelligence in healthcare. Learners are expected to define a topic area and parameters in consultation with a member of the teaching faculty and/or the program director. Specific assessments may vary but are required to demonstrate mastery of the topic. Independent studies are intended to emphasize laboratory/project-based learning (augmented with lecture/book content); this is in comparison to Tutorials which are intended to be primarily theoretical discussions on a topic (augmented with homework/labs). In addition to individual assignments for the course, students will be expected to submit a summary of their learning

experience as a final assignment for review by the AIHC Executive Committee.

AIHC 6020su. DATA CURATION IN HEALTHCARE (2cr.; A-F) N. Hugenberg – Data is required by all applications big and small. Data in Healthcare has been generated inside of departments and other organizations, often in unique and unrelated data models. This has resulted in data silos that have prevented that data from achieving full value to patients, providers, administrators, payers, and researchers. This course introduces the concept of data in all of its representations with emphasis on data models and the various Databases in contemporary usage and includes the curation and governance of that data. Data supports Healthcare applications for patient care, administration, public health reporting, research, utilization reporting and planning, and claims management. Healthcare data has a need to be cataloged, curated and governed to ensure that it is accurate, useful, and protected. Processes involved in the curation of data include data collection, validation, cleansing, transformed, translated, secure, reliable, and understood by all parties. Over the course of twelve lectures and labs, we will explore data and databases, the importance of data curation, the different methods for achieving curated information, the security of that information, and the techniques used to curate the data used in Healthcare today. This course will utilize labs for hands-on experiences related to the merging, transforming, filtering, and protecting data that makes up the healthcare environments for today and tomorrow.

AIHC 6300f,w,sp,su. CERTIFICATE CAPSTONE PROJECT (1cr.; S-N) D. Holmes – For artificial intelligence in health care (AIHC) certificate students only. Registration typically occurs for the spring quarter. Completion of the capstone project is required for successful completion of the certificate program. The topic is chosen by students and is based on their specific interest with appropriate guidance from the assigned mentor and/or program director. This course may only be taken once for credit.

AIHC 6500f,w,sp,su. TUTORIAL IN ARTIFICIAL INTELLIGENCE IN HEALTHCARE (1cr.; S-N) D. Holmes – Tutorials are arranged on an individual basis in selected advanced topics in artificial intelligence in healthcare. Learners are expected to define a topic area and parameters in consultation with a member of the teaching faculty and/or the program director. Specific assessments may vary but are required to demonstrate mastery of the topic. Tutorials are courses which are intended to be primarily theoretical discussions on a topic (augmented with homework/labs); this is in comparison to Independent Studies are intended to emphasize laboratory/project-based learning (augmented with lecture/book content). In addition to individual assignments for the course, students will be expected to submit a summary of their learning experience as a final assignment for review by the AIHC Executive Committee.

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 5100f. CHEMICAL PRINCIPLES OF BIOPOLYMER SYSTEMS. (2 cr.; A-F) J. Maher, S. Schellenberg – An introduction to the fundamental principles of biomacromolecular structure and function,

including nucleic acids, and proteins. The course also provides a survey of methods of structure determination and analysis, principles of enzyme catalysis and kinetics.

BMB 5150w. 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.

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 5400w. 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.

BMB 5520w. BIOLOGY OF AGINING. (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 5660**f**,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-kB, apoptosis, and DNA damage signaling.

BMB 6100w. MACROMOLECULAR STRUCTURE AND DYNAMICS. (2cr.; A-F; offered even years; pre-req. BMB 5100) 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 BMB 5100 or equivalent, or permission of instructor) M. Schellenberg - 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, struciursdeterriinhtion, ahd analysis of crystal structures with an emphasis of validation and interpretation of crystals 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) J. Hawse – 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: BMB 5100, CORE 6150, and BMB 5150 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 6700sp. METABOLISM AND METABOLOMICS. (3 cr.; A-F; offered odd years) 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, theirregulation by hormones, nutritional status, cellular stress, immune system andcarcinogenesis. 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. CONCEPTS OF MEMBRANE-CYTOSKELETAL DYNAMICS JOURNAL CLUB. (1 cr. /qt.; S-N; pre-req. BMB 5150) 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

BMEP 5010f,w,sp. INTEGRATIVE PHYSIOLOGY OF HEALTH AND DISEASE. (6cr.; A-F;) I. Lanza, A. Matveyenko – This course takes an integrated approach to lead students to a deeper understanding of fundamental concepts in human physiology. The goal is to foster critical thinking about how organ systems normally work, and to gain fundamental insight into processes that contribute to disease states. A combination of didactic instruction and learner-centered approaches are used to engage students in understanding structural and functional concepts from cell to organism. This 6 credit course spans 3 quarters. The topics in the first quarter will initially focus on key foundational principles of cellular physiology, followed by the nervous system and renal physiology. In quarter 2, topics will include gastrointestinal, endocrine, and reproductive, and immune systems, again with emphasis on anatomical and functional concepts that drive normal physiology and pathophysiological underpinnings of major diseases/disorders. The third quarter will explore the respiratory, cardiovascular, and musculoskeletal systems. Student evaluations will involve graded quizzes and exams based on assigned readings and information covered during faculty-guided sessions. Student engagement and participation in discussions will also be taken into consideration during evaluation.

BMEP 5020f,w,sp. QUANTITATIVE BIOMEDICAL IMAGING AND SIGNAL PROCESSING. (6cr.; A-F) M. Urban, S. Leng – This course will provide an introduction to the fundamental concepts related to medical imaging and biomedical signal processing with a quantitative emphasis. Concepts

related to acquisition of biological signals and analysis related to time-domain and frequency-domain evaluation of signals in multiple dimensions will be covered. Diagnostic imaging modalities including radiographic imaging, x-ray computed tomography, digital radiography, nuclear medicine, magnetic resonance imaging, and ultrasound will be covered.

BMEP 5030f,w,sp. BIOMEDICAL APPLICATIONS OF ENGINEERING PRINCIPLES. (6cr.; A-F) J. Lujan, K. Zhao – This course provides an overview of the application of engineering principles to address biomedical problems. It focuses on how engineering concepts and techniques can be utilized to solve biomedical challenges and advance healthcare. Through a combination of didactic lectures, case studies, and hands-on projects, students will gain an understanding of various engineering disciplines and their applications in the biomedical field, as well as how to analyze, design, and develop engineering solutions to biomedical problems.

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 5160f. INTRODUCTION TO RADIATION PHYSICS. (3 cr.; A-F; offered odd years, pre-req. calculus, atomic or modern physics) J. Johnson, 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 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) D. 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 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 5800 INTRODUCTION TO MEDICAL IMAGING. (Course will span f, w, sp, quarters = 6cr. 2cr/quarter; A-F. Will be offered as student cohort requires) S. Leng, S. Hsieh – An introduction to fundamental principles of medical imagin 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); pease contact the instructor for further information. (Not offered 2023-2024)

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. ***Course will not be offered during Winter 2024 quarter; will resume in Winter 2025.***

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 6301f. TUTORIAL IN AUTONOMIC NEUROPHYSIOLOGY. (1 cr.; S-N) D. Linden – The goal of this course is to provide students the framework to research, present and discuss topics of interest in autonomic neurophysiology.

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 6380sp. OPEN SCIENCE METHODS OF COMPUTATIONAL (NEURO) BIOLOGY. (2cr. S-N) D. Hermes - Recent advances in Open Science are resulting in an explosion of openly available data, computational tools and data visualization methods. In this course, students will learn about and become familiar with some data and tools in systems (neuro) biological research. The course will combine lectures with hands on practice, to encourage active learning of reproducible computing practices and help bridge the gap between theory and research. Student evaluations will involve participation on laboratory assignments and student presentations. The course will include a final project that will serve as the final exam

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) J. Miller and A. Haak – 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 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 6720sp. DEEP LEARNING FOR MEDICAL IMAGING (3 cr.; S-N; offered even years) T. Kline– 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. ***Course will not be offered during Winter 2024 quarter; will resume in Winter 2025.***

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 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 6853sp. READINGS IN BIOMEDICAL ENGINEERING. (2 cr.; A-F; 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 will provide in depth understanding of key aspects of endocrine physiology in health and under conditions associated with various disease states. Students will be responsible for selecting a scientific topic related to endocrine physiology for detailed study. The course director will be responsible for assigning key research articles and other materials to facilitate student-centric learning process.

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,w,sp,su. TUTORIAL IN NEURAL ENGINEERING. (2 cr.; A-F; 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 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 AND TRANSLATIONAL SCIENCE ***CTSC course auditing is NOT allowed***

CTSC 5010f,sp. CLINICAL RESEARCH PROPOSAL DEVELOPMENT. (2 cr.; A-F; pre-req., CTSC 5300 OR CTSC 5370, CTSC 5600 Highly Recommended). 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) 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-F N. 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 regulatory documents and attending 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; CTSC 5020 and CTSC 6120 are complimentary courses.) 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 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) K. Boehmer – This course will introduce students to an approach to conducting CBPR, including development of research questions; study designs and data collection methods; analysis and interpretation; and dissemination. The course will explore the concept of

community engagement (the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people), expand students' skills of identifying and engaging with appropriate partners for CBPR.

CTSC 5080f. INTRODUCTION TO HEALTH DISPARITIES. (1 cr.; A-F) K. Boehmer – Healthy People 2020 defines health disparities as a "particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage." Health disparities adversely affect groups of people who have systematically experienced greater obstacles to health based on their: racial or ethnic group; immigrant status; religion; socioeconomic status; age; mental health; cognitive, sensory, or physical disability; sexual orientation or gender identity; geographic location; veterans; or other characteristics historically linked to discrimination or exclusion." In contrast, the CDC states that "Health equity is achieved when every person has the opportunity to attain full health potential, and no one is disadvantaged from achieving this potential because of social position or other socially determined circumstances." Research has demonstrated that there are wide disparities in health throughout America and globally. This course introduces learners to key concepts in the study of health disparities and health equity, particularly in the U.S. context; unique perspectives of specific populations that have experienced health disparities; and conceptual models, values, and methods to conduct health equity research.

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 massage 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 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 5241f. RESEARCH IN PEDIATRIC POPULATIONS: STUDY DESIGN (1 cr; A-F) R. Jacobson - This course focuses on determining the appropriate study design given the balance of benefits and risk to the research participants, given the problems presented by pediatric research participants. Topics include research ethics, human participants regulation, institutional responsibility, and investigator responsibility. This course along with its companion (CTSC 5242: Research in Pediatric Populations: Implementation) addresses the special concerns and challenges faced by investigators when conducting observational or experimental research involving infants, children, and teenagers. Both this course and CTSC 5242 are taught independently. Neither is required nor strongly recommended before taking the other. Both courses concern institutional review board (IRB) interaction. The IRB provides the basis for institutional responsibility for the application of US regulation of research. The US regulation determines what study designs will work in children based on the potential benefits and risks posed by the research.

CTSC 5242sp,su. RESEARCH IN PEDIATRIC POPULATIONS: PROTOCOL IMPLEMENTATION (1 cr; A-F) R. Jacobson - This course focuses on the successful implementation of a study protocol to carry out or execute a pediatric research study given the problems presented by pediatric research participants. Topics include research funding, protocol registration, institutional (IRB) approval, parent and patient recruitment, research participant remuneration, and data collection. This course along with its companion (CTSC 5241: Research in Pediatric Populations: Study Design) addresses the special concerns and challenges faced by investigators when conducting observational or experimental research involving infants, children, and teenagers. Both this course and CTSC 5242 are taught independently. Neither is required nor strongly recommended before taking the other. Both courses concern institutional review board (IRB) interaction. The IRB provides the basis for institutional responsibility for the application of US regulation of research. The US regulation stipulates when IRB can approve pediatric research and provides the basis for how IRBs approve recruitment and retention plans.

CTSC 5250w,su. 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 5261f. THEORETICAL AND HISTORICAL FOUNDATIONS OF BIOMEDICAL ETHICS (2 cr.; A-F) A. Barwise, J. Hirsch – This course is a requirement for the biomedical ethics concentration track. This introductory course examines topics, events, and principles in biomedical ethics with the goal of recognizing historic seminal cases that have influenced the development of contemporary biomedical ethics & medicine. In addition to conducting a historical review of the medical, legal, philosophical, & ethical aspects of seminal cases, learners will acquire the skills necessary to analyze 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, physician aid in dying, ethical issues in human research, organ transplantation, fair distribution of scare medical resources, and genetics.

CTSC 5262w. HEALTH POLICY AND BIOMEDICAL ETHICS (1 cr.; A-F) A. Barwise, M. Allyse – The COVID-19 pandemic brought to the forefront the essential interactions between public health, policy, and ethical decision-making. This course is designed to illustrate how biomedical ethics research and normative analyses in bioethics can advance our thinking about particularly complex situations at the intersection of clinical practice and health policy. This course will showcase several high visibility areas that highlight the impact biomedical ethics has on the direction and evolution of medicine & public policy. This course is open to all 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; No required prerequisites; however, CTSC 5261 is strongly recommended.) 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 CTS PhD and KL2 scholars, as well as scholars in MCGSBS tracks other than CTS. For those seeking more detailed coursework aimed at preparing them to lead their own epidemiologic or clinical research studies,take CTSC 5370: Introduction to Epidemiology and CTSC 5390: Advanced Applied Epidemiology.*

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 5350w. 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 - 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 scholars as well as those seeking more detailed coursework aimed at preparing them to lead their own epidemiologic studies.*

CTSC 5390f. ADVANCED APPLIED EPIDEMIOLOGIC METHODS (2 cr.; A-F; pre-req. CTSC 5370 and CTSC 5600) M. Hassan Murad, K. Mohammed, Z. Wang - This course will provide students with the knowledge and skills required to interpret and critically appraise research studies published in the medical literature and improve their ability in the future to design such studies. This applied approach is different from that learned in the introduction to epidemiology course, in that it requires more critical thinking and will lead to acquiring appraisal skills. For each type of study discussed in this class, the instructors will explain the general terminology, underlying epidemiologic underpinnings, and provide guidelines on how to read and appraise the articles, and reflect on designing your own. The students will use standard appraisal worksheets. All students are expected to participate in the discussion.

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 (2 cr; A-F; pre-req. None; however, previous college-level coursework in Genetics and Molecular Biology is strongly recommende) 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; pre-req. None; however, CTSC 5400 is strongly recommended.) K. Kalari - This course is designed to introduce user-friendly tools 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 formats and nomenclature types that you need to be aware of while exploring genomic data. We will highlight common pitfalls when analyzing genomic data regarding poor data quality & structural variants, inconsistent annotation sources, and poor experimental design. Upon completing this course, the student will have a basic understanding of navigating through the different tools so that they can explore their own data and data in the public domain.

CTSC 5500w. GENOMIC ANALYSIS OF COMPLEX TRAITS. (1 cr.; A-F; offered even years; pre-req. CTSC 5300 or CTSC 5370 and CTSC 5600; A basic foundational knowledge of human genetics is highly recommended.) 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. Through a combination of lectures and interactive discussions, students will be equipped with fundamental knowledge for collaborative research in human genomics.

CTSC 5600w,su. INTRODUCTION TO STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH. (3 cr.; A-F) J. Aakre, K. King – No prior statistics knowledge will be assumed. Knowledge of basic algebra concepts is required. 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 5602w,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.

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 – 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 5611sp. STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH: LINEAR REGRESSION CONCEPTS AND INTERPRETATION. (2cr. A-F; pre-req. CTSC 5600, knowledge of basic algebra concepts.) S. Winham - This course provides an introduction to methods for statistical modeling and introduces some extensions of these methods such as logistic regression and Cox regression. An emphasis is placed on reading the literature. Specific topics covered include simple linear regression and multiple linear regressions. General concepts taught include understanding and interpreting published research results using linear regression. Particular attention is given to understanding model assumptions, interpretation, and generalization of results.

CTSC 5640w. ADVANCED STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH: LOGISTIC REGRESSION WITH STATISTICLA SOFTWARE. (1 cr.; A-F; pre-req. CTSC 5600, 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. OBSERVATIONAL STUDIES & CAUSAL INFERENCE (1 cr.; A-F; pre-req. CTSC 5600, CTSC 5610 or CTSC 5611, CTSC 5640 recommended.) S. Savitz– Randomized controlled trials (RCTs) are the gold standard for generating evidence to guide medical care. However, RCTs are time-consuming, expensive to conduct, and their results may not apply to patients in routine clinical practice. Further, there are many factors of interest that cannot be feasibly randomized. Observational research methods can overcome some of the challenges of RCTs to inform care delivery. The major limitation of observational research designs is that they are not randomized and observed findings may be due to differences in the underlying populations. To address this

limitation, advanced statistical approaches have been developed to conduct causal inference in non-randomized settings. This course will introduce some of these statistical approaches like propensity score matching, fixed and random effect modeling, difference-in-differences, instrumental variables, and regression discontinuity models to generate causal evidence at a faster pace and lower cost.

CTSC 5650sp. ADVANCED STATISTICS IN CLINICAL AND TRANSLATIONAL RESEARCH: SURVIVAL ANALYSIS WITH STATISTICAL SOFTWARE (1 cr.; A-F; pre-req. CTSC 5600, 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 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) 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; 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 5600 and CTSC 5300 or CTSC 5370) 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 pints 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. (Course will move from spring to fall beginning 2025)

CTSC 5815w. QUALITATIVE AND MIXED METHODS RESEARCH FOR TRANSLATIONAL SCIENCE. (2 cr.; A-F; No pre-req; however, CTSC 5810 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 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 5940f. SECONDARY DATA ANALYSIS. (1 cr.; A-F; pre-req. CTSC 5600) M. Jeffery, M. Rank – 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 patho-physiological 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 6110 f,w,sp,su. CTS WORKS IN PROGRESS (1 cr. ; S-N; registration limited to CTS PhD students only) M. Walther-Antonio – 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 6130 su,f,w,sp. CTS JOURNAL CLUB. (1 cr.; S-N; registration limited to CTS PhD students only) D. Fairweather – The CTS Journal Club is an engaging and interactive course designed to provide participants with an in-depth understanding of the latest research developments in the field of Clinical and Translational Science (CTS). This course aims to foster critical thinking, promote evidence-based practice, and facilitate lively discussions among participants. Throughout the course, participants will explore a wide range of peer-reviewed journal articles that cover diverse topics in CTS. The selected articles will reflect current trends, breakthrough discoveries, and emerging methodologies relevant to clinical research, translational medicine, and public health (1 cr. - /yr.).

CTSC 6160 sp. GENOMIC ANALYSIS AND DATA INTERPRETATIONS FOR RARE AND UNDIAGNOSED DISEASES (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 RNA seq 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, C. Zhou, 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 5200f,w,sp,su. DENTAL SPECIALTIES LITERATURE REVIEW (0.5 cr; S-N) S. Lee, TBA, TBA, S. Giri, O. Muller, T. Salinas, C. Zhou, P. Lee - 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, O. Muller, TBA - This course will teach important skills that are critical to the success of professionalism 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 FOR DENTAL SPECILTIES. (0.25 cr; A-F) TBA, C. Zhou, 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, E. Sarvas, S. Giri, 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, C. Zhou, 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 6852w. APPLIED ANATOMY FOR DENTAL RESIDENTS. (even years; 3 cr. A-F) Y. Salinas-Alvarez – Applied Anatomy for Dental Residents is 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.

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 5100f. 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. *Course previously listed as CORE 6200.*

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 degree candidates are given preference for this course.

IMM 6863f,sp. CURRENT TOPICS IN IMMUNOLOGY. (1 cr.; S-N) F. Lucien-Matteoni – 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 6865sp. REGENERATIVE T CELL IMMUNOTHERAPY AND CELLULAR ENGINEERING. (3cr.; S-N) S. Kenderian – This course is a week-long instructional class involving internal and external guest speakers from multiple different fields in cancer immunotherapy. It covers commonly used and studied cancer immunotherapy tools, including cell therapy, nucleic acid-based cancer vaccines, therapeutic monoclonal antibodies, etc. Students will be exposed to the latest ongoing research in cancer immunotherapy and will have opportunities to discuss unsolved challenges and potential solutions in the fields with the invited scientists. Students will be designing and presenting their own final projects as small groups and will be graded by course

director and teaching assistant. By the end of the course, students are expected to understand common platforms of cancer immunotherapies and corresponding advantages and disadvantages. *This class will be offered Spring 2024*

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. (2 cr.; A-F; offered odd years; pre-req. IMM 5100 or equivalent) S. Oh, A. Ting – Course is designed to provide an in-depth understanding of the generation and function of innate immune cells in health and disease. Prerequisites for this course are successful completion of Immunology IMM 5100 or Mayo Medical School, Block V, Normal Function. 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 6879sp. TUTORIAL IN ADAPTIVE IMMUNITY CONCEPTS. (2 cr.; A-F; offered even years) K. Hirohito, L. Rogers – Course is designed to provide an in-depth understanding of adaptive immunity in health and disease. Prerequisites for this course are successful completion of Immunology IMM 5100 or Mayo Medical School, Block V, Normal Function. Offered in first half of spring quarter during even years only.

IMM 6880sp. TUTORIAL IN TISSUE IMMUNITY. (2 cr.; A-F; offered odd years) A. Johnson, K. Knoop – Course is designed to provide an in-depth understanding of the how the the immune system functions in the tissues in health and disease. Prerequisites for this course are successful completion of Immunology IMM 5100 or Mayo Medical School, Block V, Normal Function. Offered in first half of spring quarter during odd years only.

IMM 6882w. TUTORIAL IN BRIDGING INNATE AND ADAPTIVE IMMUNITY. (2 cr.; A-F; offered odd years; pre-req. IMM 5100) M. Curtis, W. Ip – Course is designed to provide an in-depth understanding of the how the innate and adaptive components of the immune system communicate in health and disease. Prerequisites for this course are successful completion of Immunology IMM 5100 or Mayo Medical School, Block V, Normal Function. Offered in second half of winter quarter during odd years only.

IMM 6884w. TUTORIAL IN GENERATION AND FUNCTION OF T CELLS. (2 cr; A-F; offered even years; pre-req. IMM 5100 or equivalent) F. Gounari, V. Shapiro – The course is designed to provide an in-depth understanding of the generation and function of T lymphocytes in health and disease. The final grade will be based on class participation and the grade achieved on the comprehensive final exam. Prerequisites for this course are successful completion of Immunology IMM 5100 or Mayo Medical School, Block V, Normal Function. Offered in second half of winter quarter during even years only.

IMM 6885w. TUTORIAL IN THE GENERATION AND FUNCTION OF B CELLS. (2 cr.; A-F; offered even years; pre-req. IMM 5100 or equivalent) K. Medina, A. Novak – This course is designed to provide an in depth understanding of the generation and function of B lymphocytes in health and disease. The final grade will be based on class participation and the grade achieved on the comprehensive final exam. The prerequisites are successful completion of Immunology IMM 5100

or Mayo Medical School, Block V, Normal Function, Immunology course. Offered in first half of winter quarter during even years only.

M.D.-Ph.D.

MDPH 5000f,w,sp,su. LABORATORY ROTATION 1 FOR M.D.-Ph.D. STUDENTS. (1 cr.; S-N) TBA -First laboratory rotation (4 weeks) under supervision of faculty and staff.

MDPH 5001f,w,sp,su. LABORATORY ROTATION 2 FOR M.D.-Ph.D. STUDENTS. (1 cr.; S-N) TBA - Graduate thesis research (4 weeks) under supervision of staff.

MDPH 5002f,w,sp,su. LABORATORY ROTATION 3 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. (2 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,w. MD-PhD CLINICAL EXPERIENCE COURSE (0 cr.; S-N) A. Beyder, L. Schimmenti – For MD-PhD students in the research years to maintain focused clinical training by selecting an MD mentor and performing history/physical exams, developing a clinical plan, and, where able, participating in surgeries. Minimum of 20 hours per semester (longitudinal or immersion) during summer/fall or winter/spring). Pre-requisites: Successful completion of M1 and M2 coursework, USMLE Step 1, and Transitions to Clerkship Course (formerly Preclinical Block).

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 for MD-PhD students who have completed their PhD coursework and thesis research, successfully defended, and completed the post-defense requirements 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 GRADUATE SCHOOL

MGS 5000su. FOUNDATIONAL SKILLS. (1 cr.; S-N) B. Horazdovsky – This required course will introduce students to core professional competencies and tools for success in graduate school. Topics will include, but are not limited to personal professional growth, mentorship, communication, goal setting, and career development.

MGS 5010su. RIGOR, REPRODUCIBILITY, AND EXPERIMENTAL DESIGN. (1 cr.; S-N) B. Horazdovsky – This course will explore the critical principles of experimental design, rigor, and reproducibility in modern scientific research. Through lectures and case studies, students will master hypothesis formulation, statistical considerations, bias reduction techniques, and ethical research practices. Students will examine the reproducibility crisis, open science initiatives, and the importance of data sharing. Lecture topics will provide practical insights into real-world challenges, empowering students to enhance the quality and impact of their own research. By the end of the course, learners will possess the skills to implement rigorous experimental design strategies and contribute to a culture of transparency and excellence in biomedical sciences.

MGS 5020su. STATISTICS FOR BIOMEDICAL RESEARCH (1 cr.; S-N) B. Horazdovksy – This course provides a comprehensive introduction to statistical methods tailored specifically for graduate students in biomedical sciences, with a focus on their application in research projects within the dynamic environment of Mayo Clinic. Designed to equip students with fundamental statistical skills essential for designing experiments, analyzing data, and drawing valid conclusions, the curriculum covers key concepts and techniques applicable to various aspects of biomedical research. Topics include statistical basics, descriptive statistics, probability distributions, sampling and randomized control, hypothesis testing, regression analysis, and selecting the correct statistical test.

MGS 5030su. CORE CONCEPTS IN GENOME DYNAMICS, BIOCHEMISTRY, AND CELLULAR BIOLOGY (3 cr.; S-N) B. Horazdovsky, J. Maher - This course highlights the key concepts in genome structure and function, biomacromolecular structure and function, and the central principles governing cell biology. Through lectures, small group discussions, and group assignments, the course builds on foundational concepts of molecular mechanisms. Students will be expected to complete weekly knowledge checks and a final group presentation ensure continuous engagement and assessment of students' grasp of the material.

MGS 5050su. 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 graduate students across all tracks who have selected their thesis mentor and are beginning their second year. The course will involve two components. The first will be a didactic element that introduces funding mechanisms, grant components, communication skills, rigor and reproducibility, and data analyses. In parallel, students will choose a topic of interest and prepare the specific aims page of an NIH style small grant proposal (F-style training grant). Via a series of weekly roundtable forums discussing the merits and faults of each specific aims page throughout the writing process, the students will learn to craft a coherent and well-reasoned specific aims page of an NIH style grant. *Course previously listed as CORE 6050.*

MGS 5051f. CRITICAL THINKING AND SCIENTIFIC WRITING PART II. (1cr; S-N; pre-req. MGS 5050) J.L. Lujan, P. McLean – This course is intended for second-year graduate students across all tracks. The course will involve preparing an NIH style small grant proposal (e.g. 6-12 page F31 format) that will be critiqued by the course directors, the instructors, and by the other students in the class

in a "study section" setting. Students will base this proposal on the specific aims page developed during MGS 5050 or will choose a new topic of interest. 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. *Course previously listed as CORE 6051.*

MGS 5101f,w,sp,su. Ph.D. OPTIONAL LAB ROTATION. (2 cr.; S-N) TBA – Laboratory rotation (4 weeks) under supervision of staff. This is used for 4th and 5th rotations only. Requires Academic Affairs Committee approval prior to registration. Available to PhD, MDPhD, and CARE PhD students.

MGS 5102f,w,sp,su. Ph.D. LABORATORY ROTATION. (2 cr.; S-N) TBA – First laboratory rotation under supervision of staff.

MGS 5104f,w,sp,su. LAB ROTATION WAIVER. (2 cr. S-N) TBA – PostBac, Master's, PREP, GREP and other similar lab experiences.

MGS 5105f,w,sp,su. CARE Ph.D. LABORATORY ROTATION. (1 cr.; S-N) L. Griffiths – First CARE PhD laboratory rotation. The CARE PhD rotation provides an opportunity for students to interact with research faculty in their area of interest. This rotation experience should help CARE Ph.D. students confirm their mentor as well as identify ideal faculty for their thesis advisory committee. Only faculty with full graduate faculty privileges are eligible to host a student lab rotation and be chosen as a thesis mentor. Each CARE Ph.D. student must complete two lab rotations in two different laboratories (one credit each) for a total of two credits. A third rotation may be completed but is considered optional.

MGS 5106f,w,sp,su. CARE Ph.D. LABORATORY ROTATION. (1 cr.; S-N) L. Griffiths – Second CARE PhD laboratory rotation. The CARE PhD rotation provides an opportunity for students to interact with research faculty in their area of interest. This rotation experience should help CARE PhD students confirm their mentor as well as identify ideal faculty for their thesis advisory committee. Only faculty with full graduate faculty privileges are eligible to host a student lab rotation and be chosen as a thesis mentor. Each CARE Ph.D. student must complete two lab rotations in two different laboratories (one credit each) for a total of two credits. A third rotation may be completed but is considered optional.

MGS 5107f,w,sp,su. Ph.D. LABORATORY ROTATION. (2 cr.; S-N) TBA – Second laboratory rotation (6 weeks) under supervision of staff.

MGS 5108f,w,sp,su. Ph.D. LABORATORY ROTATION. (2 cr.; S-N) TBA – Third laboratory rotation (6 weeks) under supervision of staff.

MGS 5109f,w,sp. FOUNDATIONS IN LEADERSHIP. (1 cr.; S-N) M. Walther-Antonio – This course will teach about leadership principles for biomedical scientists, including communication styles, resilience, and emotional intelligence. Students will be expected to demonstrate an understanding of these topics and apply course concepts to complex case studies as well as their own personal circumstances. The course is intended for PhD students in biomedical sciences, but is open to all students.

MGS 5110f,w,sp. LEADERSHIP DISCUSSION TOPICS AND COACHING. (1 cr.; S-N) M. Walther-Antonio – This course will expand upon the principles taught in MGS 5100 Foundations in Leadership for Biomedical Scientists course. Students will be required to participate in group discussions and individual coaching sessions that build on the topics taught in MGS 5100. The

course is intended for PhD students in biomedical sciences, specifically those admitted to the LeaP program.

MGS 5120f,w,sp. LEADERSHIP PREPARATION. (1 cr.; S-N) M. Walther-Antonio – In this course, students will construct a project proposal, either independently or in a small group. Students will learn about the important components of project proposals through didactic course lectures. The course is intended for PhD students in biomedical sciences, specifically those admitted to the LeaP program.

MGS 5130f,w,sp. LEADERSHIP IN ACTION. (1 cr.; S-N) M. Walther-Antonio – In this course, students will construct a project proposal, either independently or in a small group. Students will learn about the important components of project proposals through didactic course lectures. The course is intended for PhD students in biomedical sciences, specifically those admitted to the LeaP program.

MGS 5200f,w,sp,su. CAREER DEVELOPMENT INTERNSHIP (CDI) (3 cr. S-N) C. Pierret – Career Development Internships (CDIs) are MCGSBS-funded opportunities for upper-level PhD students to spend 80 or more hours as interns in the areas described within the MCGSBS Career and Professional Development Framework. CDIs 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 learners with hands-on experiences in diverse career environments both internally and externally to assist with making informed career path decisions.

Prerequisites

Learners must have completed their written and oral examinations for their respective tracks (to be considered graduate candidate).

Learners must complete both the Student Request for CDI form and the CDI legal agreement form detailing the identity of the learners and mentor, their business and location, as well as a base level understanding of the intellectual property, non-disclosure between internal and external partners, and payment details for the time period of the CDI. Support for this process will be available during the Third Tuesday Office Hours or as arranged with the course director.

MGS 5500f,w. BELONGING IN THE BIOMEDICAL COMMUNITY. (1 cr.; S-N) TBA – A sense of belonging to the scientific community provides increased wellbeing, fulfilment, and partnership, ultimately leading to the learner's success. This course will provide the opportunity for students to volunteer within the Mayo Clinic surrounding communities across all campuses. Students will engage in local volunteering activities available through the Mayo Clinic CARES platform as well as participating in classroom activities that cover topics such as collaboration, interpersonal skills, ethics and values, leadership, and community engagement. The course will be conducted over 2 quarters, culminating in the presentation of the students' gained experiences. Students are required to attend scheduled class sessions and participate in at least 4 hours of volunteering per month.

MGS 6000su. RESPONSIBLE CONDUCT IN RESEARCH. (1 cr.; S-N) R. Sharp – 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. MGS 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. *Course previously listed as CORE 6000.*

MGS 6001 w,su. RESPONSIBLE CONDUCT OF RESEARCH REFRESHER COURSE. (0 cr.; pre-req MGS 6000) R. Sharp – 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 MGS 6000. Ph.D. and M.D-Ph.D. students will be notified by MCGSBS when they are required to take the refresher course. *Course previously listed as CORE 6001.*

MGS 6010su. RIGOR AND REPRODUCIBILITY (0 cr; S-N.) B. Horazdovsky – This course will focus on key concepts in scientific rigor and reproducibility. MGS 6010 curriculum will be delivered in an asynchronous format. *Course previously listed as CORE 6010.*

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 5900sp. MOLECULAR PHARMACOLOGY AND RECEPTOR SIGNALING. (3 cr.; A-F) S. Kaufmann – 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, Grehlin 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. *Course previously listed as CORE 6450.*

MPET 6205f. CLINICAL PHARMACOLOGY AND PHARMACOGENOMICS JOURNAL CLUB. (1 cr.; S-N) R. Weinshilboum, L. 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. Learners must have completed their written and oral examinations for their respective tracks (to be considered graduate candidate).

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. BMB 5100, 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,w,sp,su. CELL DEATH JOURNAL CLUB. (1 cr.; S-N) S. Kaufmann – The course is a journal club reviewing recent articles on the mechanisms of cell death in health and disease. An emphasis is placed on reviewing articles describing new, universal molecular and biochemical pathways of apoptosis and other cell death mechanisms. The course meets monthly throughout the year. No prerequisites are required. Register in fall quarter only (1 cr./yr.). Attendance required fall, winter, spring and summer for 1 year.

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) N. Norton – 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..

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.

NEUROSCIENCE

NSC 5600f,w,sp. BEHAVIORAL NEUROLOGY. (3 cr.; S-N; Register in fall, course runs fall and winter terms) TBD – The Behavioral Neurology course curriculum provides a comprehensive overview of the neuropathological, genetic, clinical characteristics (e.g., phenotypes, diagnosis, treatment), and radiographic features of neurodegenerative diseases. 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 6401 is waived for M.D.-Ph.D. students in the NSC Track (and PhD students with existing MD if pass WQE).

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, C. Blaha - 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, C. Blaha – 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 5000f,w,sp,su. SENTINEL ARTICLES IN GYNECOLOGY ONCOLOGY. (1 cr; S-N) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. C. Langstraat - This is a journal club style course that examines gynecological oncology. It provides students with the opportunity to engage in a comprehensive review of current articles, explore emerging technologies, and examine new methods in the field. Students will present an article and the class will discuss the latest studies and findings, deepening their understanding of the subject matter. This course is an opportunity for students to develop their critical thinking, analysis, and communication skills while staying up-to-date with the latest developments in the field of integrative obstetrics and gynecology. This course is intended for fellows in the OBG MS program.

OBG 5002su. GYNECOLOGICAL SURGERY JOURNAL CLUB. (1 cr; S-N) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. J. Occhino - This journal club course focuses on foundational articles in urogynecology and benign pelvic surgery. This course provides students with the opportunity to engage in a comprehensive review of both landmark and current articles that guide the practice of Urogynecology and Reconstructive Pelvic Surgery. Through the review, presentation and discussion of primary literature, students would have the chance to delve into the deepen their understanding of the subject matter. This course is an opportunity for students to develop their critical thinking, analysis, and communication/presentation skills. This course is intended for fellow in the OBG MS program.

OBG 5003f,w,sp,su. MINIMALLY INVASIVE GYNECOLOGY. (1 cr; S-N) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. T. Burnett - This journal club course focuses on essential topics in Minimally Invasive Gynecologic Surgery (MIGS). This course provides students with the opportunity to engage in a comprehensive review of current articles, explore emerging technologies, and examine new methods in the field. Through the presentation and discussion of primary literature, students would have the chance to delve into the latest studies and findings, deepening their understanding of the subject matter. This course is an opportunity for students to develop their critical thinking, analysis, and communication skills while staying up to date with the latest developments in the field of MIGS. The core articles and monthly topics align with the required reading list from the accrediting body (AAGL) and the monthly AAGL didactic schedule.

OBG 5004f,w,sp,su. REPRODUCTIVE ENDOCRINOLOGY AND INFERTILITY GYNECOLOGY JOURNAL CLUB. (1 cr; S-N) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. C. Shenoy - This journal club course focuses on newly published literature in reproductive endocrinology and infertility (REI). This course provides students with the opportunity to engage in a comprehensive review of current articles, in depth review of methodology, and examine the place of new methods in the field. Through the presentation and discussion of primary literature, students would have the chance to delve into the latest studies and findings, deepening their understanding of the subject matter. This course is an opportunity for students to develop their

critical thinking, analysis, and communication skills while staying up-to-date with the latest developments in the field of reproductive endocrinology and infertility.

OBG 5500w,sp. CASE STUDIES IN GYNECOLOGICAL ONCOLOGY. (1 cr; A-F) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. C. Langstraat - This course is designed to provide students with an in-depth understanding of the diagnosis and treatment of gynecological cancers. Through the analysis of real-world case studies, students will learn to apply their knowledge of oncology, pathology, and surgery to the management of complex patient scenarios. The course will cover a range of topics, including the latest advances in diagnostic techniques, surgical interventions, and adjuvant therapies. Students will have the opportunity to develop treatment plans and present their findings to the class. Overall, this course provides a valuable opportunity for students to deepen their understanding of gynecological oncology and to develop the skills necessary to provide high-quality care to patients. This course is intended for fellows in the OBG MS program.

OBG 5802w,sp. PROFESSIONAL SKILLS IN GYNECOLOGICAL ONCOLOGY. (1 cr; A-F) Prerequisite: must be enrolled in Gynecology Oncology or Fellowship Program, Female Pelvic Medicine, and Reconstructive Surgery Fellowship Program. C. Langstraat - This course is designed to provide students with the knowledge and skills necessary to excel in the field of gynecological oncology. The course covers a range of professional skills, including effective communication, teamwork, and ethical decision-making, as well as practical skills. Students will have the opportunity to practice these skills to prepare them for real-world scenarios. The course also includes a review of the material covered on board exams, ensuring that students are well-prepared for certification. Overall, this course provides a solid foundation for students pursuing a career in gynecology, equipping them with the skills and knowledge necessary to succeed in both clinical and professional settings. This course is intended for fellows in the OBG MS program.

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) 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 6300f. 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.

REGS 6700su. GENOMIC AND EPIGENOMIC DATA INTEGRATION. (2 cr.; S-N) I. Scarisbrick – This course will provide in-depth exposure to the most important sequencing techniques currently used for analysis of the transcriptomic, epigenomic, and genomic landscape, allowing students to better interpret results in current Regenerative Sciences literature and to venture into utilizing these techniques in their own projects. Focusing on the details of sample preparation (wet lab) and data analysis (dry lab), the course will cover Expression (RNA-seq), Epigenome 1 (ATAC-seq), Epigenome 2 (ChIPseq/CUT&RUN, CUT&TAG), Epigenome 3 (DNA methylation), and single cell analysis (scATAC and scRNA-seq) methodologies. The course will also cover different ways to present the data, since data visualization plays a critical role in genomic analysis. After completing the course, students will be able to identify data sets from each modality, critically evaluate the advantages and disadvantages of each sequencing technique, understand the experimental procedures associated with the preparation for each technique, and run at least one web-based platform for each sequencing modality. In the first quarter, students attend one consecutive week of daily, 2-hour (120 minute) classes for didactic instruction. In quarters two to four, students meet every other week for 1-hour, interactive workshops, during which they discuss and debate the use of the different modalities in scientific literature and perform analysis using their own datasets.

REGS 6820w. REGENERATIVE MEDICINE. (2 cr.; A-F) S. Wyles, W. Qu – 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

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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 5700w. INTRODUCTION TO CIROLOGY AND GENE THERAPY. (3 cr.; A-F) K. Mohni, M. Barry, P. Devaux – This course is designed to introduce the topics of molecular virology and the clinical application of viral vectors for therapeutic purposes. The course is broken up into three sections: Basic science (VGT5600), Vectors (VGT5500), and Gene Therapy (VGT5300).

It is recommended that students be familiar with basic cell biology concepts prior to taking this course.

There are two associated tutorials. The Molecular Virology tutorial (VGT 6886) is offered on odd years. Students present and discuss manuscripts that have shaped or are shaping the field of virology. The Molecular Therapy tutorial (VGT 6888) is offered on even years. Students discuss

relevant and new literature in the fields of Gene Therapy, Oncolytics, and Regenerative Medicine. *Course previously listed as CORE 6770.*

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.*

MAYO CLINIC

POLICIES & PROCEDURES

Direct links accessible only within Mayo Clinic Network; all available on the MCGSBS Policy and Procedure intranet page.

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 federals 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 for PhD 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 a fellowship award (or equivalent) as defined in the Fellowship Application and Award Policy.
  - 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
    - Final GPA of 3.0 or greater
    - Complete all required eForms (as listed above)
    - 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 within 30 days of defense

Final Defense Corrections

- 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, they 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.

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 degrees are conferred only four times a year with a diploma date in the months of February, May, August, and November. Deadlines for degree conferral are as follows:

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

- A formal commencement ceremony is held annually in May in conjunction with the Mayo Clinic Alix 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.
    - Example: Graduates with diplomas dates of August 2024, November 2024, February 2025 and May 2025 are included in the May 2025 commencement ceremony.
    - Requests to defer participation in the annual commencement ceremony by one year are considered on an individual basis, but only due to extentuating circumstances vs. personal preference. A request requires approval by the MCGSBS Executive Committee.

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
    - Finished with 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 mush complete MCGSBS checkout requirements, including return of Mayo laptop if applicable. Diploma will be withheld until completed.

Policy Notes

N/A

Academic Progress and Graduation Requirements for Master's Programs Policy

Scope

Applies to all Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) students in the master's program in pursuit of a Master of Science (M.S.) degree..

Purpose

To provide students in the MCGSBS master's programs criteria for satisfactory academic progress and to define graduation requirements for the M.S. degree.

Policy

Satisfactory Academic Progress

- Students are expected to make continuous and successful academic and professional progress toward graduation requirements for the M.S. degree.
- The concept of satisfactory progress mandates monitoring of a student's coursework, GPA, and timely completion of program milestones.
- 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 a master's degree from MCGSBS must complete a minimum period of one year in residence after admission to their degree program.
- A student must have an active primary employment role at Mayo Clinic to be eligible for enrollment in a MCGSBS master's program.
- If a student ends their employment with Mayo Clinic before graduation requirements are satisfied, the student will be withdrawn from the program effective on last date of employment.

Graduation Requirements

- In order to graduate, students must meet the following requirements within their appointed master's program dates.
    - Pass all required courses and complete required credits as defined by the specific program.
    - Final GPA of 3.0 or greater.
    - Declare a mentor by submitting the Mentor Selection eForm. Required within 6 months of program start.
    - Successfully pass Written Qualifying Exam.
        - Successfully complete final project. Tracks may include additional requirements, but at minimum this must include:
        - Postdoctoral Master's: Pass Final Oral Exam/Thesis Defense and final thesis corrections.
        - Clinical/Resident Master's: Pass Final Oral Exam/Thesis Defense and final thesis corrections.
        - Employee-Professional Master's: Complete capstone project.
    - Complete all requirements on check-out form and submit to graduate school on or before program end date.

Graduation deadlines

- The goal of MCGSBS is for students to successfully complete training leading to the M.S. degree within original appointment dates:
    - Postdoctoral: 2-5 years dependent on Mayo role and protected time
    - Employee-Professional: up to 5 years
    - Clinical/Resident: 3-5 years based on length of residency training
- If a student does not complete all graduation requirements by defined training end date, and the Advisory Committee is not supportive of an extension, the student will be dismissed from the program effective on their training end date.
- 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 Alix 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.
- Master's appointments must end a maximum 30 days after the date of the final project.
    - Students are allowed the 30 days to complete any outstanding degree requirements and make final project corrections.
- If a student does not meet the final project correction deadline, they will be required to re-defend/present their final project within six months.
    - Following the re-defense/presentation, a student is allowed 30 days to complete any outstanding degree requirements and make final project corrections. If this deadline is not met, the degree will not be awarded and there will be no further opportunities to receive the degree from MCGSBS.

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

Policy Notes

N/A

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

- 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.
- All courses must have a presence in the LMS.
- Courses must have clear, measurable learning objectives. See the Competency Policy for additional details.
- At a minimum, learning objectives must be included in the course syllabus. Ideally, learning objectives are associated with units or modules in the course.
- Faculty must utilize available, relevant educational technologies.
- 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.
- Content must be appropriate 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.
- For additional guidance regarding course technologies, see the Educational Technology Guideline.

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.
- For synchronous remote class sessions, outdated technologies should be avoided. Zoom, Teams, or Kaltura Classroom should be used. If a different platform is required, please contact MCGSBSCurr@mayo.edu. o
    - 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.

Assessment

- All courses must have assessments.
- 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.
- Exams details must be outlined in the course syllabus. See the Exam and Proctor Policy for additional information.
- Assessments are expected to be completed individually/independently, unless otherwise specified by the course director.
- 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). Grades should be entered within two weeks of the conclusion of the course. See the Grading and Evaluation of Written Materials Policy.

Learner Support

- Consideration is given to time zones and geographic location when setting course deadlines.
  - Synchronous sessions for core or track required courses should be scheduled to begin between 9am and 5pm central time. Exceptions will be considered. If you need to teach a required course outside of this window, please contact MCGSBSCurr@mayo.edu.
  - For expectations regarding proctors across different campuses/time zones, please refer to the Exam and Proctor Policy.
- Course overview or orientation is provided to students.
- 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.
- 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 and Waiver Policy

Scope

Applies to students within Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS) when they wish to transfer or waive credits and MCGSBS personnel when managing requests.

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 MCGSBS educational programs.

Policy

- 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.

Credit By Examination

- Students seeking to waive a core course are still required to complete a test-out examination. See the Course Test-Out Exam Policy for details.
- Transfer credit or credit by examination by any student of a Master's program at MCGSBS is limited to a total of six credits toward the total credits for program completion. Requirement of courses or prerequisites may qualify for waiver if approved by course director and program director. Waiver does not reduce the total credits required for program completion.

Course Substitutions

- Students may seek to substitute courses for previously completed MCGSBS courses.
- The student must have earned a grade of A or B to be considered for course substitution.
- Approval from the course director and the Graduate Program Director. Decisions will be reviewed by the MCGSBS Academic Affairs Committee.
- Coursework must have been completed within the last five years.

Course Waivers

- Students who previously completed coursework for another degree program may seek to waive requirements for MCGSBS degrees.
- Credit requirements will be considered for courses taken internally and externally. Only graduate-level courses will be considered. Undergraduate coursework will not be accepted. Courses must be equivalent to Mayo Clinic courses.
- Courses must have earned a grade of A or B to be considered for course waiver.
- Students are required to supply a syllabus. Approval from the course director and the Graduate Program Director. Decisions will be reviewed by the MCGSBS Academic Affairs Committee.
- When approved courses have been waived, students are still required to complete electives or other coursework to achieve credit. Students are still required to meet the total credit requirement of their chosen program.
- Courses designated as 'CORE' do not qualify for course waivers.

External Courses - Credit Transfers

- MCGSBS programs do not accept transfer students; however, transfer credits for graduate courses taken at another institution can be considered per the MCGSBS Credit Transfer Request Procedure.
- 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.
- If a course is not deemed equivalent but is relevant to the educational program, the course could be transferred and count as a program elective.

Total Transfer Credits and Course Waivers Allowed

- A maximum of 21 didactic credits may be transferred or waived into the Ph.D. Program.
- A maximum of nine didactic credits may be transferred or waived into the Employee Master's Program.
- A maximum of six didactic credits may be transferred or waived into the Clinical Master's Program.
- A maximum of six didactic credits may be transferred or waived into the Basic Science Master's Program.

Definitions

N/A

Policy Notes:
For M.D. - Ph.D. Students, requirements may vary compared to other Ph.D. students.

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.
- Receipt of an "F" or "N" grade in any MCGSBS course.
- Receipt of overall assessment of "does not meet expectations" on Thesis Advisory Committee progress report.
- 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 in MCGSBS courses.
    - Accumulation of two or more overall assessments of "not meeting expectations" on Thesis Advisory Committee progress report.
    - 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).
    - 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	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. 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. **If the conflict is not resolved** 3. Contact the next appropriate person in Table A to discuss problem or complaint. 4. May file a grievance in writing within 30 business days of the event in question.
Program Director/Course Leader	5. If student provides written grievance, inform appropriate school operations manager of the grievance and discuss planned response.

	6. Respond in writing within 30 business days to answer questions or resolve complaints. a. If appropriate, form panel to resolve complaint.
Learner	**If satisfactory resolution is not reached** 7. Appeal in writing within 14 business days to the Dean of the School. a. The written request must be limited to three pages and address why the learner feels the action taken was unsatisfactory.
Dean/Designee	**8.** Judge the merits of this appeal within 30 business days. a. In certain situations and at the Dean's discretion, form a panel to consider the submitted information.
Panel	**If panel is convened** 9. Request additional information or appearance before the panel of the individuals involved, if necessary. 10. Judge the merits of the appeal within 15 business days. 11. Report recommendations to the Dean.
Dean/Designee	**12.** Respond to the learner in writing. a. The decision of the Dean is final, without further appeal.
Learner (excluding MCSGME)	**For Arizona Only** 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: 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 **For Florida Only** 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: Florida Commission for Independent Education 325 W Gaines St Tallahassee, FL 32399 Phone: (850) 245-3200 Website: http://www.fldoe.org/policy/cie

	For Minnesota Complaints 15. If complaint cannot be resolved after exhausting internal grievance procedures the student may file a complaint with: 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 **For Wisconsin Only** 16. If complaint cannot be resolved after exhausting internal grievance procedures, the student may file a complaint with: 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

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: • Education Chair • Administrator • Chair	• Operations Manager • Administrator • Associate Dean
MCSGME	Mayo Clinic Alix School of Medicine **(MCASOM)**
• Ombudsperson • Operations Manager • Administrator • Associate Dean • Minority Affairs Director	• Operations Manager • Administrator • Associate Dean
Mayo Clinic Graduate School of Biomedical Sciences (MCGSBS)	**Mayo Clinic School of Continuing Professional Development (MCSCPD)**
• Operations Manager	• Operations Manager

• Administrator • Assistant Dean • Associate Dean	• 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 cumulative GPA of less than 3.0 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
    - Residency and fellowship 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	1. Contact the administrator when a learner exhibits academic or non-academic deficiencies, to determine and initiate the proper response and/or action.
Administrator	2. Determine the appropriate action, with input from the Education Leader, based on the severity of academic or non-academic deficiency: warning, probation, or dismissal. a. 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	3. Determine remediation plan to address deficiencies with the learner; include metrics to measure success when applicable. a. MCCMS reserves the right to dismiss the learner without formal warning or probation in certain non-academic deficiency cases. i. Consult with Human Resources and Legal in cases of dismissal without formal warning or probation.
Administrator / Education Leader	4. Approve remediation plan. 5. Generate and sign a formal written warning. 6. Issue the formal written warning to the learner.
Learner	7. Follow the remediation plan included in the written warning.

Administrator / Education Leader	8. Determine, in collaboration and at the end of the written warning period, and take action on one of the following: 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 9. 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. 10. 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.

Probation

Education Leader	11. Determine remediation plan to address deficiencies with the learner; include metrics to measure success when applicable. a. MCCMS reserves the right to dismiss the learner without formal warning or probation in certain non-academic deficiency cases. i. Consult with Human Resources and Legal in cases of dismissal without formal warning or probation.
Administrator and/or Program Director	12. Approve the remediation plan. 13. Generate and sign the probation document. 14. Issue the probation document to the learner.
Learner	15. Choose, within five business days, one of the following actions: a. Accept the probation. b. Appeal the probation. c. Resign from the program if option is offered. 16. Follow the remediation plan included in the probation document.
Administrator	17. 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: a. Remove the learner from probationary status. b. Extend the probationary period, if applicable. c. Dismiss the learner. d. Accept learner's resignation.

Dismissal

Administrator / Program Director	18. Notify the learner of the decision of dismissal, and whether or not resignation is an option. 19. Provide both a dismissal document and any relevant policies to the learner.
Learner	20. Choose, within five business days, one of the following actions: a. Accept the dismissal.

	b. Submit a resignation, if permitted, effective at a mutually acceptable date (resignation forfeits option to appeal). c. Appeal the dismissal (forfeits option to resign).
Administrator or Designee	21. Initiate school's check out process, if dismissed. a. Notify appropriate departments, e.g. Human Resources, Payroll, etc. b. Notify the Director of Financial Aid, Payroll or Student Services, as applicable, of the dismissal.

Appeal

Learner	22. 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	23. Provide acknowledgement in writing of receipt of appeal to learner within 48 hours. 24. Verify Dean received receipt of appeal.
Dean of School	25. Notify the Executive Dean of MCCMS that a learner has submitted an appeal. 26. Determine if the site Chief Executive Officer needs to be notified, in accordance with the Notification of Leadership Regarding Extraordinary Events.
Administrator	27. 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. 28. Provide details of Appeal Committee in writing to learner, e.g. date, time, location, etc., when meeting date is confirmed. 29. Advise learner to provide an appropriate written reason for appeal with any supporting documentation.
Learner	30. Submit written reason for appeal with any supporting documentation to the Administrator at least ten business days before the Appeals Committee meets.
Appeal Committee	31. Review relevant information. 32. 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. 33. 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. 34. Meet with learner on scheduled Appeal Committee date to hear their summary of basis for appeal. 35. Hear any needed stakeholder and/or witness accounts at the Appeal Committee meeting.

	36. 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: i. Uphold the dismissal. ii. Overturn dismissal, place in probationary status with remediation plan. c. Appeal against negative Title IX determination: 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. 37. Provide learner with written documentation of decision within 5 business days after the Appeal Committee meeting date. 38. Provide a written determination of any Title IX appeal, summarizing the reasoning behind the determination, to the Title IX Coordinator.
Administrator	39. 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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