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OUR 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..

OUR PRIMARY VALUE

The needs of the patient come first.

OUR VALUE STATEMENTS

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

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

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

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.

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

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

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

MAYO GRADUATE SCHOOL MISSION

Mayo Graduate School's overriding mission 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 Mayo Graduate School is to promote an academic environment that supports trainee and faculty development and facilitates biomedical innovation.

2011-2012 ACADEMIC CALENDAR

Summer Quarter

Registration for summer quarter courses due – June 17, 2011
Independence Day Holiday (observed) – July 4, 2011
Summer quarter begins – July 5, 2011
Last date to register or withdraw – Before one-half of the course is completed
Labor Day Holiday – September 5, 2011
Last day of quarter – September 23, 2011

Fall Quarter

Registration for fall quarter courses due – September 9, 2011
Fall quarter begins – September 26, 2011
Last date to register or withdraw – Before one-half of the course is completed
Thanksgiving Holiday – Thursday, November 24, 2011
Last day of quarter – December 16, 2011

Winter Quarter

Registration for winter quarter courses due – December 16, 2011
Winter quarter begins – January 3, 2012
Last date to register or withdraw – Before one-half of the course is completed
Last day of quarter – March 23, 2012

Spring Quarter

Registration for spring quarter courses due – March 16, 2012
Spring quarter begins – April 2, 2012
Last date to register or withdraw – Before one-half of the course is completed
Memorial Day Holiday – May 28, 2012
Last day of quarter – June 22, 2012

2012-2013 ACADEMIC CALENDAR

Summer Quarter

Registration for summer quarter courses due – June 15, 2012
Independence Day Holiday (observed) – July 4, 2012
Summer quarter begins – July 2, 2012
Last date to register or withdraw – Before one-half of the course is completed
Labor Day Holiday – September 3, 2012
Last day of quarter – September 21, 2012

Fall Quarter

Registration for fall quarter courses due – September 7, 2012
Fall quarter begins – September 24, 2012
Last date to register or withdraw – Before one-half of the course is completed
Thanksgiving Holiday – Thursday, November 22, 2012
Last day of quarter – December 14, 2012

Winter Quarter

Registration for winter quarter courses due – December 7, 2012
Winter quarter begins – January 2, 2013
Last date to register or withdraw – Before one-half of the course is completed
Last day of quarter – March 22, 2013

Spring Quarter

Registration for spring quarter courses due – March 15, 2013
Spring quarter begins – April 1, 2013
Last date to register or withdraw – Before one-half of the course is completed
Memorial Day Holiday – May 27, 2013
Last day of quarter – June 21, 2013

MAYO CLINIC

Terrence L. Cascino, M.D.
Juanita Kious Waugh Executive Dean for Education

Paula E. Menkosky
Chair, Department of Education Administration

Eddie L. Greene, M.D.
Director, Office for Diversity

MAYO GRADUATE SCHOOL

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Kim Wolfgram Salz
Administrator

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Administrator, Mayo Clinic in Arizona

Nell E. Robinson
Administrator, Mayo Clinic in Florida

INTRODUCTION

HISTORY

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

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

Mayo awarded its first Ph.D. degree in 1917 in affiliation with the University of Minnesota. Since 1984, Mayo has been an independent, degree granting institution. In January 1989, Mayo Graduate School became a separate unit that administers Ph.D. and Master's degree programs in the biomedical sciences. Enrollment currently includes approximately 160 Ph.D. or M.D.-Ph.D. candidates, and 100 Master's candidates in biomedical science fields and 300 research fellows involved in post-doctoral basic science research training. Other educational components of Mayo Clinic include:

- Mayo School of Graduate Medical Education, organized in 1915 to offer programs of graduate medical education. Enrollment currently includes nearly 1,500 residents and fellows in clinical fields.
- Mayo Medical School, an undergraduate medical school offering the M.D. degree, opened in 1972. Current enrollment includes over 180 students.
- Mayo School of Health Sciences, organized in 1973 to provide training and certification in the health professions allied to medicine. Over nearly 50 programs are offered with an enrollment of more than 1,500.
- Mayo School of Continuous Professional Development, organized in 1977 to provide continuing education for physicians, through the staff of Mayo Clinic.

Mayo Clinic is accredited by The Higher Learning Commission and is a member of the North Central Association, 230 South LaSalle Street, Suite 7-500, Chicago, Illinois, 60604, www.ncahlc.org, (800) 621-7440.

College of Medicine, Mayo Clinic is registered as a private institution with the Minnesota Office of Higher Education pursuant to 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 3,700 plus faculty members include full-time investigators in the sciences related to medicine, 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 medical 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. Please see listing of graduate faculty and their research interests on the Mayo Graduate School intranet site:
http://mayoweb.mayo.edu/mgs/documents/ListofEligibleMentors.xls

FACILITIES

The majority of the educational programs, clinical practice and research are conducted within the facilities of Mayo Clinic, located in downtown Rochester, Minnesota. Mayo Clinic in Jacksonville, Florida; and Phoenix and Scottsdale, Arizona, also participate in Mayo's clinical practice, education and research programs.

TELECOMMUNICATIONS SYSTEM

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.

ROCHESTER

Campus
The research activities in Rochester are centered in the Gonda, Guggenheim, Hilton, Opus, Stabile and Medical Sciences Buildings. Study areas and computer labs can be found in the Mitchell Student Center and administrative offices are located in the Guggenheim Building.

The Plummer Building houses Mayo's medical library system, one of the largest in the world, containing more than 350,000 bound volumes and 4,300 medical and scientific journal subscriptions, as well as study areas. Access to extensive online medical database resources is readily available. Patient-care activity is centered in the Mayo, Baldwin, and Gonda Buildings. These interconnected buildings, together with

Rochester Methodist Hospital, comprise the core of Mayo's clinical facilities in downtown Rochester. Saint Marys Hospital, located three blocks west of the downtown campus, and Rochester Methodist Hospital are integral to the education programs, providing essential clinical care experiences for students and trainees.

Community
With a population of more than 175,000, Rochester and its surrounding communities have the livable qualities of a medium-size town while offering many big-city amenities. It is a dynamic midwestern city that combines friendliness and geographical compactness with a cosmopolitan flavor. Money magazine has consistently ranked Rochester among the "best places to live" in the United States, based on its quality of life, excellent schools, reasonable cost of living, and affordable housing market.

Rochester offers a stimulating combination of arts and entertainment and education, plus a four-season calendar of sports and recreation. Active civic music and theater programs provide opportunities to participate and enjoy the arts. The University of Minnesota Rochester offers many graduate and postgraduate programs.

The Twin Cities of Minneapolis and St. Paul are an easy 75-minute drive to the north – providing access to metropolitan shopping, sporting and cultural events, and dining. Among the many attractions are the nationally recognized Guthrie Theater, Minnesota Orchestra, Walker Art Center and Mall of America. Both collegiate and professional baseball, basketball, football and hockey teams are based in the Twin Cities.

FLORIDA

Campus
Mayo Clinic in Florida was established in 1986 as a comprehensive medical facility in the southeastern United States, where advanced programs in education and research support the highest-quality patient care.

Mayo Clinic achieved the vision of establishing an integrated campus on April 12, 2008, when the Mayo Clinic Hospital opened on the campus. The hospital combines the best of high technology with quality patient care and attention to detail. Modern equipment and advanced technologies are used in a nurturing, friendly environment, merging the art of healing with the science of medicine. Additionally, Mayo Clinic in Florida will open a multidisciplinary simulation center in the spring of 2011 to take advantage of new technology to advance the delivery of medical education.

Researchers at Mayo Clinic enjoy state of the art facilities on the integrated campus. The Birdsall Medical Research Building allows researchers to investigate neurological diseases such as Alzheimer's and Parkinson's. The Griffin Cancer Research Building was completed in 2001 to support Mayo's many cancer studies.

Community
The city of Jacksonville, built along the Atlantic Ocean and the St. Johns River in north Florida, is home to more than one million residents. Known for its miles of beautiful beaches, Jacksonville attracts many

visitors for surfing, swimming, wind surfing, fishing and water skiing.

Tennis and golf are also highly popular activities in the region. The international headquarters for the Association of Tennis Professionals (ATP) and the national headquarters of the Professional Golf Association of America are located in Jacksonville.

Jacksonville is home to the annual Gator Bowl and the National Football League team, the Jacksonville Jaguars. Jacksonville University and the University of North Florida field college basketball and baseball teams.

Jacksonville has five regional shopping centers, a zoo, two major museums, eight galleries, a symphony orchestra, and several theaters and nightclubs. The educational system offers nearly 250 public and private schools and 14 regional colleges and universities.

The nationally famous Jacksonville Jazz Festival is held each year in Metropolitan Park and the renowned Jazz Keyboard Competition is held annually at the Florida Theatre.

Mayo Clinic hosts the National Marathon to Finish Breast Cancer annually in February. Proceeds from the event are designated to Mayo Clinic's Cancer research. Mayo Clinic also sponsors a cycling team which raises money to support research for transplant, diabetes and multiple sclerosis. Mayo Clinic faculty, staff and students have many opportunities to enjoy the outdoors while increasing awareness and funding to support our mission of advancing the science of healing.

ARIZONA

Campus

Mayo Clinic in Arizona opened in 1987 as a premier academic medical center in the southwestern United States, where medical research and education are fully integrated with delivering the highest-quality patient care. Campuses are located both in Scottsdale and Phoenix. Both campuses offer excellent education facilities, including classrooms, lecture halls, Simulation Center, Center for Procedural Innovation, and extensive library and computer services.

Patient care activity on the Scottsdale campus is centered around a beautiful five-story outpatient clinic. This modern facility contains an outpatient surgery center, a full-service laboratory, a pharmacy, a patient-education library, a staff medical library, an endoscopy suite and a 188-seat auditorium for patient, staff and student education programs.

The Samuel C. Johnson Research Building and the Mayo Clinic Collaborative Research Building on the Scottsdale campus houses Mayo Clinic scientists, trainees, and students using molecular biological, cell biological and genetic, and clinical and translational approaches to understand and treat cancer, immune disorders, and other diseases as well as scientists, trainees and students from Arizona State University and TGen (The Translational Genomics Research Institute).

The state-of-the-art 244-bed Mayo Clinic Hospital in northeast Phoenix opened in 1998 and is the first

hospital entirely designed and built by Mayo Clinic. It has been recognized as "the Best Hospital in Phoenix" many times by Phoenix magazine. Also on the Phoenix campus are the new Mayo Clinic Specialty Building and the Mayo Clinic Support Services Building. The Phoenix campus also includes a Child Care Center, on-campus hotel accommodations, the Arizona Transplant House, American Cancer Society-Hope Lodge, and Hospice of the Valley.

Community

Scottsdale is located in the beautiful Sonoran Desert and is one of several cities comprising greater Phoenix, Arizona – the Valley of the Sun, a metropolitan area of over 4.5 million. Scottsdale's 217,000 residents enjoy a vibrant mix of cultural and recreational opportunities. It has a nationally recognized park system, championship golf courses, tennis courts, and miles of hiking, biking and equestrian trails. Several lakes just east of the city are popular places for weekend fishing and boating.

Scottsdale is one of the world's foremost art communities, and is home to more than 125 art galleries and museums. The Scottsdale Center for the Arts hosts exhibits, music and dance performances, live adult and children's theater, and outdoor concerts and festivals year-round.

Sports fans will find collegiate and professional football, basketball, baseball and hockey teams in the Phoenix area. Regional attractions include hiking and rafting in the Grand Canyon and Sedona red rock area, and snow skiing two hours away, near Flagstaff. Various vacation opportunities are nearby in California, Nevada, and Mexico, and the ski resorts of northern Arizona and the western Rocky Mountains.

Scottsdale has over 5,500 retail shops, ranging from specialty boutiques and major department stores to outlets and malls. There are 90 public and private schools and two colleges within the city limits. Arizona State University-Tempe and University of Arizona-Phoenix are nearby.

GRADUATE STUDENT ASSOCIATION

The Mayo Graduate Student Association is comprised of Ph.D. students pursuing graduate degrees at Mayo Graduate School. Membership includes a representative from each track, a representative from the first year students, representatives from Arizona and Florida, a Mayo Graduate School Education Committee member, a representative from the M.D.-Ph.D. program, and the past president. Its purpose is to facilitate interaction among graduate students, and among students, faculty and administration. It provides a means for students to give input concerning coursework and curriculum and other Mayo Graduate School issues.

POLICIES

STIPENDS

Students accepted into the Ph.D. program receive a fellowship grant which includes a stipend and tuition and fees. The stipend, provided by Mayo Graduate School, continues until successful thesis defense or up to five years, whichever comes first, contingent upon satisfactory performance. Students have up to six months after defense for completion of all requirements. This rule does not imply that it is with stipend. Support for additional years beyond the fifth must be provided by the advisor. Stipends for all graduate students are set at a uniform level ($26,750 for 2011-2012) and are reviewed at regular intervals.

Students who are accepted into the M.D.-Ph.D. program are provided a stipend. The stipend is provided by Mayo Medical School while the student is in medical school. Mayo Graduate School 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 advisor. Mayo Medical School and Mayo Graduate School tuition and fees are provided by a full scholarship for students accepted into this combined M.D.-Ph.D. program, with satisfactory performance.

Clinical residents and research fellows accepted into the Master's program receive the usual stipend for residents or fellows at their level of training.

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

TUITION

Annual tuition for graduate students is $24,500 for Ph.D. students and $12,250 for Master's students. Tuition is $400 per quarter credit. Tuition is provided by a full scholarship for students who are enrolled in the Ph.D and M.D.-Ph.D. degree programs of Mayo Graduate School. Extramural sources of funds are used to defray tuition when appropriate.

REGISTRATION

Registration for Mayo Graduate School courses is accomplished through the Registrar's Office and must be made in writing before the applicable deadline (see Academic Calendar). Mayo courses are primarily intended for individuals appointed to the degree programs of Mayo Graduate School. Others may enroll if they show appropriate prerequisites and secure the course director's approval. Enrollment in some courses is severely limited; degree candidates are given preference for these courses. Registration forms are available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

Registration for credit

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

Changes in registration

- The current tuition refund policy is available on the Financial Aid intranet site at *http://mayoweb.mayo.edu/financialaid/pol-tuition.html*. Withdrawal forms are available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.
- **Retroactive registration after a course is completed is not permitted.**
- Students who wish to register for a course after the registration deadline date must have written permission from the course director. Students will be allowed to register for courses up to 50% of completion. Late registration forms are available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

GRADING SYSTEM

Mayo Graduate School uses two grading systems:

A	Outstanding
A-	Excellent
B+	Very Good
B	Acceptable
B-	Marginal/below standards expected
C+	Below standards
C	Poor/lowest performance to receive credit
F	Unsatisfactory

S	Satisfactory
N	No credit

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" or "N" is not considered in determination of GPA. A grade of "F" is considered in determination of the GPA. 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 cumulative credits for courses in which they received an "F" grade.

In addition to the grades, the transcripts show the following, if applicable:

I Incomplete. 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.

R Indicates a student registered for a course, did not attend and did not officially withdraw.

W Withdrawn

X Continuous registration. 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 Graduate Program Director and the course director. The higher grade will appear on the transcript and will be used in computation of the GPA.

DEFINITION OF CREDIT HOUR

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

COURSE NUMBERING

Graduate courses are designated with a 5---, 6---, or 8--- number. The 5--- level courses are introductory graduate courses, the 6--- level courses are Mayo Graduate School core courses, and the 8--- level courses are considered to be at the boundary of what is known or done in a particular field. They can be expected to be exceptionally rigorous.

RESIDENCE REQUIREMENT

Regardless of how many transfer credits are awarded, candidates for graduate degrees from Mayo Graduate School 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, and for Master’s degree candidates the period is one year.

TRANSCRIPT REQUEST

Official transcripts will be issued by the Registrar’s Office only upon receipt of a written request with the student’s signature and social security number. E-mail requests will not be accepted.

Transcript Request forms can be found on the Mayo Graduate School website at *http://mayoweb.mayo.edu/mgs/forms.html*

STUDENT RESPONSIBILITY

Each graduate student must complete all requirements for a degree established by Mayo Graduate School and the student's track. It is the student's personal responsibility to be aware of and to understand these requirements. A student's advisor 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 Mayo Graduate School. Mayo Graduate School reserves the right to modify requirements at any time.

EXTENSIONS

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

Extension Request forms can be found on the Mayo Graduate School website at *http://mayoweb.mayo.edu/mgs/forms.html*

CONFIDENTIALITY OF STUDENT RECORDS

The Family Educational Rights and Privacy Act (FERPA) affords students certain rights with respect to their education records.

The FERPA policy is available on the Mayo intranet at *http://mayoweb.mayo.edu/mccm-policies/ferpa.html*

EQUAL OPPORTUNITY/AFFIRMATIVE ACTION

Mayo Graduate School is committed to equal opportunity and affirmative action in the appointment process. This policy is in accord with the policy of Mayo Clinic which is to seek and select persons for appointment, employment or admission, and to train, advance, promote, transfer and compensate such persons on the basis of individual capability, potential or contribution to the programs and goals of the institution. In making these selections and subsequent personnel decisions, Mayo Clinic is committed to

pursuing affirmative action efforts to strengthen the participation of women, minorities, veterans, and persons with disabilities.

Additionally, Mayo Clinic respects, supports, and observes the laws, directives, and regulations of the state and federal laws that prohibit discrimination. Each department chair, administrator, supervisor and employee of Mayo Clinic is responsible for conducting appointment and employment activities in support of and in compliance with this policy.

Mayo Graduate School policies and procedures are available on the Mayo Graduate School intranet site (*http://mayoweb.mayo.edu/mgs-policies/*).

DESCRIPTION OF PH.D. DEGREE PROGRAM AND BASIC SCIENCE TRACK REQUIREMENTS

THE DOCTOR OF PHILOSOPHY PROGRAM IN BIOMEDICAL SCIENCES

Purpose and Philosophy

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

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

Mayo'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 forty-two credits is required of all Ph.D. students. Mayo'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 registration at Mayo to be eligible for the degree.

ADMISSIONS REQUIREMENTS

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

1. Hold a bachelor's degree from an accredited college or university with a minimum 3.0 grade point average based on the 4.0 scale.

2. Received scores on the verbal, analytical, and quantitative aptitude tests of the Graduate Record Examination indicating strong academic ability.

3. Completed at least one year of coursework, with demonstrated competence (B average or above), in the following undergraduate courses:
   Biology
   Calculus
   Chemistry
   Physics

   In addition, foundation courses in biochemistry, molecular biology, cell biology and physiology are highly recommended.

   Biomedical Engineering students are encouraged to have courses in quantitative science and engineering (e.g., signal processing, computer science, instrumentation).

4. Supply supporting documents, including:
   Official transcripts
   Official copies of GRE or MCAT scores
   Three letters of recommendation

Foreign applicants must take the Test of English as a Foreign Language (TOEFL) to be considered for an appointment.

Each track may establish additional requirements.

Inquiries regarding admission to the Ph.D. Program in the Biomedical Sciences should be directed to:

Mayo Graduate School
200 First Street Southwest
Rochester, MN 55905
(507) 538-1160
phd.training@mayo.edu

Completed applications must be submitted by December 1. Applications submitted or completed after this date may be considered on a space-available basis. Authority to make appointments rests with the Mayo Graduate School Education Committee. The application fee is $30.00.

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 Mayo Graduate School upon receipt.

The average number of years to degree is 5.25.

CORE COURSES

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

Summer		
Core 6150	Genome Biology (begins in late July or early August)	3 cr.
Fall		
Core 6100	Chemical Principles of Biological Systems	3 cr.
Core 6200	Basic Graduate Immunology	3 cr.
Winter		
Core 6250	Molecular Cell Biology	3 cr.
Core 6400	Molecular Genetics	3 cr.
Core 6700	Integrative Systems Physiology	3 cr.
Spring		
Core 6050	Critical Thinking and Scientific Writing	2 cr.
Core 6300	Molecular Biophysics	3 cr.
Core 6450	Molecular Pharmacology and Receptor Signaling	2 cr.
Core 6510	Molecular Mechanisms of Human Disease	3 cr.
Core 6650	Biostatistics	2 cr.
Core 6770	Virology and Gene Therapy	3 cr.
**Core 6000	Responsible Conduct of Research	1 cr.

*Students in Biomedical Engineering are not subject to the same core requirements. Please refer to the specific Biomedical Engineering track requirements.
** Required of all students.

AREA OF SPECIALIZATION/TRACK

In addition to the core courses, track courses are also required. These courses are chosen with the aid and approval of the student's advisor. Courses required by the different tracks are outlined in the next section. Any remaining credits needed to meet the 42 required credits may be selected from any area that the student and advisor deem appropriate and necessary.

The typical program structure is as follows:

Year I Core, track course work, and laboratory rotations

Year II Advanced courses and commencement of thesis research

Year III, IV, & V Primarily thesis research with some additional advanced courses, seminars and journal clubs

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

LABORATORY ROTATIONS

Each student must complete three laboratory rotations in three different laboratories for six credits. Rotations must be done in the laboratories of faculty with full graduate faculty privileges. These credits count towards the track credits required. Students who have participated in a Mayo Summer Undergraduate Research Fellowship (SURF) or the Mayo Post-baccalaureate Program may request to substitute this experience for one lab rotation. Students entering the Ph.D. program with a relevant Master's degree may petition Mayo Graduate School to waive one laboratory rotation. A minimum of 42 credits will still be required for graduation.

List of Faculty with Full Privileges
http://mayoweb.mayo.edu/mgs/documents/ListofEligibleMentors.xls

M.D.-PH.D. PROGRAM

The M.D.-Ph.D. program is a highly competitive program for students with exceptional academic records and previous research experience. Both the M.D. and Ph.D. degrees may be attained in an integrated seven to eight year program. Students follow the Mayo Medial School curriculum for two years. Step 1 of the United States Medical Licensing Examination must be taken by the end of May of the second year and a passing score must be documented before entry into the Ph.D. phase of the dual degree. Students then begin the Mayo Graduate School training. The advanced course work in the track and the thesis research

are undertaken and usually completed in the next three to four years. During the final year and a half, students complete the Mayo Medical School curriculum.

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

Core	6000	Responsible Conduct of Research
Core	6100	Chemical Principles of Biological Systems (all tracks except BME)
Core	6150	Genome Biology
Core	6300	Molecular Biophysics (required for BME)

Plus two additional courses from the list of intermediate and advanced quantitative biology courses*:

BMB	8000	Biological Macromolecules
BMB	8030	Data Analysis and Mathematical Modeling in Biomedical Research
BMB	8040	Fractals and Chaos in Biosciences
BMB	8050	Biological Kinetics
BMB	8350	Introduction to Bioinformatics
BMB	8675	Protein Structure and Dynamics
BME	8350	Advanced Concepts in Molecular Biophysics
Core	6300	Molecular Biophysics
Core	6650	Biostatistics (strongly recommended unless taken as an undergraduate)
CTSC	5600	Statistics in Clinical Research
CTSC	5601	Utilizing Statistics in Clinical Research
CTSC	5610	Introductory Statistical Methods II
CTSC	5740	Systematic Reviews and Meta-Analyses
CTSC	5750	Survival Analysis for Biomedical Applications

*BME students satisfy this requirement through BME track required courses.

M.D.-Ph.D. students are also required to take two M.D.-Ph.D. selectives

MDPD	5100	Bioinformatics Selective
MDPD	5150	Medical Scientist Survival Skills

The laboratory rotation requirement for M.D.-Ph.D. students is satisfied by completing three one-month, full-time rotations. It is recommended that one rotation be completed before entering medical school, the second between the first and second years of medical school, and the third between medical school and graduate school (after USMLE Step 1).

MDPD 5000 Laboratory Rotation is for M.D.-Ph.D. Students

Students are expected to maintain a grade point average of 3.90 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 Guidelines for Program and Dismissal outlined on the Mayo Graduate School intranet at *http://mayoweb.mayo.edu/mgs-policies/probation-dismissal.html*.

ADVISOR

A Ph.D. degree mentor must have full graduate faculty privileges. The complete list of faculty with graduate privileges begins on page 113.

List of Eligible Mentors
http://mayoweb.mayo.edu/mgs/documents/ListofEligibleMentors.xls

OFFICIAL DEGREE PROGRAM FORM

Students are expected to file an official Degree Program form before December 31 of their second academic year. This form lists all course work completed and proposed to fulfill degree requirements, including transfer credits. Fifty percent of the credits on the degree program must be graded on the A-F grading system. The Degree Program form is available on the Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html.*

CHANGES IN APPROVED PROGRAM

The approved degree program must be fulfilled in every detail to meet graduation requirements. Alterations in the program must be requested in writing and approved by the track Graduate Program Director and Mayo Graduate School.

MINIMUM GRADE REQUIREMENTS

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Guidelines for Probation and Dismissal outlined on the Mayo Graduate School intranet at

http://mayoweb.mayo.edu/mgs-policies/probation-dismissal.html.

TRANSFER CREDITS

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

Elective Course Policy
Students who wish to transfer graduate credits to substitute for a Mayo elective course must contact the Mayo course director and their Graduate Program Director. If the course director and the Graduate Program Director determine that a student has the knowledge equivalent to satisfactory performance in the Mayo course, the student may request the transfer credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Core Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a Mayo core course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive core course credits, the student is required to prove competence by taking an exam 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 core course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Track Required Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a track required course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive track required course credits, at the Mayo course director and the Graduate Program Director's discretion the student is required to prove competence by taking an exam 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 track required course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

External Courses Policy
Students who wish to transfer credits not in substitution for a Mayo course(s) may request credit for graduate courses taken at another institution if they received a grade of A or B. The request must have the approval of the student's Graduate Program Director and MayoGraduate School. A description of the course from the course catalog or a course outline must accompany the request. The time interval since the credits were earned is a consideration in such decisions. Credits must normally have been earned within the previous five years, as determined by the Graduate Program Director.

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 Examination: The written qualifying examination must be completed before September 30 of the third year for Ph.D. students and December 31 of the second year for M.D.-Ph.D. students. Mayo Graduate School must be informed of the exam date three weeks in advance so that the Ph.D. Written Qualifying Examination Report form can be sent to the exam chair. The written 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 may be taken no more than twice. If it is not passed on the first attempt, it must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination twice will result in dismissal.

Oral Qualifying Examination Committee: Oral qualifying exam committee composition requires approval of the Graduate Program Director and the Mayo Graduate School Education Executive Committee before September 30 of the third year for Ph.D. students and December 31 of the second year for M.D-Ph.D. student. All members must have graduate faculty privileges.

The oral qualifying exam committee must consist of:

- A minimum of four members from four different independent research programs
- Three of the four must have full graduate faculty privileges, including the committee chair
- Two of the four must have graduate faculty privileges in the student's degree track
- Two of the four must be designated by the Graduate Program Director as experienced examiners

The Ph.D. Oral Qualifying Exam Committee form is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

List of Graduate Faculty with Privileges
http://mayoweb.mayo.edu/mgs/documents/ListofFacultywithPrivileges.xls

List of Designated Qualifying Oral Examiners
http://mayoweb.mayo.edu/mgs/documents/DesignatedQualifyingOralExaminers.pdf

Oral Examination: When Mayo Graduate School is notified that the written examination has been passed, the oral qualifying examination may be taken. Mayo Graduate School must be informed of the date of the examination three weeks in advance so that the Ph.D. Oral Qualifying Examination Report form can be sent to the oral qualifying committee chair. The oral qualifying examination must be completed before December 31 of the third year for Ph.D. students and December 31 of the second year for M.D.-Ph.D. students. All approved committee members must be present at the exam. Only one dissenting vote will be allowed for a "Pass" or "Conditional Pass." In the event of a Conditional Pass, the specific requirements that must be satisfied by the student will be listed on the back of the Ph.D. Oral Qualifying Examination Report form. The oral qualifying examination may be taken no more than twice. If it is not passed on the first attempt, it must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination twice will result in dismissal.

THESIS

Thesis Advisory Committee: Ph.D. candidates are expected to submit to the Mayo Graduate School office the composition of their Thesis Advisory Committee no later than December 31 of the student's third year. M.D.-Ph.D. students are expected to submit to the Mayo Graduate School office the composition of their Thesis Advisory Committee no later than December 31 of their first year in the Ph.D. program. The student's advisor, who is chair of the committee, must have full graduate faculty privileges.

Thesis advisory committee composition requires approval of the Graduate Program Director and the Mayo Graduate School Education Executive Committee. All members must have graduate faculty privileges.

The Thesis Advisory Committee must consist of:

- A minimum of five members from five different independent research programs (one of the five may be an external examiner)
- Three of the five must have full graduate faculty privileges, including the committee chair
- Two of the five must have graduate faculty privileges in the student's degree track
- Two of the five must have mentored a student to degree

The Ph.D. Thesis Advisory Committee form is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

The List of Eligible Mentors is available on the Mayo Graduate School intranet site and lists all graduate faculty with full faculty privileges: *http://mayoweb.mayo.edu/mgs/forms.html*

The List of Graduate Faculty with Privileges is available on the Mayo Graduate School intranet site and lists all graduate faculty with privileges.
http://mayoweb.mayo.edu/mgs/forms.html

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

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

Preparation of thesis: The thesis is the most important document that the Ph.D. candidate will prepare during the course of graduate study and is a record of the scientific accomplishments that justify the awarding of the degree. The thesis is archival. Consequently, Mayo Graduate School has developed standards for its format and style, which should be closely followed. Guidelines for Ph.D. thesis are available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*. The student's advisor must sign a form indicating that he/she has read the thesis and that it is ready for defense prior to distribution to the committee members. The Verification that the Thesis is Ready to Defend form,

can be accessed on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*. The thesis must be submitted to the Thesis Advisory Committee at least three weeks prior to the final examination.

Students enrolled in the M.D.-Ph.D. program must submit their final thesis to their Thesis Advisory Committee and the Verification of Thesis Corrections form must be signed and submitted to the Mayo Graduate School office before they can resume studies in Mayo Medical School.

STUDENT PROGRESS

Students must have meetings every six months with their Thesis Advisory Committee. Ph.D. students will be required to enter on all registration forms the date of their last progress meeting beginning with the first required meeting at 2.5 years. If the date is not entered, students will not be registered and the form will be returned to them. Students are also expected to register each quarter and will be contacted if they have not registered.

M.D.-Ph.D. students should form their thesis committee by December 31 of their first year in the Ph.D. phase of the program and have a thesis committee meeting prior to December 31 of their second year in the Ph.D. phase of the program and every six months thereafter.

To remain in good standing, compliance with these requirements is expected. Continuation of stipend depends upon remaining in good standing.

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. Students are required to indicate in publications their affiliation with and support from Mayo Graduate School. Exceptions to the publication requirement must be submitted as a recommendation from the Thesis Advisory Committee with approval determined by the Mayo Graduate School Education Committee. This policy is effective April 1, 2008.

FINAL ORAL EXAMINATION

The final oral examination will be scheduled after 1) the qualifying written and oral examinations have been passed, 2) all course work shown on the Degree Program form has been completed and 3) a copy of the title page of the thesis is filed in the Mayo Graduate School office. Mayo Graduate School must be informed of the date of the examination three weeks in advance so that the Ph.D. Final Oral Examination Report form can be sent to the Thesis Advisory Committee chair. The exam will be open to the Mayo

public. Members of the Thesis Advisory Committee should receive copies of the thesis at least three weeks prior to the final oral examination.

One dissenting vote will be allowed for a "Pass." Any member of the Thesis Advisory Committee not present in real time via physical presence or video- or teleconferencing at the Final Oral Exam is counted as a "Fail" vote. Thus, no more than one Thesis Advisory Committee member may be absent for the Final Oral Exam. If more than one committee member feels the candidate did not pass, a determination of "Fail" must be made. The final oral examination may be taken no more than twice. If it is not passed on the first attempt, it must be retaken by the end of the quarter following the quarter in which the exam was first taken. Failing the examination twice will result in dismissal.

FINAL THESIS CORRECTIONS

After the student has passed the final oral examination, members of the Thesis Advisory Committee must sign a form indicating they are satisfied that the final corrections to the thesis have been made. Four of the five committee members must have signed before the student will be cleared for graduation. Mayo Graduate School will not certify completion of degree requirements until the final thesis has been submitted.

GRADUATION DEADLINE

Students are granted degrees four times a year: February, August, November and mid May. The latter involves a formal ceremony as part of the Mayo Clinic graduation exercises in conjunction with Mayo Medical School. 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.

To graduate in February, August or November students must have all requirements completed by the first working day of the month prior to the graduation month. To graduate in May, students must have a draft of the thesis to their advisor by March 8 and their thesis defense scheduled. All other requirements must be completed by April 8, except submittal of the thesis. The final copy of the thesis must be submitted one week before graduation day.

Students are allowed no more than six months to complete M.S. or Ph.D. degree requirements after a successful thesis defense. This policy is effective October 1, 2004. If a student does not meet the thesis deadline, he/she will be required to re-defend his/her thesis.

Graduation deadlines:

To graduate in:	**Requirements must be completed by:**
February	January 1

May	– Draft of thesis to advisor and defense scheduled by March 8
	– All requirements completed by April 8, except submittal of final thesis
	– Thesis submitted at least 1 week before graduation
August	July 1
November	October 1

BIOCHEMISTRY AND MOLECULAR BIOLOGY

P. C. Harris, Ph.D., *Graduate Program Director*
D. J. Katzmann, Ph.D., *Education Coordinator*

Biochemistry and Molecular Biology Track:
Biochemistry and Structural Biology; Cell Biology and Genetics; Cancer Biology Subtracks

Ph.D. Degree

I. Minimum Requirements

The Department of Biochemistry and Molecular Biology (BMB) offers a flexible track for graduate 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). The requirements for the BMB track conform to the general requirements of the Mayo Graduate School. A total of 42 credits are required which should include ten credits of specified courses from the core curriculum, six credits of laboratory rotations, two credits of BMB Works in Progress (BMB 5200), two credits of BMB Journal Club (BMB 8500), two credits for the Thesis Proposal, six credits of Intermediate courses, eight credits of Advanced courses and six elective credits. Four credits can come from Other Journal Clubs, that count toward the Advanced (two) and Elective (two) credits.

II. Course Work

Core Courses (10 credits required)

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

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

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

*In special circumstances and after completion of 3 rotations, a shorter rotation may be allowable at the discretion of the GPD.
M.D.-Ph.D. students satisfy this requirement with three one-month full-time rotations.

Track Requirements (6 credits required)

BMB	5200	BMB Works in Progress (1 cr./yr.)*	2 cr.
BMB	8500	BMB Journal Club (1 cr./yr.)**	2 cr.
BMB	8900	BMB Thesis Proposal	2 cr.

*Two credits maximum. Students must attend all years enrolled in the program and present annually after

Year 1. At least 70% attendance is required.
**Two credits maximum. Students must attend all years enrolled in the program and present annually at the journal club and also attend the associated BMB Seminar. At least 70% attendance is required at both the journal club and seminar.

Intermediate Courses (6 credits required)

BMB	5000	Introduction to Cancer Biology	3 cr.
BMB	5400	Developmental Biology	2 cr.
Core	6050	Critical Thinking and Writing	2 cr.
Core	6300	Molecular Biophysics	3 cr.
Core	6400	Molecular Genetics	3 cr.
Core	6510	Mechanisms of Human Disease	3 cr.
Core	6650	Biostatistics	2 cr.

Advanced Courses (8 credits required)

BMB	5350	Hormones and Cancer	1 cr.
BMB	8000	Biological Macromolecules	3 cr.
BMB	8030	Data Analysis and Math Modeling In Biomedical Research	3 cr.
BMB	8040	Fractals and Chaos in Bioscience	2 cr.
BMB	8050	Biological Kinetics	3 cr.
BMB	8070	Cancer Biology II: Molecular Mechanisms	3 cr.
BMB	8075	Epigenetics of Cancer and Addiction	3 cr.
BMB	8320	Special Topics in Cancer Biology	1 cr.
BMB	8350	Introduction to Bioinformatics	2 cr.
BMB	8650	Receptor Trafficking and Signaling	2 cr.
BMB	8660	Transcription, Chromatin and Epigenetics	2 cr.
BMB	8665	DNA/Protein Interactions, Repair, Replication and Recombination	2 cr.
BMB	8675	Protein Structure and Dynamics	2 cr.

Electives (6 credits required)

Any courses approved for graduate credit.

Other Journal Clubs (maximum of 4 credits: 2 Advanced and 2 Elective)

BMB	8510	Cancer Biology Journal Club	1 cr/qtr.
BMB	8520	Current Topics in Aging Research*	1 cr/qtr.
BMB	8801	Concepts of Vesicular Trafficking Journal Club	1 cr/qtr.

Courses to be selected in consultation with your thesis advisor.
* Two credits maximum.

Research

BMB 8890 Research in Biochemistry and Molecular Biology
Must enroll every quarter once a thesis laboratory is selected.
Directed research projects under the supervision of a faculty advisor.

III. Qualifying Exams and Thesis Research

Students are expected to complete their rotations and select the laboratory for their thesis studies within 6 months of joining the program.

Written qualifying exam: Students take the written qualifying exam at the end of the first year. The exam is a two day exam and held on the Friday and Monday flanking the second weekend in July. The first day of the written exam covers the basics of Biochemistry and Molecular Biology as covered in the core courses: Core 6100, Core 6150 and Core 6250. In addition, a limited number of questions are based on the material in the Intermediate Courses, Core 6400 and BMB 5000. Thirty paragraph length answers are required from a total of 40 questions. The second day of the exam consists of demonstrating critical evaluation and understanding of two related published papers. Three sets of papers reflecting the three areas of emphasis of the track: BSB, CBG or CB, are available and the student selects one set of papers from which 15 questions are answered. The exam is prepared and graded by the faculty and a pass rate of 70% is required for both parts of the exam.

Oral qualifying exam: Students are expected to take the oral qualifying exam during the winter of the second year, approximately one year after joining their thesis laboratory. Before taking the exam the student must prepare a final version of their thesis proposal and circulate it to their thesis committee at last 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 the graduate school requirements and be approved by the Graduate Program Director.

Thesis proposal: The written thesis proposal now matches the new format of NIH R01 grants and, hence, is limited to 14 pages, including illustrations but not including references. In the students 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).
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 (2-3 pages).
Innovation: How is the project you are proposing novel and groundbreaking (~1 page)?
Approach: Describes 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 (8-10 pages).

Reflecting the importance the track puts on the quality of this document and the role it plays in planning you thesis studies, 2 credits are given for preparing and defending the proposal.

BIOMEDICAL ENGINEERING

G. C. Sieck, Ph.D., *Graduate Program Director*
S. J. Riederer, Ph.D., *Education Coordinator*

Ph.D. Degree

I. Minimum Requirements

A minimum of 42 credits of course work is required for a Ph.D. in the Biomedical Engineering Track. Nineteen credits must be taken from the basic Biomedical Engineering courses and seven credits must be taken from the core curriculum. Six credits must be taken in laboratory rotations (minimum of three rotations). Ten technical credits are required in the track and may be selected from general courses and four major areas of emphasis in Biomedical Engineering: biomechanics, biomedical imaging, molecular biophysics and physiology. Each area of emphasis may require certain courses to be taken.

II. Course Work

Core and Track Requirements (26 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6300	Molecular Biophysics	3 cr.
*Core	6700	Integrated Systems Physiology	3 cr.
BME	5000	Principles of Biomedical Engineering I	3 cr.
BME	5050	Principles of Biomedical Engineering II	3 cr.
BME	5200	Advanced Engineering Mathematics	4 cr.
*BME	5300	Cell and Neurophysiology	3 cr.
BME	8600	Biomedical Engineering Seminar	1 cr.
BME	8650	BME Journal Club	1 cr.
BME	8704	Digital Signal Processing	4 cr.

* BME M.D.-Ph.D. students may exclude these cores in accordance to the M.D.-Ph.D. core requirements

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

MGS	5102	Lab Rotations (8 weeks)	2 cr.

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

Research

BME 8890 Research in Biomedical Engineering
Must enroll every quarter once a thesis laboratory is selected.
Directed research projects under the supervision of a faculty advisor.

Biomedical Engineering has four major areas of emphasis.

- **Biomechanics**

Emphasis Requirements (11 credits required)

BME	5453	Fundamental Concepts in Biomechanics	3 cr.
BME	5802	Principles of Biomechanics	3 cr.
BME	8857	Tutorial in Cellular Mechanics	2 cr.
BME	8710	Numerical Methods in Biomedical Research	3 cr.

Additional Courses:

BME	5800	Physics and Technical Principles of Medical Imaging	3 cr.
BME	8861	Tutorial in Skeletal Muscle Physiology	2 cr.
BME	8800	Principles of Solid Mechanics	3 cr.
BME	8881	Mechanics of Deformable	3 cr.

- **Biomedical Imaging**

Emphasis Requirements (13 credits required)

Coursework in Imaging (minimum of 5 credits required)

BME	5160	Introduction to Radiation Physics	3 cr.
BME	5740	Magnetic Resonance Imaging Systems	3 cr.
BME	8302	Tutorial in Ultrasonic Imaging	2 cr.

Laboratory Experience (minimum of 2 credits required)

BME	5450	Laboratory Methods in Biomedical Image Processing	3 cr.
BME	8730	Laboratory Methods in Magnetic Resonance Imaging	2 cr.

Additional Mathematics-Related Coursework in two of the following three areas is required with a minimum of 2 credits in each of the areas chosen (minimum of 6 credits required):

Advanced Digital Signal Processing			
BME	8470	2D Digital Signal Processing	4 cr.
BME	8705	Digital Signal Processing II	4 cr.
BME	8770	Fuzzy Logic Theory and Applications	4 cr.

Statistics

CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis	1 cr.
CTSC	5720	Clinical Trials Design and Conduct	1 cr.
Image Processing			
BME	8490	Advanced Topics in Biomedical Image Processing	3 cr.

- **Molecular Biophysics**

Emphasis Requirements (minimum of 11 credits required)

Required:

Core	6100	Chemical Principles of Biological Systems	3 cr.

Choose at least one:

Core	6450	Molecular Pharmacology and Receptor Biology	2 cr.
BME	8350	Advanced Concepts in Molecular Biophysics	4 cr.

Additional Courses

Choose three or more of the following:

BMB	8000	Biological Macromolecules	3 cr.
BMB	8030	Data Analysis and Mathematical Modeling in Biomedical Research	1 cr.
BMB	8050	Biological Kinetics	3 cr.
BMB	8675	Protein Structure and Dynamics	2 cr.
Core	6150	Genome Biology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Core	6400	Molecular Genetics	3 cr.

- **Physiology**

Emphasis Requirements (10 credits required)

BME	8830	Laboratory Methods in Physiology	2 cr.

Additional Courses

Choose at least four of the following:

BME	8870	Systems Physiology I	3 cr.
BME	8871	Systems Physiology II	3 cr.
BME	8872	Systems Physiology III	3 cr.
BME	8000	Tutorial in Exercise Physiology	2 cr.
BME	8300	Tutorial in Neurophysiology	3 cr.
BME	8855	Tutorial in Cardiovascular Physiology	3 cr.
BME	8856	Tutorial in Respiratory Physiology	3 cr.
BME	8858	Tutorial in Smooth Muscle Physiology	2 cr.
BME	8859	Tutorial in Renal Physiology	2 cr.
BME	8860	Tutorial in Endocrine Physiology	2 cr.
BME	8861	Tutorial in Skeletal Muscle Physiology	2 cr.
BME	8862	Tutorial in Neuromotor Control Physiology	2 cr.

III. Qualifying Exam and Dissertation Research

During the first two years of the program, each student is expected to select a laboratory and thesis advisor.

This occurs largely as a result of lab rotations. By the beginning of the second year all students should select an area of emphasis. Students may combine areas. By the end of the second year, all students must take and satisfactorily pass a comprehensive qualifying exam, consisting of both written and oral components, before formally beginning their dissertation research. This exam focuses on required courses as well as advanced courses in the selected area of emphasis. As arranged by the thesis advisor, the student may spend several weeks in a laboratory at another institution to learn new or advanced techniques related to the research topic selected for the thesis.

Early in the second year of the program it is expected that all students will have selected a thesis advisor and Thesis Advisory Committee with approval of the Biomedical Engineering Education Committee. By the beginning of the third year of study, students must prepare a written prospectus and formally present to the Thesis Advisory Committee the background, rationale and hypothesis of their proposed dissertation research and any preliminary results they may have obtained.

Each student meets at least twice a year with his/her committee to discuss his/her progress. The committee decides when the research has progressed sufficiently so that a dissertation can be written, and is responsible for coordinating the final thesis defense. The committee may include a qualified outside reviewer from an academic institution other than the Mayo Graduate School. All members of the Biomedical Engineering faculty are encouraged to attend every thesis defense, which includes a formal seminar on the results of the dissertation research presented by the candidate.

CLINICAL AND TRANSLATIONAL SCIENCE

A. J. Windebank, M.D., *Graduate Program Director*

Ph.D. Degree

I. Course Work

Core Courses

*Core	6000	Responsible Conduct of Research	1 cr.
*Core	6100	Chemical Principles of Biological Systems	3 cr.
*Core	6150	Genome Biology	3 cr.
*Core	6510	Mechanisms of Human Disease	3 cr.

* Required Courses

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

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

MGS	5102	Lab Rotations (8 weeks)	2 cr.

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

Track Requirements

CTSC	5000	Introduction to Clinical Research	1 cr.
CTSC	5010	Clinical Research Protocol Development	2 cr.
CTSC	5020	Regulatory Issues in Clinical Research	1 cr.
CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
CTSC	5600	Statistics in Clinical Research	2 cr.
CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
CTSC	5720	Clinical Trials: Design and Conduct	1 cr.
CTSC	8110	CTSA Grand Rounds(1 cr./qtr./yr.)	2 cr.
		(Students gain credit only for quarters in which	they present)
CTSC	8120	Case Studies in Translation	2 cr.
		Grant Writing Workshop	0 cr.
		Writing for Scientific Publication Workshop	0 cr.

Advanced and Elective Courses

Forty-two credits are required for graduation. In addition to the core and track requirements, courses should be selected after consultation between the student, his/her advisor, and the Graduate 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 graduate school core courses in the basic science disciplines.

Research

CTSC 8890 Research in Clinical and Translational Science
Must enroll every quarter once a thesis laboratory is selected.
Directed research projects under the supervision of a faculty advisor.

II. Qualifying Exam and Thesis Research

The Qualifying Examination for the Clinical and Translational Science Track is both a written and an oral examination. The written qualifying examination which covers the breadth of material in the core courses is divided into two parts. The first part of the examination is comprised of short answer essay questions covering statistics, epidemiology, biochemistry and genome biology. The second part of the examination is preparing a short proposal based on a translational research question. The exam will be prepared and graded by the faculty responsible for teaching the courses. This examination will be offered two times each year. The exam must be completed successfully before the end of the second year in the program.

For the oral qualifying exam, students will submit a written thesis proposal and defend their thesis research proposal. 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 Clinical and Translational Science Predoctoral Education Coordinator. This proposal must be submitted to the oral qualifying exam committee four weeks prior to the examination. The oral examination will be composed of two or three parts. The first part will be an oral presentation by the student of his/her proposal; the second part will be a discussion between the student and the oral qualifying exam committee about this proposal. If there were any conditional elements or weaknesses identified at the time of the written qualifying examination, 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. The oral qualifying exam must be completed within six months of completing the written qualifying exam.**

IMMUNOLOGY

H. Kita, M.D., *Graduate Program Director*

Ph.D. Degree

I. Course Work

Core Course (16 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6200	Basic Graduate Immunology	3 cr.
Core electives*			6 cr.

* Students may take any core courses approved for graduate credit as electives.

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

MGS	5102	Lab Rotations (8 weeks)	2 cr.

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

Track Requirements (4 credits required)

During the first two years, students must take a total of four credits as follows: IMM 8863 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 8862, IMM 8863, IMM 8867, or one credit can be from a journal club in another track.

IMM	8862	Current Topics in Cell Activation and Signaling	1 cr.
IMM	8863	Current Topics in Immunology	1 cr.
IMM	8867	Current Topics in Hypersensitivity Reactions	1 cr.

Track Tutorials (12 credits required)

Students are required to take the following tutorial courses.

IMM	8877	Tutorial in Molecular Basis of Immune Recognition	2 cr.
IMM	8879	Tutorial in Cellular Activation	2 cr.
IMM	8880	Tutorial in Immunopathology	2 cr.
IMM	8882	Tutorial in Innate Immunity and Inflammation	2 cr.
IMM	8884	Tutorial in Tumor Immunology	2 cr.
IMM	8885	Tutorial in the Generation and Function of B Cells	2 cr.

Electives (4 credits required)

Any courses approved for graduate credit. 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

IMM 8852 Research in Immunology
Must enroll every quarter once a thesis laboratory is selected
Directed research projects under the supervision of a faculty advisor.

II. Qualifying Exam and Dissertation Research

By the end of the first year of the program, each student is expected to select a laboratory and thesis advisor. At the end 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. Within two months after passing the written exam, all students must take and satisfactorily pass an oral qualifying exam, but 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 Graduate Program Director/Education Coordinator, with input from the student and the advisor. The student and advisor may choose two examiners and the Immunology Graduate Program Director/Education Coordinator, drawing from a designated pool of examiners, will choose the remaining three.

A written thesis proposal, presentation, and thesis committee discussion of the proposal must be completed by the middle of the student's third graduate year. Immunology Track degree candidates, however, are strongly encouraged to complete this requirement within two months of successfully passing the oral qualifying exam. The composition of the Thesis Advisory Committee will be determined by the mentor with input from the student and must be approved by the Immunology Graduate Program Director and Mayo Graduate School. The Thesis Advisory Committee must consist of a minimum of five faculty members. A minimum of three members must have full privileges within the Immunology Track.

MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

R. M. Weinshilboum, Ph.D., *Graduate Program Director*
D.C. Mays, Ph.D., *Education Coordinator*

Ph.D. Degree

I. Course Work

Core Courses (14 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Core	6450	Molecular Pharmacology and Receptor Signaling	2 cr.
Core	6650	Biostatistics	2 cr.

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

MGS	5102	Lab Rotations (8 weeks)	2 cr.

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

Track Requirements (10 credits required)

MPET	5100	Pharmacology Seminar Series (required attendance; no credit)	
MPET	5808	Introduction of Molecular Pharmacology	4 cr.
MPET	8800	Research Seminars in Pharmacology (1 cr./yr.)	4 cr.
MPET	8805	Drug Metabolism, Pharmacogenomics, and Carcinogenesis	2 cr.

Track Tutorials (6 credits required, 3 tutorials required)

BMB	8665	DNA/Protein Interactions, Repair, Replication and Recombination	2 cr.
MPET	8655	Mechanisms of Cell Growth and Death	2 cr.
MPET	8802	Cardiovascular Biology and Molecular Pharmacology	2 cr.
MPET	8812	Tutorial in Receptor Biology	2 cr.
MPET	8814	Cellular Pharmacology of Agents that Target Cancer and AIDS	2 cr.
MPET	8815	Neurobehavioral Pharmacology	2 cr.

Electives (6 credits required)

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

Research

MPET 8801 Research in Pharmacology
Must enroll every quarter once a thesis laboratory is selected.
Directed research projects under the supervision of a faculty advisor.

II. Qualifying Exams and Thesis Research

Written qualifying exam: Students can take the written qualifying exam at the end of the first or second year. The written exam covers the fundamentals of pharmacology, including the material covered in Molecular Pharmacology and Receptor Signaling (Core 6450), Introduction of Molecular Pharmacology (MPET 5808), Drug Metabolism, Pharmacogenomics and Carcinogenesis (MPET 8805). The exam also covers material from MPET tutorials. Because students select from a menu of questions in these areas, not all tutorials must be taken before sitting for the written qualifying exam. The exam is prepared and graded by the faculty,

Oral qualifying exam: The oral qualifying exam must be taken by September 30 of the student's second year. In this exam, students orally present a preliminary thesis proposal, which serves as a springboard for faculty to probe the student's background knowledge, ability to propose hypotheses, and design experiments to test hypotheses. The oral qualifying exam committee must conform to the graduate school requirements and be approved by the Graduate Program Director.

Thesis proposal: A written thesis proposal must be presented to your thesis committee by the middle of the third year (preferably within 2 months of completing the oral qualifying exam). The proposal should be divided into the following sections:

Abstract: Summary of your project.
Specific Aims: Describe briefly the aims of your project and hypotheses.
Background and 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.
Preliminary Data: Describe the results you (and others) have obtained in by your host laboratory (and in collaboration) that set the scene for your proposal, and support your hypotheses.
Experimental Design and Methods: Describes what you plan to do and how you plan to do it.

NEUROBIOLOGY OF DISEASE

A. J. Bieber, Ph.D., *Graduate Program Director*
I. O. Scarisbrick, Ph.D., *Education Coordinator, Mayo Clinic in Rochester*
R. Rademakers, Ph.D., *Education Coordinator, Mayo Clinic in Florida*

Ph.D. Degree

I. Course Work

Core Courses (14 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6050	Critical Thinking and Scientific Writing	2 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Core	6650	Biostatistics	2 cr.

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

MGS	5102	Lab Rotations (8 weeks)	2 cr.

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

Track Requirements (18 credits required)

NSCI	8210	Neurobiology of Disease	4 cr.
NSCI	8401	Basic Neuroanatomy	1 cr.
NSCI	8500	Neuroscience Seminar (1 cr./yr.)*	2 cr.
NSCI	8600	Special Topics in Neuroscience (1 cr./yr.)*	2 cr.
NSCI	8650	Works in Progress (1 cr./yr.)*	2 cr.
NSCI	8850	Principles of Neuroscience	3 cr.
NSCI	8852	Topics in Neuroscience Research	1 cr.
NSCI	8860	Advanced topics in Neuroscience	3 cr.

* Two credits maximum.

Electives (4 credits required)

Any course approved for graduate credit. Courses should be selected in consultation with the thesis advisor and track educational coordinator.

Highly Recommended Courses

Core	6200	Basic Immunology	3 cr.
Core	6300	Molecular Biophysics	3 cr.
Core	6400	Molecular Genetics	3 cr.
Core	6450	Molecular Pharmacology	2 cr.

Research

NSCI 8900 Research in the Neurobiology of Disease
Must enroll every quarter once a thesis laboratory is selected.
Directed research projects under the supervision of a faculty advisor.

Forty-two credits are required for graduation. In addition to the core and track requirements, additional courses should be selected after consultation between the student and his/her advisor.

II. Qualifying Exam and Thesis Research

The qualifying examination for the Neurobiology of Disease track is comprised of a two-part written qualifying exam and the oral qualifying examination. The first part of the written qualifying exam is administered at the end of the first academic quarter and covers the core neuroscience coursework. This exam involves a mixture of essay and multiple choice questions. The second part of the written qualifying exam is taken at the end of the second academic quarter (after completion of the scientific writing course) and involves writing a mini-grant proposal based upon a recent research article chosen in consultation with the education coordinator and a faculty mentor. The guidelines and expectations for this proposal are explicitly presented during the critical thinking and scientific writing course (CORE 6050).

Upon successful completion of the written qualifier, students are expected to immediately discuss the oral exam with the Graduate Program Director. Mayo Graduate School formally allows students to delay their oral exam until the end of the 10th quarter. While this will always remain an option, students are strongly encouraged to schedule the exam during the 4th quarter of their tenure. As the current track strategy is to complete the written qualifier well before the end of the first year, and because preliminary data are not an emphasis for the oral exam, the only obstacle to early completion of the oral is the readiness level of the student. The oral examining committee will always include the Graduate Program Director and the Education Coordinator(s) 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. In addition to the two or three standing members, additional members (to a total of four) are chosen for their expertise in the general area of research relevant to the student's proposal. These members may be the faculty mentor or may be selected from the current group of neuroscience faculty involved in education. All members must be approved by the standing exam committee and should be selected after extensive discussion between the student and his/her faculty mentor. The oral exam will be driven by a well-written, in-depth proposal focused upon the student's general research area. This proposal must include a clear hypothesis, logical specific aims and experimental goals, and an extensive introduction and review of the current literature relevant to the topic. The proposal will not require preliminary data – such data may be included in order to justify a certain aim or experimental objective, but will not form the basis for questioning and will not determine the outcome of the examination. Students will generally receive ample instruction into the format and expected content of the proposal during the basic neuroscience core course, the scientific writing course, and the special topics

course. 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 his/her readiness for advancement to candidacy.

After successfully passing the oral qualifying exam, students will schedule a thesis proposal meeting which will also serve as the first official thesis committee meeting. This meeting can happen at any time after advancement to candidacy, but must be completed by the end of the 10th quarter. Students must prepare a polished thesis proposal that specifically outlines the hypothesis, specific aims, and experimental objectives of their Ph.D. research. This proposal must be provided to the thesis committee at least two weeks before the thesis proposal meeting. The committee will review the proposal and determine whether it represents an appropriate starting point for a thesis project. The initial thesis proposal is not a contract between the student and the committee – all Ph.D. projects evolve in response to actual experimentation and the final thesis research may differ substantially from the original proposal. An important aspect of successful Ph.D. training is constant communication with the thesis committee.

VIROLOGY AND GENE THERAPY

R. Cattaneo, Ph.D., *Graduate Program Director*

Ph.D. Degree

I. Minimum Requirements

The requirements for the Virology and Gene Therapy track conform to the general requirements of the Mayo Graduate School in which a total of 42 credits are required for graduation. A minimum of 16 credits is required for the core curriculum, eight credits of VGT tutorials, six credits of laboratory rotations, six credits of journal club/current topics and six credits as deemed appropriate for an individual student's program.

II. Course Work

Core Courses (16 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6200	Basic Graduate Immunology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Core	6770	Intro to Virology and Gene Therapy	3 cr.

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

MGS	5102	Lab Rotations (8 weeks)	2 cr.

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

Track Requirements (6 credits required)

VGT	8740	Viruses and Vectors Journal Club (1 cr./yr.)	3 cr.
VGT	8745	Current Topics in VGT (1 cr./yr.)	3 cr.

Track Tutorials (8 credits required)

Tutorials will be presented in the areas of Virology and Gene Therapy and in related areas. Students are required to take all four of the tutorials.

IMM	8884	Tutorial in Tumor Immunology (even years)	2 cr.
VGT	8884	Viral Disease Tutorial (odd years)	2 cr.
VGT	8886	Tutorial in Molecular Virology (odd years)	2 cr.

VGT 8888 Tutorial in Gene Therapy (even years) 2 cr.

Electives (6 credits required)

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

Research

VGT 8890 Research in Virology and Gene Therapy
Must enroll every quarter once a thesis laboratory is selected.
Directed research projects under the supervision of a faculty advisor.

DESCRIPTION OF MASTER'S DEGREE PROGRAM AND BASIC SCIENCE TRACK REQUIREMENTS

MASTER OF SCIENCE PROGRAM IN BIOMEDICAL SCIENCES

The Master of Science (M.S.) Program in Biomedical Sciences is available only to:

1) Physicians and dentists enrolled in clinical residency programs and/or research fellowships of the Mayo School of Graduate Medical Education (basic science specialty requirements described below – clinical science specialty requirements described in a later section);

2) Employees (requirements described in a later section);

3) Candidates for the Ph.D. in good academic standing, but unable to complete all the requirements for the doctorate – requirements are outlined on the Mayo Graduate School intranet at *http://mayoweb.mayo.edu/mgs-policies/master-degree-options.html*

MASTER OF SCIENCE PROGRAM IN BIOMEDICAL SCIENCES BASIC SCIENCE SPECIALTIES

The primary purpose of this program is to enhance the scholarly dimension of the participants enrolled. 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 advisor, appropriate supervision, and a suitable approach to the analysis and presentation of the results.

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

ELIGIBILITY

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

TUITION

Tuition may be covered by a Mayo Graduate School scholarship for Mayo graduate courses taken to meet Master's degree requirements. Mayo will not reimburse other costs that may be associated with the degree program.

APPLICATION

Candidates must complete a Master's Program in Biomedical Sciences Application form. The application must be approved by the track Graduate Program Director and Mayo Graduate School. This form is available from the Mayo Graduate School office.

TIME REQUIREMENT

All requirements must be satisfied within six months of the thesis defense or within one year after completion of the residency or fellowship.

REGISTRATION REQUIREMENT

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

MINIMUM CREDIT REQUIREMENTS

Students must complete a minimum of 12 credits in basic biomedical sciences and 12 additional credits in the track. (See individual specialty track descriptions for specific course requirements. The biomedical science credit requirement does not apply to the Clinical and Translational Science track). Six of the 12 credits in the track must be didactic credits. It is expected that a minimum of one year will be devoted to research. Students are not admitted to a specialty track unless there is reasonable assurance that course work required for completion of degree requirements is available.

TRANSFER CREDITS

A total of 6 didactic credits may be transferred into the Basic Science Master's Program.

Elective Course Policy
Students who wish to transfer graduate credits to substitute for a Mayo elective course must contact the Mayo course director and their Graduate Program Director. If the course director and the Graduate Program Director determine that a student has the knowledge equivalent to satisfactory performance in the Mayo course, the student may request the transfer credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Core Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a Mayo core course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive core course credits, the student is required to prove competence by taking an exam 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 core course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Track Required Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a track required course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive track required course credits, at the Mayo course director and the Graduate Program Director's discretion the student is required to prove competence by taking an exam 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 track required course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

External Courses Policy
Students who wish to transfer credits not in substitution for a Mayo course(s) may request credit for graduate courses taken at another institution if they received a grade of A or B. The request must have the approval of the student's Graduate Program Director and Mayo Graduate School. A description of the course from the course catalog or a course outline must accompany the request. The time interval since the credits were earned is a consideration in such decisions. Credits must normally have been earned within the previous five years, as determined by the Graduate Program Director.

ADVISOR

A Master's degree mentor must have Mayo Graduate School full or Master's graduate faculty privileges.

List of Graduate Faculty with Privileges
http://mayoweb.mayo.edu/mgs/documents/ListofFacultywithPrivileges.xls

The complete list of faculty with graduate privileges begins on page.

OFFICIAL DEGREE PROGRAM FORM

Students are expected to submit their Degree Program form to Mayo Graduate School before the end of the first year of registration. The form must include the minimum number of courses/credits necessary to fulfill degree requirements (credits may vary depending on the chosen track but the minimum Mayo Graduate School credit requirement must be met) and be approved by the track Graduate Program Director. Fifty percent of the credits on the degree program must be graded on the A-F grading system.

The Degree Program form is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html.*

CHANGES IN APPROVED PROGRAM

The approved degree program must be fulfilled in every detail to meet graduation requirements. Alterations in the program must be requested in writing and approved by the track Graduate Program Director and Mayo Graduate School.

MINIMUM GRADE REQUIREMENTS

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Guidelines for Probation and Dismissal outlined on the Mayo Intranet at *http://mayoweb.mayo.edu/mgs-policies/probation-dismissal/html*.

EXAMINATIONS

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

examination may be scheduled.

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

The student's advisor must sign a form indicating that he/she has read the thesis and that it is ready for defense prior to distribution to the Thesis Advisory Committee members. The Verification that the Thesis is Ready to Defend form can be accessed on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*. A copy of the title page of the thesis and the form must be submitted to the Mayo Graduate School office. The thesis must be submitted to the Thesis Advisory Committee at least three weeks before the final oral examination.

Only one dissenting vote is allowed for a "Pass." Any member of the Thesis Advisory Committee not present in real time via physical presence or video- or teleconferencing at the Final Oral Exam is counted as a "Fail" vote. Thus, no more than one Thesis Advisory Committee member may be absent for the Final Oral Exam. In the case where a student fails the examination, the committee will recommend to the student and to Mayo Graduate School remedial studies that should be undertaken by the student before the student retakes the examination. The final oral examination may be taken no more than twice and must be retaken within six months. Failing the examination twice will result in dismissal.

THESIS

Thesis Protocol: The protocol must be submitted to Mayo Graduate School during the first quarter in the laboratory. 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 Master's Thesis Protocols is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*. The protocol must be submitted with the form, Recommended Action on Thesis Protocol for Basic Science Master's Degree, also available on the intranet site.

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

Thesis Advisory Committee: With the thesis protocol, students should submit the Master's Thesis Advisory Committee form recommending the members of their thesis advisory/final oral examining committee and the Degree Program form. All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. The examining committee consists of a minimum of four individuals, one of whom is the student's advisor, who serves as chair of the committee. No more than two members of the committee may have teaching/examining privileges. One member must be from outside the track and no member other than the chair may be from among a student's research advisors. The recommended committee must be approved by the track Graduate Program Director and Mayo Graduate School.

Progress Meetings: The Master's Thesis Advisory Committee must meet every six months from the date of committee approval. Documentation of student progress, signed by all members of the Thesis Advisory Committee, should be submitted to Mayo Graduate School after each of these meetings. There is no standard form for this.

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 archival. Consequently, Mayo Graduate School has developed a standard for its format and style, which should be closely followed. Guidelines for Master's thesis are available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

Final Thesis Corrections: After the student has passed the final oral examination, members of the Thesis Advisory Committee must sign a form indicating they are satisfied that the final corrections to the thesis have been made. Three of the four committee members must have signed before the student will be cleared for graduation. Mayo Graduate School will not certify completion of degree requirements until the final thesis has been submitted.

GRADUATION

Students are granted degrees four times a year: February, August, November and mid May. The latter involves a formal ceremony as part of the Mayo Clinic graduation exercises in conjunction with Mayo Medical School. No ceremony is held in February, August or November, but students who graduate at one of these times are encouraged to participate in the May ceremony.

Students are allowed no more than six months to complete M.S. or Ph.D. degree requirements after a successful thesis defense. This policy is effective October 1, 2004. If a student does not meet this deadline, he/she will be required to re-defend his/her thesis.

Graduation deadlines:

To graduate in:	**Requirements must be completed by:**
February	January 1
May	– Draft of thesis to advisor and defense scheduled by March 8
	– All requirements completed by April 8, except submittal of final thesis
	– Thesis submitted at least 1 week before graduation
August	July 1
November	October 1

BIOCHEMISTRY AND MOLECULAR BIOLOGY

P. C. Harris, Ph.D., *Graduate Program Director*
D. J. Katzmann, Ph.D., *Education Coordinator*

Biochemistry and Molecular Biology Track:
Biochemistry and Structural Biology; Cell Biology and Genetics; Cancer Biology Subtracks

Master's Degree

The Department of Biochemistry and Molecular Biology (BMB) offers a flexible track 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). The BMB Master's degree track is open to residents and research fellows in the Mayo School of Graduate Medical Education.

Course Requirements

A. Biomedical Science Requirements (12 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Additional biomedical science credits			2 cr.

B. Track Requirements (12 credits required)

Intermediate Courses (6 credits required)*

BMB	5000	Introduction to Cancer Biology	3 cr.
BMB	5400	Developmental Biology	2 cr.
Core	6300	Molecular Biophysics	3 cr.
Core	6400	Molecular Genetics	3 cr.
Core	6510	Mechanisms of Human Disease	3 cr.
Core	6650	Biostatistics	2 cr.

Advanced Courses (6 credits required)*

BMB	5350	Hormones and Cancer	1 cr.
BMB	8000	Biological Macromolecules	3 cr.
BMB	8030	Data Analysis and Math Modeling In Biomedical Research	3 cr.
BMB	8040	Fractals and Chaos in Bioscience	2 cr.
BMB	8050	Biological Kinetics	3 cr.

BMB	8070	Cancer Biology II: Molecular Mechanisms	3 cr.
BMB	8075	Epigenetics, Epidemiology and	3 cr.
BMB	8320	Special Topics in Cancer Biology	1 cr.
		Genomics of Cancer	
BMB	8350	Introduction to Bioinformatics	2 cr.
BMB	8650	Receptor Trafficking and Signaling	2 cr.
BMB	8660	Transcription, Chromatin, and Epigenetics	2 cr.
BMB	8665	DNA/Protein Interactions, Repair,	2 cr.
		Replication and Recombination	
BMB	8675	Protein Structure and Dynamics	2 cr.

Other Journal Clubs (maximum of 4 credits: 2 Advanced and 2 Elective)*

BMB	8510	Current Topics in Cancer Biology	1 cr.
BMB	8520	Current Topics in Aging Research**	1 cr/qtr.
BMB	8801	Concepts of Vesicular Trafficking Journal Club	1 cr.

*Courses to be selected in consultation with your project advisor.
** Two credits maximum**.**

C. Research

Students are required to register for BMB 8840 Research in Biochemistry and Molecular Biology (6 credits/quarter) for a total of 4 quarters or 24 credits. In addition, the Master of Science degree requires passing the BMB written qualifying exam and the defense of a thesis.

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 (see below). The exam is a two-day exam and held on the Friday and Monday flanking the second weekend in July. The first day of the written exam covers the basics of Biochemistry and Molecular Biology as covered in the core courses: Core 6100, Core 6150 and Core 6250. In addition, a limited number of questions are based on the material in the Intermediate Courses, Core 6400 and BMB 5000. Thirty paragraph-length answers are required from a total of 40 questions. The second day of the exam consists of demonstrating critical evaluation and understanding of two related published papers. Three sets of papers reflecting the three areas of emphasis of the track: BSB, CBG or CB, are available and the student selects one set of papers from which 15 questions are answered. The exam is prepared and graded by the faculty, and a pass rate of 70% is required for both parts of the exam.

CLINICAL AND TRANSLATIONAL SCIENCE

G. E. Smith, Ph.D., *Graduate Program Director*

Master's Degree

This program is designed for Mayo Clinic residents and fellows who hold appointments to the programs of Mayo School of Graduate Medical Education, and other Mayo faculty and staff who are interested in expanding their clinical research experience. Professionals with doctoral degrees, or admitted to doctoral programs, also are eligible. Potential candidates for the degree must hold Mayo appointments of sufficient duration to complete program requirements.

Technical Requirements

Blackboard Learn is a Learning Management System that is utilized in most of the CTSA courses. Course content is delivered either entirely on-line, in a blended classroom/on-line setting, or classroom only. Blackboard Learn may be used in all delivery modalities and thus requires CTSC students to have access to a computer for coursework completion.

Course Requirements

The curriculum for the Master's degree consists of 24 credits. The student must complete all of the required courses listed below. The elective credits may be chosen from those listed below or other courses listed in the Mayo Graduate School Catalog with approval.

Core Courses (17 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
CTSC	5000	Introduction to Clinical Research	1 cr.
CTSC	5010	Clinical Research Protocol Development	2 cr.
CTSC	5020	Regulatory Issues in Clinical Research	1 cr.
CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
CTSC	5310	Clinical Epidemiology II	1 cr.
CTSC	5390	Advanced Applied Epidemiological Methods	2 cr.
CTSC	5600	Statistics in Clinical Research	2 cr.
CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
CTSC	5610	Introductory Statistical Methods II	3 cr.
CTSC	5690	Critical Appraisal of Statistical Methods in the Medical Literature	1 cr.
CTSC	5720	Clinical Trials: Design and Conduct	1 cr.
		Write Winning Grants Workshop	0 cr.
		Writing for Biomedical Publication Workshop	0 cr.

Elective Courses (7 credits required)

CTSC	5070	Community-Based Participatory Research	2 cr.
CTSC	5080	Eliminating Health Disparities	1 cr.
CTSC	5081	Health Disparities Field Experience	1 cr.
CTSC	5090	Leadership Principles for Clinical Research in the 21st Century (Career Development Scholars)	1 cr.
CTSC	5130	Immune Signatures in Disease Outcome & Response to Therapy	1 cr.
CTSC	5190	Complementary and Alternative Medicine	1 cr.
CTSC	5201	Independent Study for Clinical Practice Issues	1-2 cr.
CTSC	5202	Independent Study of Laboratory Methods	1-2 cr.
CTSC	5230	Cardiovascular Research Seminar	1 cr.
CTSC	5240	Principles and Practices of Pediatric Research	2 cr.
CTSC	5270	Hepatobiliary Pathobiology	1 cr.
CTSC	5271	GI Cellular Physiology	1 cr.
CTSC	5280	Applied Enteric Neurosciences in Health and Disease	1 cr.
CTSC	5290	GI Population Sciences	1 cr.
CTSC	5500	Introduction to Genetic Epidemiology	1 cr.
CTSC	5510	Genetic Epidemiology II	1 cr.
CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis	1 cr.
CTSC	5660	Bioinformatics: Statistical Design & Analysis	1 cr.
CTSC	5710	Managing and Displaying Data	1 cr.
CTSC	5740	Systematic Reviews and Meta Analyses	2 cr.
CTSC	5750	Survival Analysis for Biomedical Applications	2 cr.
CTSC	5760	Medical Decision Making	1 cr.
CTSC	5761	Evidence-based Medicine for Clinical Researchers	1 cr.
CTSC	5770	Diagnostic Testing Strategies	1 cr.
CTSC	5810	Qualitative Research Design, Methods and Analysis	1 cr.
CTSC	5820	Introduction to Survey Research	1 cr.
CTSC	5850	Introduction to Psychological and Behavioral Measurement	1 cr.
CTSC	5860	Behavioral Interventions in Clinical Trials	1 cr.
CTSC	5910	Economic Evaluation in Health Care	1 cr.
CTSC	5920	Intro to Health Systems Engineering	1 cr.
CTSC	5930	A Toolkit to Analyze the U.S. Healthcare System	1 cr.
CTSC	5960	Medical Informatics for the Clinical Researcher	2 cr.
CTSC	8110	CTSA Grand Rounds	1 cr.
CTSC	8120	Case Studies in Translation	2 cr.

IMMUNOLOGY

H. Kita, M.D., *Graduate Program Director*

Master's Degree

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

Course Requirements

A. Biomedical Science Requirements (16 credits required)

Students will be expected to complete 16 credits of course work (or the equivalent) selected from the Biomedical Sciences core curriculum. Core 6000 and 6200 must be selected. Students with extensive background in particular areas of the core curriculum will have the opportunity to test out of the core courses.

B. Advanced Courses in Immunology (12 credits required)

Each student will be expected to take a minimum of three tutorials offered by the Immunology faculty in areas specific to the student's research interest.
IMM 8863 must be taken at least once. The three remaining credits In Current Topics can be any combination of the following journal clubs:

IMM	8862	Current Topics in Cell Activation and Signaling
IMM	8863	Current Topics in Immunology
IMM	8867	Current Topics in Hypersensitivity Reactions

C. Research

Students are required to register for IMM 8840 Research in Immunology (6 credits/quarter) for a total of 4 quarters or 24 credits.

MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

R. M. Weinshilboum, Ph.D., *Graduate Program Director*
D. C. Mays, Ph.D., *Education Coordinator*

Master's Degree

The department of Molecular Pharmacology and Experimental Therapeutics offers an M.S. degree track within the Biomedical Sciences Program. This track is only open to residents and research fellows in the Mayo School of Graduate Medical Education.

Course Requirements

A. Biomedical Science Requirements (12 credits required)

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

B. Track Requirements (12 credits required)

Core	6450	Molecular Pharmacology and Receptor Signaling	2 cr.
MPET	5808	Introduction of Molecular Pharmacology	4 cr.
MPET	8805	Drug Metabolism, Pharmacogenomics, and Carcinogenesis	2 cr.

Track Tutorials (6 credits required from the following)

BMB	8665	DNA/Protein Interactions, Repair, Replication, and Recombination	2 cr.
MPET	8655	Mechanisms of Cell Growth and Death	2 cr.
MPET	8802	Cardiovascular Biology and Molecular Pharmacology	2 cr.
MPET	8812	Tutorial in Receptor Biology	2 cr.
MPET	8814	Cellular Pharmacology of Agents that Target Cancer and AIDS	2 cr.
MPET	8815	Neurobehavioral Pharmacology	2 cr.

C. Research

Students are required to register for MPET 8840 Research in Molecular Pharmacology and Experimental Therapeutics (6 credits/quarter) for a total of 4 quarters or 24 credits. Students will identify a research advisor on entry into the degree program. It is assumed that the equivalent of twelve months will be spent in full-time academic work, which will consist primarily of research, but will also involve advanced course work.

NEUROBIOLOGY OF DISEASE

A. J. Bieber, Ph.D., *Graduate Program Director*
I. O. Scarisbrick, Ph.D., *Education Coordinator Mayo Clinic in Rochester*
R. Rademakers, Ph.D., *Education Coordinator Mayo Clinic in Florida*

Master's Degree

This program is intended to provide residents, fellows, staff, and faculty with a flexible Master's degree that emphasizes the neurobiology of disease.

Course Requirements

The curriculum for the Neurobiology of Disease Master's degree consists of 24 credits of coursework and 24 research credits. Successful acquisition of the Master's of Science degree will require passing a written qualifying examination and oral defense of a thesis.

A. Course Requirements (24 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6050	Critical Thinking and Scientific Writing	2 cr.
CTSC	5000	Introduction to Clinical Research	1 cr.
CTSC	5600	Statistics in Clinical Research	2 cr.
CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
CTSC	5610	Introductory Statistical Methods II	3 cr.
CTSC	5660	Bioinformatics	1 cr.
CTSC	5690	Critical Appraisal of Statistical Methods	1 cr.
NSCI	8210	Neurobiology of Disease	4 cr.
NSCI	8500	Neuroscience Seminar (1 cr./yr.)	1 cr.
NSCI	8600	Special Topics in Neuroscience (1 cr./yr.)	2 cr.
NSCI	8854	Basic Clinical Neuroscience	5 cr.

B. Research (24 credits required)

Students will register for NSCI 8840 Research in the Neurobiology of Disease (6 credits per quarter) for a total of 4 quarters and 24 credits.

DESCRIPTION OF EMPLOYEE MASTER'S DEGREE PROGRAM AND TRACK REQUIREMENTS

MASTER OF SCIENCE PROGRAM IN BIOMEDICAL SCIENCES FOR MAYO EMPLOYEES

The Master's Degree in Biomedical Sciences is designed to develop the individual's information base in a basic science field and 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. Although employees currently do not receive direct salary benefit from attaining a Master's degree, receipt of the degree may make the employee qualified for a job of a higher classification, should one become available.

ELIGIBILITY

Enrollment is restricted to permanent Mayo employees. 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, and must have received scores on the verbal, analytical, and quantitative aptitude tests of the Graduate Record Examination (GRE) indicating strong academic ability. Applicants, who meet these criteria and have a strong letter of support from their Mayo supervisor, are eligible for admission. Alternatively, an applicant may be asked by the program to register for six credits from the core curriculum of Mayo Graduate School. If a 3.0 GPA is maintained in those courses, the applicant may be eligible for admission.

TUITION

Tuition may be covered by a Mayo Graduate School scholarship for Mayo graduate courses taken to meet Master's degree requirements. Mayo will not reimburse other costs that may be associated with the degree program.

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APPLICATION

Candidates must complete a Master's Program in Biomedical Sciences Application form. The application must be approved by the track Graduate Program Director and Mayo Graduate School. This form is available from the Mayo Graduate School office. Supporting documents include transcripts from previous colleges, GRE scores, supervisor's endorsement and three letters of recommendation.

TIME REQUIREMENT

All requirements for the Master's degree must be completed within five years. The five-year period begins on the date the letter of acceptance is sent to the student. Permanent Mayo employees whose Mayo employment terminates are required to notify Mayo Graduate School; their Mayo Graduate School appointment will also end.

REGISTRATION REQUIREMENT

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

MINIMUM CREDIT REQUIREMENTS

Students must complete a minimum of 36 credits. Eighteen of the credits must be in the track and a minimum of 8 credits in one or more related fields outside the track, including CORE 6000, "Responsible Conduct of Research." Six of the credits in the track must be didactic credits. The selection of the courses to be used to meet these requirements will be determined by the student and the track Graduate Program Director.

TRANSFER CREDITS

A total of 9 didactic credits may be transferred into the Employee Master's Program.

Elective Course Policy
Students who wish to transfer graduate credits to substitute for a Mayo elective course must contact the Mayo course director and their Graduate Program Director. If the course director and the Graduate Program Director determine that a student has the knowledge equivalent to satisfactory performance in the Mayo course, the student may request the transfer credits. A letter from the course director and the

Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Core Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a Mayo core course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive core course credits, the student is required to prove competence by taking an exam 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 core course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Track Required Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a track required course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive track required course credits, at the Mayo course director and the Graduate Program Director's discretion the student is required to prove competence by taking an exam 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 track required course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

External Courses Policy
Students who wish to transfer credits not in substitution for a Mayo course(s) may request credit for graduate courses taken at another institution if they received a grade of A or B. The request must have the approval of the student's Graduate Program Director and Mayo Graduate School. A description of the course from the course catalog or a course outline must accompany the request. The time interval since the credits were earned is a consideration in such decisions. Credits must normally have been earned within the previous five years, as determined by the Graduate Program Director.

ADVISOR

A Master's degree mentor must have Mayo Graduate School full or Master's graduate faculty privileges.

List of Graduate Faculty with Privileges
http://mayoweb.mayo.edu/mgs/documents/ListofFacultywithPrivileges.xls

The complete list of faculty with graduate privileges begins on page

OFFICIAL DEGREE PROGRAM FORM

Students are expected to submit their Degree Program form to Mayo Graduate School on or before completing 15 credits of coursework. The form must include the minimum number of courses/credits necessary to fulfill degree requirements (credits may vary depending on the chosen track but the minimum Mayo Graduate School credit requirement must be met) and be approved by the track Graduate Program

Director. Fifty percent of the credits on the degree program must be graded on the A-F grading system.

The Degree Program form is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html.*

CHANGES IN APPROVED PROGRAM

The approved degree program must be fulfilled in every detail to meet graduation requirements. Alterations in the program must be requested in writing and approved by the track Graduate Program Director and Mayo Graduate School.

MINIMUM GRADE REQUIREMENT

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Guidelines for Probation and Dismissal outlined on the Mayo intranet at *http://mayoweb.mayo.edu/mgs.policies/probation-dismissal.html.*

PROJECT

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

Employee Master's Advisory Committee: The Employee Master's Advisory Committee will consist of a minimum of four faculty members, three from the student's track and one from outside the track. All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. No more than two members may have teaching/examining privileges. The composition of this committee will be determined by Mayo Graduate School upon recommendation by the student and the student's track Graduate Program Director. The recommendations are submitted on the Employee Master's Advisory Committee form available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

EXAMINATION

Comprehensive Examination: At the completion of the required course work, students must take a comprehensive written examination. Mayo Graduate School must be informed of the date of the examination three weeks in advance so that the Master's Comprehensive Examination Report form can be

sent to the track Graduate Program Director. The examination is designed to evaluate the student's depth and breadth of knowledge in the student's track and related fields of study. The Comprehensive Examination may be taken after courses on the Degree Program form are completed.

Only one dissenting vote will be allowed for a "Pass." Any member of the Project Advisory Committee not present in real time via physical presence or video- or teleconferencing at the Final Oral Exam is counted as a "Fail" vote. Thus, no more than one Project Advisory Committee member may be absent for the Final Oral Exam. In the case where a student fails the examination, the committee will recommend to the student and to Mayo Graduate School remedial studies that should be undertaken by the student before the student retakes the examination. The Comprehensive Examination may be taken no more than twice and must be retaken within six months. Failing the examination twice will result in dismissal.

GRADUATION

Students are granted degrees four times a year: February, August, November and mid-May. The latter involves a formal ceremony as part of the Mayo Clinic graduation exercises in conjunction with the Mayo Medical School. No ceremony is held in February, August or November, but students who do graduate at one of these times are encouraged to participate in the May ceremony.

Graduation deadlines:

To graduate in:	**Requirements must be completed by:**
February	January 1
May	– Draft of project to advisor and comprehensive exam scheduled by March 8
	– All requirements completed by April 8, except submittal of final project
August	July 1
November	October 1

BIOCHEMISTRY AND MOLECULAR BIOLOGY

P. C. Harris, Ph.D., *Graduate Program Director*
D. J. Katzmann, Ph.D., *Education Coordinator*

Biochemistry and Molecular Biology Track:
Biochemistry and Structural Biology; Cell Biology and Genetics; Cancer Biology Subtracks

Employee Master's Degree

The Department of Biochemistry and Molecular Biology (BMB) offers a flexible track for Employee 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). The requirements for the Employee Master's Degree in Biochemistry and Molecular Biology conform to the general requirements of the Mayo Graduate School in which a total of 36 credits are required for graduation.

Course Requirements

Core Courses (10 credits required)

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

Track (5 credits required)

BMB	8300	Master's Project	3 cr.
BMB	8500	BMB Journal Club (1 cr./yr.)*	2 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 presenting at the Cancer Biology Journal Club.

Intermediate Courses (6 credits required)

BMB	5000	Introduction to Cancer Biology	3 cr.
BMB	5400	Developmental Biology	2 cr.
Core	6050	Critical Thinking and Writing	2 cr.
Core	6300	Molecular Biophysics	3 cr.
Core	6400	Molecular Genetics	3 cr.
Core	6510	Mechanisms of Human Disease	3 cr.
Core	6650	Biostatistics	2 cr.

Advanced Courses (8 credits required)

BMB	5350	Hormones and Cancer	1 cr.
BMB	8000	Biological Macromolecules	3 cr.
BMB	8030	Data Analysis and Math Modeling In Biomedical Research	3 cr.
BMB	8040	Fractals and Chaos in Bioscience	2 cr.
BMB	8050	Biological Kinetics	3 cr.
BMB	8070	Cancer Biology II: Molecular Mechanisms	3 cr.
BMB	8075	Epigenetics of Cancer and Addiction	3 cr.
BMB	8320	Special Topics in Cancer Biology	1 cr.
BMB	8350	Introduction to Bioinformatics	2 cr.
BMB	8650	Receptor Trafficking and Signaling	2 cr.
BMB	8660	Transcription, Chromatin, and Epigenetics	2 cr.
BMB	8665	DNA/Protein Interactions, Repair, Replication and Recombination	2 cr.
BMB	8675	Protein Structure and Dynamics	2 cr.

Electives (7 credits required)

Any course approved for graduate credit.

Other Journal Clubs (maximum of 4 credits: 2 Advanced and 2 Elective)

BMB	8510	Cancer Biology Journal Club	1 cr./qtr.
BMB	8520	Current Topics in Aging Research*	1 cr/qtr.
BMB	8801	Concepts of Vesicular Trafficking Journal Club	1 cr./qtr.

Courses to be selected in consultation with your project advisor.
*Two credits maximum.

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 (see below). The exam is a two-day exam and held on the Friday and Monday flanking the second weekend in July. The first day of the written exam covers the basics of Biochemistry and Molecular Biology as covered in the core courses: Core 6100, Core 6150 and Core 6250. In addition, a limited number of questions are based on the material in the Intermediate Courses, Core 6400 and BMB 5000. Thirty paragraph-length answers are required from a total of 40 questions. The second day of the exam consists of demonstrating critical evaluation and understanding of two related published papers. Three sets of papers reflecting the three areas of emphasis of the track: BSB, CBG or CB, are available and the student selects one set of papers from which 15 questions are answered. The exam is prepared and graded by the faculty, and a pass rate of 70% is required for both parts of the exam.

Master's 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 project. The project should be written as a comprehensive review of a fundamental question within the field of interest and include details of practical experimental approaches employed to investigate this problem. A perspective of where the candidate sees the field now and speculation about how the field will be advanced in the immediate future should also be included. The typical length of the text of the project is 50-75 double-spaced pages, including figures (but not references).

The project will consist of a: Title page; Contents page; Abstract (one page); Introduction to the subject; Sections discussing different aspects of the question; and a Conclusion and Future Directions part. As in all scientific writing, the project should be precise and concise and give a balanced view of the area of study. The review should be fully referenced (~100 references is typical) and include illustrations and tables as necessary to show data and explain difficult concepts that are better understood visually. This document must be written in close consultation with the project advisor and must be submitted to the Employee Master's Advisory Committee for review at least one month prior to the final project review date.

Prior to this meeting the committee will carefully review, edit, and critique the project and will provide any changes to the student during the meeting. 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 Mayo Graduate School immediately upon completion of the defense.

Advisory Committee

Each student shall 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 project. Selection of members of this committee should be discussed with the advisor and the Graduate Program Director and arranged prior to beginning the Master's project. The committee will be chaired by the advisor and meet with the student before starting the Master's project. One of these committee members should have graduate privileges outside the area of specialization.

BIOMEDICAL ENGINEERING

G. C. Sieck, Ph.D., *Graduate Program Director*
S. J. Riederer, Ph.D., *Education Coordinator*

Employee Master's Degree

The Employee Master's Degree track in Biomedical Engineering is open only to permanent employees of Mayo Clinic. Admission to the program requires an interview with the Graduate Program Director. A total of 36 credits with maintenance of at least a 3.0 GPA are required for graduation.

Course Requirements

Core Courses (7 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6300	Molecular Biophysics	3 cr.
Core	6700	Integrated Systems Physiology	3 cr.

Track Requirements (21 credits required)

BME	5000	Principles of Biomedical Engineering I	3 cr.
BME	5050	Principles of Biomedical Engineering II	3 cr.
BME	5200	Advanced Engineering Mathematics	4 cr.
BME	5300	Cell and Neurophysiology	3 cr.
BME	8400	Master's Project	3 cr.
BME	8600	Biomedical Engineering Seminar (required annual attendance)	1 cr.
BME	8650	BME Journal Club (required annual attendance)	1 cr.
BME	8704	Digital Signal Processing	4 cr.

Electives (8 credits)

Thirty-six total credits are required to complete the program. In addition to the core and track requirements, 8 elective credits should be selected after consultation between the student and the Graduate Program Director. A minimum GPA of 3.0 will be required for combined coursework.

Qualifying Exam and Master's Project

The qualifying examination for the Employee Master's Degree in Biomedical Engineering is comprised of a two-part written qualifying exam. The first part is administered at the beginning of August and will cover track-required courses. The second part will be taken one week after part I. A form signed by the track Graduate Program Director will be submitted to Mayo Graduate School upon successful completion of the written qualifying exam.

In consultation with the Graduate Program Director, the student will select a Master's degree advisor within the first year of the program. The advisor must have graduate school privileges and must not be the employee's direct supervisor. In consultation with the Graduate Program Director and the Master's degree advisor, the student will select an Employee Master's Advisory Committee comprised of four faculty members. This committee must include, at a minimum, either the Graduate Program Director or the track Education Coordinator. This committee should meet at least yearly to assess the student's progress and provide guidance regarding the project. A form indicating the composition of the committee must be submitted to Mayo Graduate School.

The Master's project forms the central element of the Master's degree. The student should enroll in BME 8400 (Master's Project) 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 project must be approved in advance by the Biomedical Engineering Education Committee. This document must be written in close consultation with the Master's degree advisor 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 project review date.

The final project review is the final project committee meeting. Prior to this meeting the committee will carefully review, edit, and critique the 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 review. Three of four committee members must vote to pass the student and a form signed by all committee members must be submitted to Mayo Graduate School immediately upon completion of the review.

IMMUNOLOGY

H. Kita, M.D., *Graduate Program Director*

Employee Master's Degree

Students must complete a minimum of 36 credits.

Courses in Area of Specialization (18 credit minimum)

Core	6200	Basic Graduate Immunology	3 cr.
IMM	8400	Master's Project	3 cr.
*IMM	8863	Current Topics in Immunology	1 cr.
IMM	8877	Tutorial in Molecular Basis of Immune Recognition	2 cr.
IMM	8879	Tutorial in Cellular Activation	2 cr.
IMM	8880	Tutorial in Immunopathology	2 cr.
IMM	8882	Tutorial in Innate Immunity and Inflammation	2 cr.
IMM	8884	Tutorial in Tumor Immunology	2 cr.
IMM	8885	Tutorial in the Generation and Function of B Cells	2 cr.

*Current Topics courses may be taken more than once

Outside Major Area of Specialization (8 credit minimum)

Core	6000	Responsible Conduct of Research (required)	1 cr.

Electives (10 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.

MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

R. M. Weinshilboum, Ph.D., *Graduate Program Director*
D. C. Mays, Ph.D., *Education Coordinator*

Employee Master's Degree

The requirements for the Employee Master's Degree in Molecular Pharmacology and Experimental Therapeutics conform to the general requirements of the Mayo Graduate School in which a minimum of 36 credits are required for graduation.

Core Courses (14 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Core	6450	Molecular Pharmacology and Receptor Signaling	2 cr.
Core	6650	Biostatistics	2 cr.

Track Requirements (10 credits required)

MPET	5808	Introduction of Molecular Pharmacology	4 cr.
MPET	8100	Master's Project	3 cr.
MPET	8800	Research Seminars in Pharmacology	1 cr.
MPET	8805	Drug Metabolism, Pharmacogenomics, and Carcinogenesis	2 cr.

Track Tutorials (6 credits required, 3 tutorials required)

BMB	8665	DNA/Protein Interactions, Repair, Replication, and Recombination	2 cr.
MPET	8655	Mechanisms of Cell Growth and Death	2 cr.
MPET	8802	Cardiovascular Biology and Molecular Pharmacology	2 cr.
MPET	8812	Tutorial in Receptor Biology	2 cr.
MPET	8814	Cellular Pharmacology of Agents that Target Cancer and AIDS	2 cr.
MPET	8815	Neurobehavioral Pharmacology	2 cr.

Electives (6 credits required)

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

Written Examination

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

Master's Project

Master's degree candidates must complete a written project under the direction of a faculty advisor with graduate faculty privileges. The written 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 advisor and three additional members with graduate faculty privileges. The committee must be approved by the Graduate Program Director and Mayo Graduate School. The committee will evaluate the scope and content of the Master's project during an oral defense of the project. Three of the four members must vote to pass the student for a successful defense.

NEUROBIOLOGY OF DISEASE

A. J. Bieber, Ph.D., *Graduate Program Director*
I. O. Scarisbrick, Ph.D., *Education Coordinator, Mayo Clinic in Rochester*
R. Rademakers, Ph.D., *Education Coordinator, Mayo Clinic in Florida*

Employee Master's Degree

The Employee Master's Degree track in the Neurobiology of Disease is open only to permanent employees of Mayo Clinic. Admission to the program requires an interview with the graduate program director and the completion of 6 or more credits in MGS core coursework with maintenance of at least a 3.0 GPA.

Course Requirements

Core Courses (12 credits required)

Core	6000	Responsible Conduct of Research	1 cr.
Core	6100	Chemical Principles of Biological Systems	3 cr.
Core	6150	Genome Biology	3 cr.
Core	6250	Molecular Cell Biology	3 cr.
Core	6650	Biostatistics	2 cr.

Track Requirements (15 credits required)

NSCI	5500	Critical Thinking and Scientific Writing	3 cr.
NSCI	8100	Master's Project	3 cr.
NSCI	8401	Basic Neuroanatomy	1 cr.
NSCI	8500	Molecular Neuroscience Seminar (1cr./yr.)*	2 cr.
NSCI	8600	Special Topics in Neuroscience (1cr./yr.)*	2 cr.
NSCI	8850	Principles of Neuroscience	3 cr.
NSCI	8852	Topics in Neuroscience Research	1 cr.

* Two credits maximum

Electives (9 credits)

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

Qualifying Exam and Master's Project

The qualifying examination for the Employee Master's Degree in the Neurobiology of Disease is comprised of a two-part written qualifying exam. The first part is administered at the end of the neuroscience core

course (NSCI 8850/8852) and will cover the core neuroscience competencies. The second part will be taken after completion of the scientific writing course (NSCI 5500) and will involve writing a mini-grant proposal based upon a recent research article chosen by the education coordinator. A form signed by the track Graduate Program Director will be submitted to Mayo Graduate School upon successful completion of the written qualifying exam.

In consultation with the Graduate Program Director, the student will select a Master's degree advisor with the first year of the program. The advisor must have graduate school privileges and must not be the employee's direct supervisor. In consultation with the Graduate Program Director and the project advisor, the student will select a Master's Project Committee comprised of four faculty members. This committee must include, at a minimum, either the Graduate Program Director or the track Education Coordinator. This committee should meet yearly to assess the student's progress and provide guidance regarding the project. A form indicating the composition of the committee must be submitted to Mayo Graduate School.

The project forms the central element of the Master's degree. The student should enroll in NSCI 8100 (Master's Project) 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. While the final form of the project is at the discretion of the project 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 project advisor and must be submitted to the project committee for review at least one month prior to the 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 project advisor, one for the track, and one for the student). Binding should be coordinated with the program director or education coordinator.

The project defense is the final project committee meeting. Prior to this meeting the committee will carefully review, edit, and critique the 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 Mayo Graduate School immediately upon completion of the defense.

DESCRIPTION OF MASTER'S DEGREE PROGRAM AND CLINICAL TRACK REQUIREMENTS

MASTER OF SCIENCE PROGRAM IN BIOMEDICAL SCIENCES CLINICAL SPECIALTIES

The primary purpose of the degree program 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 advisor, appropriate supervision, and a suitable approach to the analysis and presentation of the results.

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

ELIGIBILITY

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

TUITION

Tuition may be covered by a Mayo Graduate School scholarship for Mayo graduate courses taken to meet Master's degree requirements. Mayo will not reimburse other costs that may be associated with the degree program.

APPLICATION

Candidates must complete an Application for Graduate Training Master's Program in Biomedical Sciences-Clinical Specialties form. The application must be approved by the track Graduate Program Director and Mayo Graduate School. This form is available from the Mayo Graduate School office.

TIME REQUIREMENT

All requirements must be satisfied within six months of the project defense or within one year after completion of the residency or fellowship.

REGISTRATION REQUIREMENT

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

MINIMUM CREDIT REQUIREMENTS

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

TRANSFER CREDITS

A total of 6 didactic credits may be transferred into the Clinical Master's Program.

Elective Course Policy
Students who wish to transfer graduate credits to substitute for a Mayo elective course must contact the Mayo course director and their Graduate Program Director. If the course director and the Graduate Program Director determine that a student has the knowledge equivalent to satisfactory performance in the Mayo course, the student may request the transfer credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Core Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a Mayo core course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive core course credits, the student is required to prove competence by taking an exam 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 core course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

Track Required Course Policy
Students who wish to transfer graduate credits to substitute or to waive credits for a track required course must contact the Mayo course director and their Graduate Program Director. To substitute or to waive

track required course credits, at the Mayo course director and the Graduate Program Director's discretion the student is required to prove competence by taking an exam 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 track required course, the student may request the transfer or waived credits. A letter from the course director and the Graduate Program Director must be sent to the Mayo Graduate School office to document the knowledge.

External Courses Policy
Students who wish to transfer credits not in substitution for a Mayo course(s) may request credit for graduate courses taken at another institution if they received a grade of A or B. The request must have the approval of the student's Graduate Program Director and Mayo Graduate School. A description of the course from the course catalog or a course outline must accompany the request. The time interval since the credits were earned is a consideration in such decisions. Credits must normally have been earned within the previous five years, as determined by the Graduate Program Director.

ADVISOR

A Master's degree mentor must have Mayo Graduate School full or Master's graduate faculty privileges.

List of Graduate Faculty with Privileges
http://mayoweb.mayo.edu/mgs/documents/ListofFacultywithPrivileges.xls

The complete list of faculty with graduate privileges begins on page

OFFICIAL DEGREE PROGRAM FORM

Students are expected to submit their Degree Program form to Mayo Graduate School before the end of the first year of registration. The form must include the minimum number of courses/credits necessary to fulfill degree requirements (credits may vary depending on the chosen track but the minimum Mayo Graduate School credit requirement must be met) and be approved by the track Graduate Program Director. Fifty percent of the credits on the degree program must be graded on the A-F grading system.

The Degree Program form is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html.*

CHANGES IN APPROVED PROGRAM

The approved degree program must be fulfilled in every detail to meet graduation requirements. Alterations in the program must be requested in writing and approved by the track Graduate Program

Director and Mayo Graduate School.

MINIMUM GRADE REQUIREMENTS

Students are expected to maintain a grade point average of 3.0 in didactic course work. Students whose performance falls below this standard in a given quarter will be placed on academic probation, as described in the Guidelines for Probation and Dismissal outlined on the Mayo intranet at *http://mayoweb.mayo.edu/mgs-policies/probation-dismissal.html.*

EXAMINATIONS

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

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

The student's advisor must sign a form indicating that he/she has read the thesis and that it is ready for defense prior to distribution to the Thesis Advisory Committee members. The Verification that the Thesis is Ready to Defend form can be accessed on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*. A copy of the title page of the project and the form must be submitted to the Mayo Graduate School office. The project must be submitted to the Thesis Advisory Committee at least three weeks before the final oral examination.

Only one dissenting vote is allowed for a "Pass." Any member of the Thesis Advisory Committee not present in real time via physical presence or video- or teleconferencing at the Final Oral Exam is counted as a "Fail" vote. Thus, no more than one Thesis Advisory Committee member may be absent for the Final Oral Exam. In the case where a student fails the examination, the committee will recommend to the student and to Mayo Graduate School remedial studies that should be undertaken by the student before the student retakes the examination. The final oral examination may be taken no more than twice and must be retaken within six months. Failing the examination twice will result in dismissal.

THESIS

Thesis Protocol: The protocol must be submitted to Mayo Graduate School no later than six months after admission to the program. This protocol must clearly define the candidate's role in the thesis and must have sufficient detail to permit review by an advisory committee. An Outline for the Master's Thesis Protocol is available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*. The protocol must be submitted with the form, Recommended Action on Thesis Protocol for Clinical Master's Degree, also available on the intranet site.

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

Thesis Advisory Committee: With the thesis protocol, students should submit the Master's Thesis Advisory Committee form recommending the members of their advisory/final oral examining committee and the Degree Program form. All members must have graduate faculty privileges and the chair must have a minimum of Master's graduate faculty privileges. The examining committee consists of a minimum of four individuals, one of whom is the student's advisor, who serves as chair of the committee. No more than two members of the committee can have teaching/examining privileges. One member must be from outside the track and no member other than the chair can be from among a student's research advisors. The recommended committee must be approved by the track Graduate Program Director and Mayo Graduate School.

Progress Meetings: The Master's Thesis Advisory Committee must meet every six months from the date of committee approval. Documentation of student progress, signed by all members of the Thesis Advisory Committee, should be submitted to Mayo Graduate School after each of these meetings. There is no standard form for this.

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 archival. Consequently, Mayo Graduate School has developed a standard for its format and style, which should be closely followed. Guidelines for Master's thesis are available on the Mayo Graduate School intranet site at *http://mayoweb.mayo.edu/mgs/forms.html*.

Final Thesis Corrections: After the student has passed the final oral examination, members of the Thesis Advisory Committee must sign a form indicating they are satisfied that the final corrections to the thesis have been made. Three of the four committee members must have signed before the student will be cleared for graduation. Mayo Graduate School will not certify completion of degree requirements until the final thesis has been submitted.

GRADUATION

Students are granted degrees four times a year: February, August, November and mid-May. The latter

involves a formal ceremony as part of the Mayo Clinic graduation exercises in conjunction with Mayo Medical School. No ceremony is held in February, August or November, but students who do graduate at one of these times are encouraged to participate in the May ceremony.

Students are allowed no more than six months to complete M.S. or Ph.D. degree requirements after a successful thesis defense. This policy is effective October 1, 2004. If a student does not meet this deadline, he/she will be required to re-defend his/her thesis.

Graduation deadlines:

To graduate in:	**Requirements must be completed by:**
February	January 1
May	– Draft of thesis to advisor and defense scheduled by March 8
	– All requirements completed by April 8, except submittal of final thesis
	– Thesis submitted at least 1 week before graduation
August	July 1
November	October 1

DENTISTRY – ORTHODONTICS

J. E. Volz, D.D.S., *Graduate Program Director*

Master's Degree

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

Biomedical Sciences Courses (all required)

Anat	8852	Surgical Anatomy of the Head and Neck	3 cr.
BME	5802	Principles of Biomechanics	3 cr.

BME	8878	Tutorial in Bone Physiology	3 cr.
BME	5453	Fundamental Concepts in Biomechanics	3 cr.
Core	6000	Responsible Conduct of Research	1 cr.
CTSC	5600	Statistics in Clinical Research	1 cr.
CTSC	5601	Utilizing Statistics in Clinical Research	2 cr.
Derm	8870	Oral Medicine & Oral Diagnosis	1 cr.
Odon	8857	Research in Selected Problems (1 cr./qtr. - 10 qtrs. required)	10 cr.

Orthodontic Didactic Courses (all required)

Odon	8806	Orthodontic Seminar: Technique (1 cr./qtr. - 2 qtrs. required)	2 cr.
Odon	8807	Orthodontic Seminar: Literature Review	1 cr.
Odon	8808	Orthodontic Seminar: Case Presentation	1 cr.
Odon	8809	Surgical Orthodontic Seminar	1 cr.
Odon	8810	Clinical Oro-Facial Pathology and Developmental Disorders	1 cr.
Pdon	8884	Periodontics/Orthodontics Seminar	1 cr.

Orthdontic Clinical Courses (all required)

Odon	8804	Clinical Orthodontics	6 cr.
Odon	8805	Advanced Clinical Orthodontics	6 cr.

DENTISTRY – PERIODONTICS

D. A. Assad, D.D.S., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

*Anat	8852	Surgical Anatomy of Head and Neck	3 cr.
*Core	6000	Responsible Conduct of Research	1 cr.
*CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
*CTSC	5610	Introductory Statistical Methods II	3 cr.
*Derm	8870	Oral Medicine & Oral Diagnosis	1 cr.
*Pdon	8857	Research in Selected Problems (2 cr./qtr. - 6 qtrs. required)	12 cr.

*Required courses

Periodontics Didactic Courses (all required)

Pdon	8883	Periodontal Seminar/Current Literature (1 cr./qtr. - 3 qtrs. required)	3 cr.
Pdon	8884	Periodontics/Orthodontics Seminar	1 cr.
Pdon	8886	Classic Literature in Periodontics	2 cr.
Pros	8870	Occlusion	1 cr.

Periodontics Clinical Courses (all required)

Pdon	8880	Clinical Periodontics (6 cr./qtr. - 1 qtr. required)	6 cr.

DENTISTRY – PROSTHODONTICS

T. J. Salinas, D.D.S., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

*Anat	8852	Surgical Anatomy of Head and Neck	3 cr.
*BME	5802	Principles of Biomechanics	3 cr.
BME	8878	Tutorial in Physiology of Bone	3 cr.
*Core	6000	Responsible Conduct of Research	1 cr.
CTSC	5000	Introduction to Clinical Research	1 cr.
CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
CTSC	5610	Introduction to Statistical Methods II	3 cr.
CTSC	5640	Advanced Logistic Regression	1 cr.
*Derm	8870	Oral Medicine & Oral Diagnosis	1 cr.
*Pros	8857	Research in Selected Problems (2 cr./qtr. - 6 qtrs. required)	12 cr.

*Required courses

Prosthodontic Didactic Courses (all required)

Pros	8841	Prosthodontic Seminar (Complete Dentures) (1 cr./qtr. - 2 qtrs. required)	2 cr.
Pros	8843	Prosthodontic Seminar (Partial Dentures)	1 cr.
Pros	8845	Prosthodontic Seminar (Fixed)	1 cr.
Pros	8847	Seminar: Maxillofacial Prosthetics–Advanced Prosthodontics	1 cr.

Pros	8848	Seminar: Current Literature	
Pros	8849	Seminar: Maxillofacial Prosthetics (Extraoral) and Advanced Prosthodontics	1 cr.
Pros	8850	Seminar: Implant Prosthodontics	1 cr.
Pros	8859	Peridontal and Prosthodontic Considerations in Dentistry	1 cr.
Pros	8862	Dental Materials	1 cr.
Pros	8871	Physiology, Pharmacology and Pre-Prosthetic Surgery	1 cr.
Pros	8873	Cranio-mandibular Disorders and Facial Pain	1 cr.
Pros	8874	Prosthodontic Management of the Geriatric Patient	1 cr.

Prosthodontic Clinical Courses (all required)

Pros	8840	Clinical Prosthodontics: Complete Dentures (6 cr./qtr. - 2 qtrs. required)	12 cr.
Pros	8842	Clinical Prosthodontics: Partial Dentures (6 cr./qtr. - 4 qtrs. required)	24 cr.
Pros	8844	Maxillofacial Prosthetics (intraoral)--Advanced Prosthodontics (6 cr./qtr. - 3 1/2 qtrs. required)	21 cr.
Pros	8846	Maxillofacial Prosthetics (Extraoral)-- Advanced Prosthodontics (6 cr./qtr. - 1/2 qtr. required	3 cr.
Pros	8851	Dental Roentgenology	1 cr.
Pros	8852	Oral Diagnosis and Treatment of Cranio-mandibular Disorders	2 cr.
Pros	8854	Implant Prosthodontics (6 cr./qtr. - 3 qtrs. required)	18 cr.
Pros	8880	Dental Laboratory Technology	6 cr.
I	8866	Oncology (Special Clinical and Laboratory Techniques	1 cr.
SpPa	8861	Speech Pathology	2 cr.
ENT	8851	Clinical Otolaryngology	6 cr.
R	8853	Radiation Oncology	2 cr.

OBSTETRICS & GYNECOLOGY – FEMALE PELVIC MEDICINE/ RECONSTRUCTIVE SURGERY

J. B. Gebhart, M.D., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

Didactic

*Core	6000	Responsible Conduct of Research	1 cr.
*CTSC	5000	Introduction to Clinical Research	1 cr.

*CTSC	5010	Clinical Research Protocol Development	2 cr.
*CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
*CTSC	5310	Clinical Epidemiology II	1 cr.
*CTSC	5390	Advanced Applied Epidemiologic Methods	2 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
*CTSC	5610	Introductory Statistical Methods II	3 cr.

* Required courses

Workshops - to be taken during first year of fellowship

Writing for Biomedical Publication
Write Winning Grants

Research

**BMB	8840	Research in Biochemistry and Molecular Biology	6 cr.
**IMM	8840	Research in Immunology	6 cr.
**MPET	8840	Research in Pharmacology	6 cr.
**ObG	8840	Research in Obstetrics-Gynecology	6 cr.

**Four quarters of one of these is required.

Urogynecology/Reconstructive Pelvic Surgery Didactic Courses

Anat	8000	Anatomy of the Pelvis-Perineum (Register winter quarter; attendance required winter and spring quarters)	2 cr./yr.
ObG	5803	Introduction to Surgical Gynecology (1 cr./qtr. - 4 qtrs. required) Begin summer quarter of first year of fellowship; Register once for 4 consecutive quarters	4 cr.

Urogynecology/Reconstructive Pelvic Surgery Clinical Courses

ObG	8870	Advanced Urogynecologic Operative Surgery (6 cr./qtr. - 4 qtrs. required) Begin summer quarter of second year of fellowship; register once for 4 consecutive quarters	24 cr.

OBSTETRICS & GYNECOLOGY – GYNECOLOGIC ONCOLOGY

W. A. Cliby, M.D., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

Didactic

*BMB	5000	Cancer Biology I	3 cr.
*Core	6000	Responsible Conduct of Research	1 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
*CTSC	5610	Introductory Statistical Methods II	3 cr.

* Required courses

Additional elective courses may be taken after discussion and approval by the Graduate Program Director. Courses available but are not limited to:

CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
CTSC	5310	Clinical Epidemiology II	1 cr.
CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis	1 cr.

Workshops - to be taken during first year of fellowship
*Writing for Biomedical Publication
*Writing Winning Grants

Research

**BMB	8840	Research in Biochemistry and Molecular Biology	6 cr.
**IMM	8840	Research in Immunology	6 cr.
**MPET	8840	Research in Pharmacology	6 cr.
**ObG	8840	Research in Obstetrics-Gynecology	6 cr.

**Four quarters of one of these is required.

Gynecologic Oncology Didactic Courses

*Anat	8000	Anatomy of the Pelvis-Perineum (Register winter quarter; attendance required winter and spring quarters)	2 cr./yr.
*ObG	5803	Introduction to Surgical Gynecology (1 cr./qtr. – 4 qtrs. required) Begin summer quarter of first year of fellowship; register once for 4 consecutive quarter	4 cr.

Gynecologic Oncology Clinical Courses

*ObG	8857	Gynecologic Oncology (6 cr./qtr. - 5 qtrs. required) Begin summer quarter of second year of fellowship;	30 cr.

register once for 5 consecutive quarters.

OBSTETRICS & GYNECOLOGY – MATERNAL FETAL MEDICINE

B.C. Brost, M.D., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

Didactic

*Core	6000	Responsible Conduct of Research	1 cr.
*CTSC	5000	Introduction to Clinical Research	1 cr.
*CTSC	5010	Clinical Research Protocol Development	2 cr.
*CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
*CTSC	5310	Clinical Epidemiology II	1 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
*CTSC	5610	Introductory Statistical Methods II	3 cr.

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

CTSC	5390	Advanced Applied Epidemiologic Methods	2 cr.
CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis	1 cr.
CTSC	5760	Medical Decision Making	1 cr.
CTSC	5820	Introduction to Survey Research	1 cr.
CTSC	5910	Economic Evaluation in Health Care	1 cr.

*Required courses

Workshops
Writing for Biomedical Publication
Write Winning Grants

Research

**BMB	8840	Research in Biochemistry and Molecular Biology	6 cr.
**IMM	8840	Research in Immunology	6 cr.
**MPET	8840	Research in Pharmacology	6 cr.
**ObG	8840	Research in Obstetrics-Gynecology	6 cr.

**Four quarters of one of these is required.

Maternal Fetal Medicine Didactic Courses

Anat	8000	Anatomy of the Pelvis-Perineum (Register winter quarter; attendance required winter and spring quarters)	2 cr./yr.
ObG	5804	Introduction to Maternal Fetal Medicine (1 cr./qtr. - 4 qtrs. required) Begin summer quarter of first year of fellowship; register once for 4 consecutive quarters	4 cr.

Maternal Fetal Medicine Clinical Courses

ObG	8875	Maternal Fetal Medicine (6 cr./qtr. - 4 qtrs. required)	24 cr.

OBSTETRICS & GYNECOLOGY – REPRODUCTIVE ENDOCRINOLOGY AND INFERTILITY

G. S. Daftary, M.D., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

Didactic

*Core	6000	Responsible Conduct of Research	1 cr.
*CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.

Must choose one of the following basic science courses:

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

*Required courses

Additional elective courses may be taken after discussion and approval by the Graduate Program Director. Courses available but are not limited to:

BMB	8350	Genomic/Proteomic Analysis Using Bioinformatic Techniques	1 cr.
BMB	8660	Transcription, Chromatin, and Epigenetics	2 cr.
CTSC	5000	Introduction to Clinical Research	1 cr.
CTSC	5010	Clinical Research Protocol Development	2 cr.

CTSC	5310	Clinical Epidemiology II	1 cr.
CTSC	5390	Advanced Applied Epidemiologic Methods	2 cr.
CTSC	5610	Introductory Statistical Methods II	3 cr.
CTSC	5640	Logistic Regression	1 cr.
CTSC	5650	Survival Analysis	1 cr.
CTSC	5760	Medical Decision Making	1 cr.
CTSC	5820	Introduction to Survey Research	1 cr.
CTSC	5910	Economic Evaluation in Health Care	1 cr.

Workshops - Recommended but not required
Writing for Biomedical Publication
Write Winning Grants

Research

**BMB	8840	Research in Biochemistry and Molecular Biology	6 cr.
**IMM	8840	Research in Immunology	6 cr.
**MPET	8840	Research in Pharmacology	6 cr.
**ObG	8840	Research in Obstetrics-Gynecology	6 cr.

**Four quarters of one of these is required.

Reproductive Endocrinology & Infertility Didactic Courses

*Anat	8000	Anatomy of the Pelvis-Perineum (Register winter quarter; attendance required winter and spring quarters)	2 cr./yr.
ObG	5805	Introduction to Reproductive Endocrinology and Infertility (1 cr./qtr. - 5 qtrs. required) Begin summer quarter of first year of fellowship; register once for 5 consecutive quarters	5 cr.

Reproductive Endocrinology & Infertility Clinical Courses

ObG	8865	Reproductive Endocrinology and Infertility (6 cr./qtr. - 5 qtrs. required) Begin summer quarter of first year of fellowship; register once for 5 consecutive quarters	30 cr.

ORTHOPEDICS

N. S. Turner, M.D., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses (all required)

Anat	8855	Orthopedic Anatomy (2 cr./qtr. - 2 qtrs. required)	4 cr.
BME	8878	Tutorial in Physiology of Bone	3 cr.
BME	5802	Principles of Biomechanics	3 cr.
Core	6000	Responsible Conduct of Research	1 cr.
BMB	8840	Research in Biochemistry and Molecular Biology (6 cr. / qtr. -2 qtrs. required)	12 cr.
M	5805	Microbiology of Musculoskeletal System	1 cr.
OR	8890	Research in Orthopedics (6 cr./qtr. - 4 qtrs. required)	24 cr.

Orthopedics Didactic Courses (all required)

Or	5803	Prosthetics for Orthopedics	1 cr.
Or	8550	Nonstructured Microvascular	2 cr.
Or	8860	Basic Knowledge and Motor Skills of Orthopedic Specialties	3 cr.

Orthopedics Clinical Courses (all required)

Or	8851	Orthopedic Diagnosis	6 cr.
Or	8852	Adult Reconstruction	6 cr.
Or	8853	Surgery of the Hand	6 cr.
Or	8854	Pediatric Orthopedics	6 cr.
Or	8855	Orthopedic Oncology	6 cr.
Or	8856	Fractures	2 cr.
R	8854	Radiology of the Musculoskeletal System	1 cr.

OTORHINOLARYNGOLOGY

E. J. Moore, M.D., *Graduate Program Director*

Master's Degree

Biomedical Sciences Courses

*Anat	8852	Surgical Anatomy of Head and Neck	3 cr.
Anat	8860	Special Topics in Anatomy	1-4 cr.
BME	8859	Renal Physiology	2 cr.
*Core	6000	Responsible Conduct of Research	1 cr.
Core	6200	Basic Graduate Immunology	3 cr.
Core	6450	Molecular Pharmacology and Receptor Biology	2 cr
*ENT	8890	Graduate Research (6 cr./qtr. - 2 qtrs. required)	12 cr.
CTSC	5300	Introduction to Clinical Epidemiology	1 cr.
*CTSC	5600	Statistics in Clinical Research	2 cr.
*CTSC	5601	Utilizing Statistics in Clinical Research	1 cr.
CTSC	5640	Advanced Logistic Regression	1 cr.
MPET	8803	Biochemical Basis of Neuropharmacology	3 cr.
MPET	8812	Tutorial in Receptor Biology	2 cr.

*Required courses, an additional six credits to be chosen from courses listed, for a total of at least 25 credits in the Biomedical Sciences area. Other biomedical sciences courses may be included as electives at the discretion of the advisor.

Otorhinolaryngology Didactic Courses (all required)

ENT	5150	Core Curriculum	2 cr.
ENT	5300	Core Colloquium	1 cr.
ENT	8100	Problems in Clinical Diagnosis	4 cr.
ENT	8300	Soft Tissue and Plastic Reconstruction	1 cr.
ENT	8500	Rhinology and Rhinologic Surgery Dissection	3 cr.
ENT	8800	Seminar: Otorhinolaryngology	1 cr./yr.
ENT	8857	Temporal Bone Anatomy and Surgery of the Temporal Bone	3 cr.

Otorhinolaryngology Clinical Courses (all required)

ENT	8851	Clinical Otorhinolaryngology	6 cr.
ENT	8852	Preoperative and Postoperative Care of Patients	6 cr.
ENT	8853	Operative Otorhinolaryngology	6 cr.
ENT	8854	Operative Otorhinolaryngology	6 cr.

LIST OF GRADUATE FACULTY

WITH PRIVILEGES

List of Graduate Faculty with Privileges
http://mayoweb.mayo.edu/mgs/documents/ListofFacultywithPrivileges.xls

TRACK	TRACK DESCRIPTION
BMB	Biochemistry and Molecular Biology
BME	Biomedical Engineering
CTSC	Clinical and Translational Science
DENT	Dentistry
DERM	Dermatology
ENT	Otorhinolaryngology
IMM	Immunology
MPET	Molecular Pharmacology and Experimental Therapeutics
NSCI	Molecular Neuroscience
OBG	Obstetrics and Gynecology
OR	Orthopedic Surgery
VGT	Virology and Gene Therapy

NAME	TRACK	LEVEL
Pawlina, Wojciech MD	ANAT	Teach/Exam
Anastasiadis, Panagiotis Z PhD	BMB	Full
Bajzer, Zeljko PhD	BMB	Full
Bergsagel, Peter Leif MD	BMB	Full
Billadeau, Daniel D PhD	BMB	Full
Brozovich, Frank V MD PhD	BMB	Full
Burghardt, Thomas Patrick PhD	BMB	Full
Cattaneo, Roberto PhD	BMB	Full
Chang, Xiu-Bao PhD	BMB	Full
Copland, John A III PhD	BMB	Full
Couch, Fergus J PhD	BMB	Full
Eberhardt, Norman L PhD	BMB	Full
Ekker, Stephen C PhD	BMB	Full
Federspiel, Mark J PhD	BMB	Full
Gendler, Sandra J PhD	BMB	Full
Gores, Gregory James MD	BMB	Full
Grande, Joseph Peter MD PhD	BMB	Full
Harris, Peter C PhD	BMB	Full
Horazdovsky, Bruce F PhD	BMB	Full
Hu, Jinghua PhD	BMB	Full
Isaya, Grazia MD PhD	BMB	Full
Jenkins, Robert Brian MD PhD	BMB	Full
Katzmann, David J PhD	BMB	Full
Kaufmann, Scott H MD PhD	BMB	Full
Kocher, Jean-Pierre A PhD	BMB	Full
Kumar, Rajiv MD	BMB	Full
La Russo, Nicholas F MD	BMB	Full
Lee, James J PhD	BMB	Full
Lee, Nancy A PhD	BMB	Full
Leof, Edward B PhD	BMB	Full
Limper, Andrew Harold MD	BMB	Full

Ling, Kun PhD	BMB	Full
Lingle, Wilma L PhD	BMB	Full
Loftus, Joseph C PhD	BMB	Full
Lupu, Ruth PhD	BMB	Full
Macura, Slobodan I PhD	BMB	Full
Maher, Louis James III PhD	BMB	Full
Mc Cormick, Daniel J PhD	BMB	Full
Mc Niven, Mark A PhD	BMB	Full
Mer, Georges PhD	BMB	Full
Miller, Laurence J MD	BMB	Full
Mukhopadhyay, Debabrata PhD	BMB	Full
Ogut, Ozgur PhD	BMB	Full
Oursler, Merry Jo PhD	BMB	Full
Owen, Whyte G PhD	BMB	Full
Patel, Robin MD	BMB	Full
Pittelkow, Mark Robert MD	BMB	Full
Prendergast, Franklyn G MD PhD	BMB	Full
Radisky, Derek C PhD	BMB	Full
Radisky, Evette S PhD	BMB	Full
Ramirez Alvarado, Marina PhD	BMB	Full
Romero, Michael F PhD	BMB	Full
Salisbury, Jeffrey L PhD	BMB	Full
Scrable, Heidi Jean PhD	BMB	Full
Shah, Vijay MD	BMB	Full
Shridhar, Vijayalakshmi PhD	BMB	Full
Simari, Robert David MD	BMB	Full
Smith, David I PhD	BMB	Full
Spelsberg, Thomas C PhD	BMB	Full
Storz, Peter PhD	BMB	Full
Strehler, Emanuel E PhD	BMB	Full
Sussman, Caroline R PhD	BMB	Full
Thibodeau, Stephen N PhD	BMB	Full
Thomas, Charles Francis Jr. MD	BMB	Full
Thompson, E Aubrey PhD	BMB	Full
Tindall, Donald J PhD	BMB	Full
Toft, David O PhD	BMB	Full
Urrutia, Raul Alfredo MD	BMB	Full
Van Deursen, Jan PhD	BMB	Full
Ward, Christopher James MBChB PhD	BMB	Full
Weinshilboum, Richard MD	BMB	Full
Westendorf, Jennifer Jane PhD	BMB	Full
Wieben, Eric D PhD	BMB	Full
Xu, Xiaolei PhD	BMB	Full
Young, Charles Y-F PhD	BMB	Full
Zhang, Zhiguo PhD	BMB	Full
Abraham, Roshini S PhD	BMB	Master
Fernandez Zapico, Martin E MD	BMB	Master
Goetz, Matthew Philip MD	BMB	Master
Highsmith, W Edward Jr. PhD	BMB	Master
Vella, Adrian MD	BMB	Master

Bible, Keith Christophe MD PhD	BMB	Teach/Exam
Caride, Ariel J	BMB	Teach/Exam
Cliby, William Arthur MD	BMB	Teach/Exam
Conover, Cheryl A PhD	BMB	Teach/Exam
D Assoro, Antonio B MD PhD	BMB	Teach/Exam
Dawson, D Brian PhD	BMB	Teach/Exam
Hartmann, Lynn Carol MD	BMB	Teach/Exam
Heemers, Hannelore Valerie PhD	BMB	Teach/Exam
Huang, Haojie PhD	BMB	Teach/Exam
Jiang, Shi-Wen MD	BMB	Teach/Exam
Leontovich, Alexey A PhD	BMB	Teach/Exam
Li, Peter W PhD	BMB	Teach/Exam
Lomberk, Gwen Alyce PhD	BMB	Teach/Exam
Marks, David L PhD	BMB	Teach/Exam
Masyuk, Tetyana Volodymyrivna PhD	BMB	Teach/Exam
Mc Gowan, Eileen M PhD	BMB	Teach/Exam
Mcgarry, Michael Patrick PhD	BMB	Teach/Exam
Molina, Julian Rodrigo MD PhD	BMB	Teach/Exam
O Neill, Brian Patrick MD	BMB	Teach/Exam
Parney, Ian F MD PhD	BMB	Teach/Exam
Poland, Gregory A MD	BMB	Teach/Exam
Raghavakaimal, Sreekumar PhD	BMB	Teach/Exam
Szabo, Csilla PhD	BMB	Teach/Exam
Thorland, Erik Carl PhD	BMB	Teach/Exam
Uhm, Joon Ho MD	BMB	Teach/Exam
Vasmatzis, George PhD	BMB	Teach/Exam
Amadio, Peter C MD	BME	Full
An, Kai-Nan PhD	BME	Full
Bajzer, Zeljko PhD	BME	Full
Belohlavek, Marek MD PhD	BME	Full
Bernstein, Matthew A PhD	BME	Full
Brozovich, Frank V MD PhD	BME	Full
Burghardt, Thomas Patrick PhD	BME	Full
Burnett, John C Jr. MD	BME	Full
Charkoudian, Nisha PhD	BME	Full
Chini, Eduardo Nunes MD PhD	BME	Full
Daniel, Erik Stephen PhD	BME	Full
Ehman, Richard Lorne MD	BME	Full
Erickson, Bradley J MD PhD	BME	Full
Farrugia, Gianrico MD	BME	Full
Fatemi, Mostafa PhD	BME	Full
Felmlee, Joel P PhD	BME	Full
Gilbert, Barry Kent PhD	BME	Full
Greenleaf, James F PhD	BME	Full
Henley, John Richard PhD	BME	Full
Herman, Michael G PhD	BME	Full
Hubmayr, Rolf Dieter MD	BME	Full
Jack, Clifford R Jr. MD	BME	Full
Johnson, Bruce David PhD	BME	Full
Joyner, Michael Joeseph MD	BME	Full

Kaufman, Kenton R PhD	BME	Full
Khosla, Sundeep MD	BME	Full
Kirkland, James L MD PhD	BME	Full
Kline, Robert W PhD	BME	Full
Lee, Kendall H MD PhD	BME	Full
Lerman, Lilach O MD PhD	BME	Full
Lieske, John C MD	BME	Full
Linden, David R PhD	BME	Full
Macura, Slobodan I PhD	BME	Full
Manduca, Armando PhD	BME	Full
Mantilla, Carlos B MD PhD	BME	Full
McCollough, Cynthia H PhD	BME	Full
Miller, Jordan Daniel PhD	BME	Full
Miller, Virginia M PhD	BME	Full
Nyberg, Scott L MD PhD	BME	Full
O Driscoll, Shawn William MD PhD	BME	Full
O'Connor, Michael Kieran PhD	BME	Full
Ordog, Tamas MD	BME	Full
Pabelick, Christina MD	BME	Full
Pang, Yuan Ping PhD	BME	Full
Prakash, Y S MD PhD	BME	Full
Qian, Qi MD	BME	Full
Riederer, Stephen J PhD	BME	Full
Ritman, Erik L MD PhD	BME	Full
Robb, Richard Arlin PhD	BME	Full
Rodriguez-Porcel, Martin G MD	BME	Full
Romero, Michael F PhD	BME	Full
Scarisbrick, Isobel A PhD	BME	Full
Sieck, Gary C PhD	BME	Full
Sine, Steven M PhD	BME	Full
Sussman, Caroline R PhD	BME	Full
Szurszewski, Joseph H PhD	BME	Full
Thompson, James R PhD	BME	Full
Torres, Vicente MD PhD	BME	Full
Yaszemski, Michael J MD PhD	BME	Full
Chen, Shigao PhD	BME	Master
Abenstein, John P MD	BME	Teach/Exam
Alizad, Azra MD	BME	Teach/Exam
Antolak, John A PhD	BME	Teach/Exam
Aquino, Wilkins PhD	BME	Teach/Exam
Araoz, Philip A MD	BME	Teach/Exam
Bahn, Mark M MD PhD	BME	Teach/Exam
Bartholmai, Brian Jack MD	BME	Teach/Exam
Basford, Jeffrey R MD PhD	BME	Teach/Exam
Bite, Uldis MD	BME	Teach/Exam
Blanco, Michael C DVM	BME	Teach/Exam
Blezek, Daniel J	BME	Teach/Exam
Chang, Minhwang PhD	BME	Teach/Exam
Collins, Douglas Alonzo MD	BME	Teach/Exam
Curry, Timothy Brian MD PhD	BME	Teach/Exam

Cusma, Jack Tindaro PhD	BME	Teach/Exam
Dadsetan, Mahrokh PhD	BME	Teach/Exam
Davis, Brian J MD PhD	BME	Teach/Exam
Dragomir Daescu, M Dan	BME	Teach/Exam
Eberhardt, Norman L PhD	BME	Teach/Exam
Edmonson, Heidi Alissa PhD	BME	Teach/Exam
Fetterly, Kenneth A PhD	BME	Teach/Exam
Frisk, Craig S DVM PhD	BME	Teach/Exam
Gades, Naomi M DVM	BME	Teach/Exam
Gay, Ralph Edward MD	BME	Teach/Exam
Gibbons, Simon James PhD	BME	Teach/Exam
Glockner, James MD	BME	Teach/Exam
Gloviczki, Peter MD	BME	Teach/Exam
Gorny, Krzysztof R PhD	BME	Teach/Exam
Grant, Katharine Lynn Rowley PhD	BME	Teach/Exam
Hangiandreou, Nicholas James PhD	BME	Teach/Exam
Hartmann, Lynn Carol MD	BME	Teach/Exam
Holmes, David Richard III PhD	BME	Teach/Exam
Huston, John III MD	BME	Teach/Exam
Jayachandran, Muthuvel PhD	BME	Teach/Exam
Juranic, Nenad Oskar PhD	BME	Teach/Exam
Kallmes, David F MD	BME	Teach/Exam
Kantor, Birgit MD	BME	Teach/Exam
Karnitz, Larry M PhD	BME	Teach/Exam
Katusic, Zvonimir S MD PhD	BME	Teach/Exam
Kearns, Ann E MD PhD	BME	Teach/Exam
Kemp, Bradley J PhD	BME	Teach/Exam
King, Bernard Francis MD	BME	Teach/Exam
Kofler, James M PhD	BME	Teach/Exam
Kruse, Jon J PhD	BME	Teach/Exam
Kumar, Rajiv MD	BME	Teach/Exam
Kwartowitz, David M PhD	BME	Teach/Exam
Leng, Shuai PhD	BME	Teach/Exam
Lerman, Amir MD	BME	Teach/Exam
Lewallen, David G MD	BME	Teach/Exam
Lin, Chen	BME	Teach/Exam
Lowe, Val MD	BME	Teach/Exam
Lu, Lichun PhD	BME	Teach/Exam
Maran, Avudaiappan PhD	BME	Teach/Exam
Mcgee, Kiaran Patrick PhD	BME	Teach/Exam
Miller, Robert Clell MD	BME	Teach/Exam
Mullan, Brian Patrick MD	BME	Teach/Exam
Nassr, Ahmad MD	BME	Teach/Exam
Ottesen, Hal H PhD	BME	Teach/Exam
Oursler, Merry Jo PhD	BME	Teach/Exam
Owen, Whyte G PhD	BME	Teach/Exam
Packer, Douglas L MD	BME	Teach/Exam
Pavlicek, William PhD	BME	Teach/Exam
Pemberton, John Hogeland MD	BME	Teach/Exam
Pirko, Istvan MD	BME	Teach/Exam

Pisansky, Thomas Michael MD	BME	Teach/Exam
Redfield, Margaret May MD	BME	Teach/Exam
Rhodes, Deborah Jane MD	BME	Teach/Exam
Rock, Michael G MD	BME	Teach/Exam
Roy, Tuhin K MD PhD	BME	Teach/Exam
Schueler, Beth Ann PhD	BME	Teach/Exam
Shu, Yunhong PhD	BME	Teach/Exam
Sturchio, Glenn Martin PhD	BME	Teach/Exam
Toft, David O PhD	BME	Teach/Exam
Yu, Lifeng PhD	BME	Teach/Exam
Zhan, Wen-Zhi MD	BME	Teach/Exam
Zhang, Xiaoming PhD	BME	Teach/Exam
Zhao, Chunfeng MD	BME	Teach/Exam
Zhao, Kristin Daigle	BME	Teach/Exam
Zobitz, Mark Edward	BME	Teach/Exam
Bahn, Rebecca Sue MD	CTSC	Full
Callstrom, Matthew R MD PhD	CTSC	Full
Camilleri, Michael MD	CTSC	Full
Cerhan, James R MD PhD	CTSC	Full
Chute, Christopher Gregory MD Dr PH	CTSC	Full
De Andrade, Mariza PhD	CTSC	Full
Dietz, Allan B PhD	CTSC	Full
Ebbert, Jon Owen MD	CTSC	Full
Gabriel, Sherine E MD	CTSC	Full
Geda, Yonas Endale MD	CTSC	Full
Grande, Joseph Peter MD PhD	CTSC	Full
Harris, Marcelline R PhD	CTSC	Full
Hurt, Richard D MD	CTSC	Full
Jensen, Michael Dennis MD	CTSC	Full
Koenig, Barbara A PhD	CTSC	Full
Loprinzi, Charles Lawrence MD	CTSC	Full
Lucchinetti, Claudia F MD	CTSC	Full
Mandarino, Lawrence J PhD	CTSC	Full
Nair, K Sreekumaran MD PhD	CTSC	Full
Oberg, Ann L PhD	CTSC	Full
Petersen, Gloria M PhD	CTSC	Full
Pirko, Istvan MD	CTSC	Full
Port, John D MD PhD	CTSC	Full
Rizza, Robert Allan MD	CTSC	Full
Roberts, Lewis Rowland MBChB PhD	CTSC	Full
Roger, Veronique Lee MD	CTSC	Full
Schaff, Hartzell V MD	CTSC	Full
Schaid, Daniel J PhD	CTSC	Full
Smith, Glenn E PhD LP	CTSC	Full
Therneau, Terry M PhD	CTSC	Full
Vachon, Celine M PhD	CTSC	Full
Warner, David Oman MD	CTSC	Full
Windebank, Anthony John MD	CTSC	Full
Yang, Ping MD PhD	CTSC	Full
Afessa, Bekele MD	CTSC	Master

Ahlquist, David Alan MD	CTSC	Master
Ahlskog, J Eric MD PhD	CTSC	Master
Alberts, Steven Robert MD	CTSC	Master
Allison, Thomas G PhD	CTSC	Master
Amin, Shreyasee MD	CTSC	Master
Amrami, Kimberly Katz MD	CTSC	Master
Andrews, James C MD	CTSC	Master
Appleton, Christopher P MD	CTSC	Master
Arndt, Carola A S MD	CTSC	Master
Bacon, Douglas R MD	CTSC	Master
Baddour, Larry M MD	CTSC	Master
Ballman, Karla Veronica PhD	CTSC	Master
Baron, Todd H Sr. MD	CTSC	Master
Barton, Debra Lynn RN PhD	CTSC	Master
Basford, Jeffrey R MD PhD	CTSC	Master
Basu, Ananda MBBS MD	CTSC	Master
Bauer, Brent A MD	CTSC	Master
Beebe, Timothy J PhD	CTSC	Master
Bender, Claire Elizabeth MD	CTSC	Master
Berbari, Elie F MD	CTSC	Master
Berger, Richard Allen MD PhD	CTSC	Master
Bharucha, Adil Eddie MBBS MD	CTSC	Master
Bjarnason, Haraldur MD	CTSC	Master
Boyce, Thomas George MD	CTSC	Master
Brown, Robert D Jr. MD	CTSC	Master
Bundrick, John Bennett MD	CTSC	Master
Cascino, Gregory D MD	CTSC	Master
Cataliotti, Alessandro MD PhD	CTSC	Master
Chari, Suresh T MD	CTSC	Master
Colligan, Robert C PhD LP	CTSC	Master
Cook, David Allan MD	CTSC	Master
Cosio, Fernando G MD	CTSC	Master
Crowell, Michael D PhD	CTSC	Master
Cunningham, Julie M PhD	CTSC	Master
Daly, Richard C MD	CTSC	Master
Deschamps, Claude MD	CTSC	Master
Edell, Eric Scott MD	CTSC	Master
Farley, David Ray MD	CTSC	Master
Fletcher, Joel Garland MD	CTSC	Master
Gajic, Ognjen MD	CTSC	Master
Gersh, Bernard John MBChB	CTSC	Master
Gores, Gregory James MD	CTSC	Master
Gostout, Christopher J MD	CTSC	Master
Hagler, Donald Joseph MD	CTSC	Master
Halling, Kevin Carl MD PhD	CTSC	Master
Hanssen, Arlen Dale MD	CTSC	Master
Hartmann, Lynn Carol MD	CTSC	Master
Hays, J Taylor MD	CTSC	Master
Heit, John A MD	CTSC	Master
Hensrud, Donald Douglas MD	CTSC	Master

Holmes, David R Jr. MD	CTSC	Master
Holmes, Jonathan M MD	CTSC	Master
Horlocker, Terese T MD	CTSC	Master
Huddleston, Jeanne Marie MD	CTSC	Master
Huebner, Marianne PhD	CTSC	Master
Huskins, W Charles MD	CTSC	Master
Jacobson, Robert M MD	CTSC	Master
Jaffe, Allan S MD	CTSC	Master
Joyner, Michael Joeseph MD	CTSC	Master
Juhn, Young J MD	CTSC	Master
Kamath, Patrick Sequeira MD	CTSC	Master
Kaur, Judith S MD	CTSC	Master
Kay, Neil Elliot MD	CTSC	Master
Keegan, B Mark MD	CTSC	Master
Kim, Woong R MD	CTSC	Master
Kirkland, Lisa L MD	CTSC	Master
Klein, Christopher Jon MD	CTSC	Master
Knopman, David S MD	CTSC	Master
Kullo, Iftikhar Jan MD	CTSC	Master
Larson, Timothy Stanton MD	CTSC	Master
Leibson, Cynthia L PhD	CTSC	Master
Lerman, Amir MD	CTSC	Master
Lindor, Keith Douglas MD	CTSC	Master
Litzow, Mark Robert MD	CTSC	Master
Locke, Giles Richard III MD	CTSC	Master
Loftus, Edward Vincent Jr. MD	CTSC	Master
Lopez Jimenez, Francisco MD	CTSC	Master
Luthra, Harvinder S MD	CTSC	Master
Markovic, Svetomir Nenad MD PhD	CTSC	Master
Martenson, James Austin Jr. MD	CTSC	Master
Matteson, Eric Lawrence MD	CTSC	Master
Mc Bane, Robert Donald MD	CTSC	Master
Mc Mahon, M Molly MD	CTSC	Master
Melton, Lee Joseph III MD	CTSC	Master
Meyer, Fredric Bruce MD	CTSC	Master
Michet, Clement J MD	CTSC	Master
Miles, John M MD	CTSC	Master
Miller, Fletcher A Jr. MD	CTSC	Master
Mohney, Brian Glenn MD	CTSC	Master
Molina, Julian Rodrigo MD PhD	CTSC	Master
Montori, Victor Manuel MD	CTSC	Master
Mulvagh, Sharon Lee MD	CTSC	Master
Murray, Joseph A MD	CTSC	Master
Nelson, Heidi MD	CTSC	Master
Nichols, Francis C III MD	CTSC	Master
O Leary, Patrick William MD	CTSC	Master
Olson, Janet E PhD	CTSC	Master
Osmon, Douglas R MD	CTSC	Master
Pankratz, Vernon Shane PhD	CTSC	Master
Pardi, Darrell Spencer MD	CTSC	Master

Pellikka, Patricia Ann MD	CTSC	Master
Pemberton, John Hogeland MD	CTSC	Master
Petersen, Ronald Carl MD PhD	CTSC	Master
Petty, George W MD	CTSC	Master
Poland, Gregory A MD	CTSC	Master
Pollock, Bruce E MD	CTSC	Master
Preiss, Christi Ann PhD	CTSC	Master
Rabinstein, Alejandro Abraham MD	CTSC	Master
Radecki Breitkopf, Carmen PhD	CTSC	Master
Redfield, Margaret May MD	CTSC	Master
Reed, Ann M MD	CTSC	Master
Reeder, Guy Scott MD	CTSC	Master
Rocca, Walter A MD	CTSC	Master
Rodeheffer, Richard J MD	CTSC	Master
Rodriguez, Vilmarie MD	CTSC	Master
Ryu, Jay H MD	CTSC	Master
Sarr, Michael Gregory MD	CTSC	Master
Shen, Win-Kuang MD	CTSC	Master
Sieck, Gary C PhD	CTSC	Master
Sim, Franklin H MD	CTSC	Master
Sloan, Jeff A PhD	CTSC	Master
Specks, Ulrich MD	CTSC	Master
Spinner, Robert Jay MD	CTSC	Master
Steinmann, Scott P MD	CTSC	Master
Stewart, Elizabeth A MD	CTSC	Master
Takahashi, Paul Y MD	CTSC	Master
Talley, Nicholas Joseph MD PhD	CTSC	Master
Tangalos, Eric George MD	CTSC	Master
Targonski, Paul Victor MD PhD	CTSC	Master
Thomas, Randal J MD	CTSC	Master
Tucker, Sharon J RN PhD	CTSC	Master
Turner, Stephen T MD	CTSC	Master
Vege, Santhi Swaroop MD	CTSC	Master
Vickers Douglas, Kristin S PhD LP	CTSC	Master
Wahner Roedler, Dietlind MD	CTSC	Master
Wang, Kenneth Ke Ning MD	CTSC	Master
Weinshenker, Brian G MD	CTSC	Master
Wermers, Robert Alan MD	CTSC	Master
Wigle, Dennis MD PhD	CTSC	Master
Wirrell, Elaine C MD	CTSC	Master
Worrell, Gregory Alan MD PhD	CTSC	Master
Wright, R Scott MD	CTSC	Master
Wu, Qing	CTSC	Master
Altchuler, Steven Ira MD PhD	CTSC	Teach/Exam
Atkinson, Elizabeth J	CTSC	Teach/Exam
Aubry, Marie Christine MD	CTSC	Teach/Exam
Bailey, Kent R PhD	CTSC	Teach/Exam
Bamlet, William Robert	CTSC	Teach/Exam
Bergstralh, Eric John	CTSC	Teach/Exam
Berry, Daniel John MD	CTSC	Teach/Exam

Beutler, Andreas Sebastian MD	CTSC	Teach/Exam
Biernacka, Joanna Monika PhD	CTSC	Teach/Exam
Boardman, Lisa Allyn MD	CTSC	Teach/Exam
Boeve, Bradley F MD	CTSC	Teach/Exam
Bonacci, Robert Paul MD	CTSC	Teach/Exam
Borrud, Aleta Alyce MD	CTSC	Teach/Exam
Bostwick, J Michael MD	CTSC	Teach/Exam
Bower, James Howard MD	CTSC	Teach/Exam
Bresnahan, John F MD	CTSC	Teach/Exam
Brisbin, Abra G PhD	CTSC	Teach/Exam
Britton, Jeffrey William MD	CTSC	Teach/Exam
Burton, Mary C MD	CTSC	Teach/Exam
Buttar, Navtej Singh MD	CTSC	Teach/Exam
Carter, Rickey Edward PhD	CTSC	Teach/Exam
Casey, Darren P PhD	CTSC	Teach/Exam
Cass, Joseph R MD	CTSC	Teach/Exam
Cetta, Frank Jr. MD	CTSC	Teach/Exam
Cha, Stephen Shih-Li	CTSC	Teach/Exam
Chareonthaitawee, Panithaya MD	CTSC	Teach/Exam
Chen, Horng H MD	CTSC	Teach/Exam
Cima, Robert Roland MD	CTSC	Teach/Exam
Clark, Matthew M PhD LP	CTSC	Teach/Exam
Collazo Clavell, Maria Loida MD	CTSC	Teach/Exam
Connolly, Heidi Maria MD	CTSC	Teach/Exam
Creagan, Edward T MD	CTSC	Teach/Exam
Crowson, Cynthia S	CTSC	Teach/Exam
Curry, Timothy Brian MD PhD	CTSC	Teach/Exam
Danielson, David R MD	CTSC	Teach/Exam
Dietz, Niki Michele MD	CTSC	Teach/Exam
Dong, Haidong MD PhD	CTSC	Teach/Exam
Dueck, Amylou Constance PhD	CTSC	Teach/Exam
Dunn, William Frederick MD	CTSC	Teach/Exam
Eckel Passow, Jeanette Elaine PhD	CTSC	Teach/Exam
Eisenach, John Howard MD	CTSC	Teach/Exam
Enders, Felicity Turner Boyd PhD	CTSC	Teach/Exam
Ernste, Floranne Clayton MD	CTSC	Teach/Exam
Famuyide, Abimbola Olaniyan MBBS	CTSC	Teach/Exam
Flynn, Priscilla M	CTSC	Teach/Exam
Foxx-Orenstein, Amy Elisabeth DO	CTSC	Teach/Exam
Fridley, Brooke L PhD	CTSC	Teach/Exam
Frimannsdottir, Katrin Regina	CTSC	Teach/Exam
Frye, Robert L MD	CTSC	Teach/Exam
Gastineau, Dennis Arthur MD	CTSC	Teach/Exam
Goode, Ellen L PhD	CTSC	Teach/Exam
Graner, Darlene Eileen CCC-SLP	CTSC	Teach/Exam
Greene, Eddie L MD	CTSC	Teach/Exam
Grossardt, Brandon R	CTSC	Teach/Exam
Grothey, Axel MD	CTSC	Teach/Exam
Hagan, John Bryant MD	CTSC	Teach/Exam
Hanson, Gregory J MD	CTSC	Teach/Exam

Hebl, James Russell MD	CTSC	Teach/Exam
Hentz, Joseph G	CTSC	Teach/Exam
Herrick, Linda M RN PhD	CTSC	Teach/Exam
Hess, Erik Paul MD	CTSC	Teach/Exam
Heublein, Denise M	CTSC	Teach/Exam
Hodge, David Orel	CTSC	Teach/Exam
Hopkins, Matthew Robert MD	CTSC	Teach/Exam
Huddleston, Paul M III MD	CTSC	Teach/Exam
Inwards, Carrie Y MD	CTSC	Teach/Exam
Jacobson, Debra J	CTSC	Teach/Exam
Johnson, Bruce David PhD	CTSC	Teach/Exam
Kane, Sunanda V MD	CTSC	Teach/Exam
Kendrick, Michael Leland MD	CTSC	Teach/Exam
Khan, Shakila Perveen MD	CTSC	Teach/Exam
Klocke, David L MD	CTSC	Teach/Exam
Krauss, William E MD	CTSC	Teach/Exam
Kremers, Walter K PhD	CTSC	Teach/Exam
Kudva, Yogish C MBBS	CTSC	Teach/Exam
Lapid, Maria Isabel MD	CTSC	Teach/Exam
Larson, Dirk R	CTSC	Teach/Exam
Laughlin, Shannon Kathleen MD	CTSC	Teach/Exam
Lazaridis, Konstantinos N MD	CTSC	Teach/Exam
LeBlanc, Annie PhD	CTSC	Teach/Exam
Lennon, Ryan John	CTSC	Teach/Exam
Levy, Michael Jack MD	CTSC	Teach/Exam
Liebow, Mark MD	CTSC	Teach/Exam
Limburg, Paul John MD	CTSC	Teach/Exam
Mack, Kenneth J MD PhD	CTSC	Teach/Exam
Mahoney, Douglas William	CTSC	Teach/Exam
Malec, James F PhD LP	CTSC	Teach/Exam
Mandrekar, Jayawant N PhD	CTSC	Teach/Exam
Mandrekar, Sumithra Jay PhD	CTSC	Teach/Exam
Manning, Dennis M MD	CTSC	Teach/Exam
Maradit Kremers, Hilal MD	CTSC	Teach/Exam
Marsh, W Richard MD	CTSC	Teach/Exam
Maz, Mehrdad MD	CTSC	Teach/Exam
Mc Donald, Furman Sylvester MD	CTSC	Teach/Exam
Mc Iver, Bryan MBChB PhD	CTSC	Teach/Exam
McCormick, Jennifer PhD	CTSC	Teach/Exam
Mookadam, Farouk MBBCh	CTSC	Teach/Exam
Moynihan, Timothy J MD	CTSC	Teach/Exam
Murad, Mohammad Hassan MD	CTSC	Teach/Exam
Naessens, James M ScD	CTSC	Teach/Exam
Nkomo, Vuyisile T MD	CTSC	Teach/Exam
Nuttall, Gregory Austin MD	CTSC	Teach/Exam
Okuno, Scott Heitaka MD	CTSC	Teach/Exam
Olson, Eric John MD	CTSC	Teach/Exam
Olson, Marianne E RN PhD	CTSC	Teach/Exam
Ommen, Steve R MD	CTSC	Teach/Exam
Park, Miguel A MD	CTSC	Teach/Exam

Parker, Alexander S PhD	CTSC	Teach/Exam
Pathak, Jyotishman PhD	CTSC	Teach/Exam
Penheiter, Alan Richard	CTSC	Teach/Exam
Petersen, Bret Thomas MD	CTSC	Teach/Exam
Petersen, Wesley O PhD	CTSC	Teach/Exam
Pittock, Sean Joseph MD	CTSC	Teach/Exam
Porrata, Luis F MD	CTSC	Teach/Exam
Poterucha, John James MD	CTSC	Teach/Exam
Pruthi, Sandhya MD	CTSC	Teach/Exam
Qin, Rui PhD	CTSC	Teach/Exam
Reinholz, Gregory G PhD	CTSC	Teach/Exam
Roberts, Rosebud O MBChB	CTSC	Teach/Exam
Rohleder, Thomas R PhD	CTSC	Teach/Exam
Romero, Yvonne MD	CTSC	Teach/Exam
Rose, Teresa Marie	CTSC	Teach/Exam
Rummans, Teresa Anne MD	CTSC	Teach/Exam
Ryu, Euijung PhD	CTSC	Teach/Exam
Saito Loftus, Yuri Ann MD	CTSC	Teach/Exam
Sampathkumar, Priya MD	CTSC	Teach/Exam
Sargent, Daniel Jay PhD	CTSC	Teach/Exam
Schroeder, Darrell R	CTSC	Teach/Exam
Scott, Christopher Grant	CTSC	Teach/Exam
Scott, Robert L MD	CTSC	Teach/Exam
Seferian, Edward G MD	CTSC	Teach/Exam
Shah, Nilay D PhD	CTSC	Teach/Exam
Shelerud, Randy A MD	CTSC	Teach/Exam
Shi, Qian PhD	CTSC	Teach/Exam
Slager, Susan L PhD	CTSC	Teach/Exam
Smigielski, Jeffrey S PhD LP	CTSC	Teach/Exam
Sohail, Muhammad Rizwan MD	CTSC	Teach/Exam
Sprung, Juraj MD PhD	CTSC	Teach/Exam
St Sauver, Jennifer PhD	CTSC	Teach/Exam
Stroebel, Robert J MD	CTSC	Teach/Exam
Stubbs, James R MD	CTSC	Teach/Exam
Suman, Vera Jean PhD	CTSC	Teach/Exam
Szarka, Lawrence A MD	CTSC	Teach/Exam
Sztajnkrycer, Matthew D MD PhD	CTSC	Teach/Exam
Tang, Hui PhD	CTSC	Teach/Exam
Tung, Ericka Ellen MD	CTSC	Teach/Exam
Varkey, Prathibha MBBS	CTSC	Teach/Exam
Walker, Randall Craig MD	CTSC	Teach/Exam
Warnes, Carole A MD	CTSC	Teach/Exam
Warrington, Kenneth Joseph MD	CTSC	Teach/Exam
Weaver, Amy L	CTSC	Teach/Exam
Wennberg, Paul Wade MD	CTSC	Teach/Exam
West, Colin Patrick MD PhD	CTSC	Teach/Exam
Weston, Susan A	CTSC	Teach/Exam
Wong Kee Song, Louis Michel MD	CTSC	Teach/Exam
Wood, Douglas L MD	CTSC	Teach/Exam
Woodrum, David Arthur MD PhD	CTSC	Teach/Exam

Wu, Wenting PhD	CTSC	Teach/Exam
Yawn, Barbara Padgett MD	CTSC	Teach/Exam
Yost, Kathleen J PhD	CTSC	Teach/Exam
Ytterberg, Steven R MD	CTSC	Teach/Exam
Ziegenfuss, Jeanette Yuvaraj PhD	CTSC	Teach/Exam
Zinsmeister, Alan R PhD	CTSC	Teach/Exam
Assad, Daniel A DDS	DENT	Master
Carr, Alan B DMD	DENT	Master
Koka, Sreenivas DDS PhD	DENT	Master
Regennitter, Frederick J DDS	DENT	Master
Reid, Kevin Ian DMD	DENT	Master
Salinas, Thomas J DDS	DENT	Master
Sebo, Thomas J MD PhD	DENT	Master
Sheridan, Phillip J DDS	DENT	Master
Strand, Edythe A PhD	DENT	Master
Viozzi, Christopher F DDS MD	DENT	Master
Volz, John E DDS	DENT	Master
Eckel, Laurence John MD	DENT	Teach/Exam
Garces, Yolanda Isabel MD	DENT	Teach/Exam
Keller, Eugene E DDS	DENT	Teach/Exam
Kennel, Kurt Arthur MD	DENT	Teach/Exam
Rieck, Kevin Lee DDS MD	DENT	Teach/Exam
Rogers, Roy S III MD	DENT	Teach/Exam
Van Ess, James Michael DDS MD	DENT	Teach/Exam
Van Roekel, Ned DDS	DENT	Teach/Exam
Bruce, Alison June MBChB	DERM	Teach/Exam
Kasperbauer, Jan Lee MD	ENT	Master
Mc Donald, Thomas J MD	ENT	Master
Olsen, Kerry D MD	ENT	Master
Bauch, Christopher D PhD	ENT	Teach/Exam
Beatty, Charles Wayne MD	ENT	Teach/Exam
Driscoll, Colin Lea W MD	ENT	Teach/Exam
Gustafson, Ray O MD	ENT	Teach/Exam
Moore, Eric Jason MD	ENT	Teach/Exam
Orvidas, Laura Jean MD	ENT	Teach/Exam
Pallanch, John F MD	ENT	Teach/Exam
Barry, Michael A PhD	IMM	Full
Billadeau, Daniel D PhD	IMM	Full
Bram, Richard J MD PhD	IMM	Full
David, Chella S PhD	IMM	Full
Dong, Haidong MD PhD	IMM	Full
Faubion, William Alvis MD	IMM	Full
Gil Pages, Diana PhD	IMM	Full
Hedin, Karen Elaine PhD	IMM	Full
Jelinek, Diane F PhD	IMM	Full
Johnson, Aaron J PhD	IMM	Full
Kita, Hirohito MD	IMM	Full
Knutson, Keith L PhD	IMM	Full
Kwon, Eugene D MD	IMM	Full
Lennon, Vanda A MD PhD	IMM	Full

Lustgarten, Joseph PhD	IMM	Full
Markovic, Svetomir Nenad MD PhD	IMM	Full
Medina, Kay L PhD	IMM	Full
Mukherjee, Pinku PhD	IMM	Full
Murray, Joseph A MD	IMM	Full
Pease, Larry R PhD	IMM	Full
Platt, Jeffrey L MD	IMM	Full
Poeschla, Eric M MD	IMM	Full
Rodriguez, Moses MD	IMM	Full
Schrum, Adam G PhD	IMM	Full
Shapiro, Virginia M S PhD	IMM	Full
Wettstein, Peter J PhD	IMM	Full
Brunn, Gregory John PharmD RPh	IMM	Teach/Exam
Mangalam, Ashutosh Kumar PhD	IMM	Teach/Exam
Plager, Douglas A PhD	IMM	Teach/Exam
Radhakrishnan, Suresh PhD	IMM	Teach/Exam
Rajagopalan, Govindarajan PhD	IMM	Teach/Exam
Taneja, Veena PhD	IMM	Teach/Exam
Weaver, Eric A PhD	IMM	Teach/Exam
Ackerman, Michael John MD PhD	MPET	Full
Ames, Matthew M PhD	MPET	Full
Brimijoin, William S PhD	MPET	Full
Choi, Doo-Sup PhD	MPET	Full
Diasio, Robert B MD	MPET	Full
Fernandez Zapico, Martin E MD	MPET	Full
Fields, Alan P PhD	MPET	Full
Karnitz, Larry M PhD	MPET	Full
Katusic, Zvonimir S MD PhD	MPET	Full
Kaufmann, Scott H MD PhD	MPET	Full
Lou, Zhenkun PhD	MPET	Full
Machida, Yuichi PhD	MPET	Full
Miller, Laurence J MD	MPET	Full
Murray, Nicole R PhD	MPET	Full
Nelson, Timothy James MD PhD	MPET	Full
Olson, Timothy Mark MD	MPET	Full
Pang, Yuan Ping PhD	MPET	Full
Poland, Gregory A MD	MPET	Full
Prendergast, Franklyn G MD PhD	MPET	Full
Richelson, Elliott MD	MPET	Full
Stewart, Alexander Keith MBChB	MPET	Full
Terzic, Andre MD PhD	MPET	Full
Wang, Liewei MD PhD	MPET	Full
Weinshilboum, Richard MD	MPET	Full
Berg, Kevin Douglas RPh	MPET	Teach/Exam
Dzeja, Petras Petras PhD	MPET	Teach/Exam
Erlichman, Charles MD	MPET	Teach/Exam
Jahangir, Arshad MD	MPET	Teach/Exam
Ko, Li Wen PhD	MPET	Teach/Exam
Mays, Dennis Charles PhD	MPET	Teach/Exam
Moyer, Thomas P PhD	MPET	Teach/Exam

Murray, Michael James MD PhD	MPET	Teach/Exam
Nath, Karl A MD	MPET	Teach/Exam
Reid, Joel M PhD	MPET	Teach/Exam
Sarkaria, Jann N MD	MPET	Teach/Exam
Sevlever, Daniel PhD	MPET	Teach/Exam
Bieber, Allan J PhD	NSCI	Full
Brimijoin, William S PhD	NSCI	Full
Bu, Guojun PhD	NSCI	Full
Choi, Doo-Sup PhD	NSCI	Full
Dickson, Dennis W MD	NSCI	Full
Henley, John Richard PhD	NSCI	Full
Howe, Charles Lee PhD	NSCI	Full
Isaya, Grazia MD PhD	NSCI	Full
Jenkins, Robert Brian MD PhD	NSCI	Full
Leissring, Malcolm Arthur PhD	NSCI	Full
Lennon, Vanda A MD PhD	NSCI	Full
Mantilla, Carlos B MD PhD	NSCI	Full
Mc Niven, Mark A PhD	NSCI	Full
Petrucelli, Leonard PhD	NSCI	Full
Poduslo, Joseph F PhD	NSCI	Full
Rademakers, Rosa PhD	NSCI	Full
Richelson, Elliott MD	NSCI	Full
Robb, Richard Arlin PhD	NSCI	Full
Rodriguez, Moses MD	NSCI	Full
Rosenberry, Terrone L PhD	NSCI	Full
Scarisbrick, Isobel A PhD	NSCI	Full
Sieck, Gary C PhD	NSCI	Full
Sine, Steven M PhD	NSCI	Full
Somers, Virend MD PhD	NSCI	Full
Strehler, Emanuel E PhD	NSCI	Full
Taner, Nilufer MD PhD	NSCI	Full
Weinshilboum, Richard MD	NSCI	Full
Windebank, Anthony John MD	NSCI	Full
Younkin, Steven G MD PhD	NSCI	Full
Caselli, Richard John MD	NSCI	Master
Scheithauer, Bernd MD	NSCI	Master
Aksamit, Allen James Jr. MD	NSCI	Teach/Exam
Benarroch, Eduardo Elias MD	NSCI	Teach/Exam
Burghardt, Thomas Patrick PhD	NSCI	Teach/Exam
Carter, Jonathan L MD	NSCI	Teach/Exam
Dadsetan, Mahrokh PhD	NSCI	Teach/Exam
Dickey, Chad A PhD	NSCI	Teach/Exam
Dyck, Peter J MD	NSCI	Teach/Exam
Eckman, Elizabeth Adams PhD	NSCI	Teach/Exam
Eggers, Scott Daniel MD	NSCI	Teach/Exam
Engel, Andrew G MD	NSCI	Teach/Exam
Eriksen, Jason PhD	NSCI	Teach/Exam
Flemming, Kelly Denise MD	NSCI	Teach/Exam
Gomez, Timothy Scott PhD	NSCI	Teach/Exam
Graff Radford, Neill R MD	NSCI	Teach/Exam

Jack, Clifford R Jr. MD	NSCI	Teach/Exam
Kimmel, David Whitney MD	NSCI	Teach/Exam
Ko, Li Wen PhD	NSCI	Teach/Exam
Lagerlund, Terrence Daniel MD	NSCI	Teach/Exam
Low, Phillip Anson MD	NSCI	Teach/Exam
McLaren, Jay William PhD	NSCI	Teach/Exam
Meyer, Fredric Bruce MD	NSCI	Teach/Exam
O Brien, Peter C PhD	NSCI	Teach/Exam
Olson, Lyle James MD	NSCI	Teach/Exam
Petersen, Ronald Carl MD PhD	NSCI	Teach/Exam
Ross, Owen Anthony PhD	NSCI	Teach/Exam
Schmalstieg, William Frank MD	NSCI	Teach/Exam
Wang, Huan MD PhD	NSCI	Teach/Exam
Wiebers, David O MD	NSCI	Teach/Exam
Brost, Brian C MD	OBG	Master
Chien, Jeremy R PhD	OBG	Master
Cliby, William Arthur MD	OBG	Master
Coddington, Charles C III MD	OBG	Master
Creedon, Douglas James MD PhD	OBG	Master
Daftary, Gaurang S MD	OBG	Master
Davies, Norman Paul MBBS MD	OBG	Master
Dowdy, Sean Christophe MD	OBG	Master
Gebhart, John B MD	OBG	Master
Gostout, Bobbie S MD	OBG	Master
Klingele, Christopher Joseph MD	OBG	Master
Long, Harry J III MD	OBG	Master
Mariani, Andrea MD	OBG	Master
Pawlina, Wojciech MD	OBG	Master
Podratz, Karl Clarence MD PhD	OBG	Master
Rose, Carl H MD	OBG	Master
Stanhope, C Robert MD	OBG	Master
Trabuco, Emanuel Coutinho MD	OBG	Master
Veldhuis, Johannes D MD	OBG	Master
Watson, William J MD	OBG	Master
Boldt, Kristi Lee MD	OBG	Teach/Exam
Heise, Robert H Jr. MD	OBG	Teach/Exam
Jones, Monica Brown MD	OBG	Teach/Exam
Kastner, Thomas Martin MD	OBG	Teach/Exam
Amadio, Peter C MD	OR	Master
An, Kai-Nan PhD	OR	Master
Berger, Richard Allen MD PhD	OR	Master
Dahm, Diane Lynn MD	OR	Master
Levy, Bruce Allen MD	OR	Master
Lewallen, David G MD	OR	Master
Lu, Lichun PhD	OR	Master
Moran, Steven Lawrence MD	OR	Master
Morrey, Bernie Francis MD	OR	Master
Patel, Robin MD	OR	Master
Rock, Michael G MD	OR	Master
Sanchez Sotelo, Joaquin MD PhD	OR	Master

Shaughnessy, William Joseph MD	OR	Master
Steckelberg, James M MD	OR	Master
Torchia, Michael E MD	OR	Master
Turner, Norman S III MD	OR	Master
Zhao, Kristin Daigle	OR	Master
Anding, William J	OR	Teach/Exam
Bishop, Allen Thorp MD	OR	Teach/Exam
Cofield, Robert H MD	OR	Teach/Exam
Currier, Bradford Leonard MD	OR	Teach/Exam
Hanssen, Arlen Dale MD	OR	Teach/Exam
Kakar, Sanjeev MD	OR	Teach/Exam
Kile, Todd Alan MD	OR	Teach/Exam
Kitaoka, Harold B MD	OR	Teach/Exam
Rose, Peter Sean MD	OR	Teach/Exam
Shives, Thomas C MD	OR	Teach/Exam
Sim, Franklin H MD	OR	Teach/Exam
Stans, Anthony A MD	OR	Teach/Exam
Stuart, Michael Jerome MD	OR	Teach/Exam
Badley, Andrew David MD	VGT	Full
Cattaneo, Roberto PhD	VGT	Full
Dingli, David MD PhD	VGT	Full
Federspiel, Mark J PhD	VGT	Full
Galanis, Evanthia MD	VGT	Full
Ikeda, Yasuhiro DVM PhD	VGT	Full
Katusic, Zvonimir S MD PhD	VGT	Full
Morris, John Columbus III MD	VGT	Full
Peng, Kah Whye PhD	VGT	Full
Poeschla, Eric M MD	VGT	Full
Poland, Gregory A MD	VGT	Full
Rodriguez, Moses MD	VGT	Full
Russell, Stephen J MD PhD	VGT	Full
Simari, Robert David MD	VGT	Full
Vasmatzis, George PhD	VGT	Full
Vile, Richard Geoffrey PhD	VGT	Full
Devaux, Patricia PhD	VGT	Teach/Exam
Munguia, Audelia PhD	VGT	Teach/Exam
Navaratnarajah, Chanakha K PhD	VGT	Teach/Exam
Sit, Arthur J MD	VGT	Teach/Exam
Yao, Joseph D MD	VGT	Teach/Exam

COURSE LISTINGS

SYMBOLS AND EXPLANATIONS

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

A-F	Grading Scale
S-N	Grading Scale
f,w,s,su	Following course number indicates fall, winter, spring, or summer quarters respectively.
i	Following course number indicates instructor approval required.

Courses designated as "clinical" or "research" are open only to selected categories of students (usually residents or degree candidates enrolled in the training programs of the appropriate department).

ANATOMY

Anat 8000w. ANATOMY OF THE PELVIS AND PERINEUM. (2 cr; S-N) Pawlina, Cliby
Six two hour dissection and demonstration periods on the female pelvis and perineum. Primarily intended for residents and fellows in Obstetrics and Gynecology.

Anat 8852s. SURGICAL ANATOMY OF HEAD AND NECK. (3 cr; A-F; offered even years) Pawlina, Moore
Cadaver dissection and lecture demonstration. Laboratory participation required for credits. Primarily intended for residents and fellows in Otorhinolaryngology.

Anat 8855f,w,s,su. ORTHOPEDIC ANATOMY. (2 cr; S-N) Lachman
Lectures, prosections and demonstrations of gross anatomy of the musculoskeletal system with special emphasis on relationships and surgical approaches.

Anat 8860f,w,s. SPECIAL TOPICS IN ANATOMY. (1-4 cr; A-F) Lachman, Pawlina
Dissection of cross sections and/or regions of special interest.

BIOCHEMISTRY AND MOLECULAR BIOLOGY

BIOCHEMISTRY AND MOLECULAR BIOLOGY
Biochemistry and Structural Biology; Cell Biology and Genetics;
Cancer Biology Subtracks

BMB 5000f. CANCER BIOLOGY I: INTRODUCTION TO CANCER BIOLOGY; MOLECULAR, CELLULAR AND GENETIC BASIS OF CANCER. (3 cr; A-F) Billadeau
This course will provide an introductory foundation for understanding cancer biology through the discussion of normal and abnormal tissue pathology, and the molecular, cellular and genetic mechanisms that contribute to tumorigenesis. Topics that will be covered in the course include: the histopathology of cancer, tumor initiation and promotion, oncogenes and tumor suppressors, cell cycle control, cell migration and angiogenesis. In addition, several lectures will focus on the cellular, molecular and genetic approaches to study cancer in vitro and in animal models.

BMB 5200f. BMB WORKS IN PROGRESS. (1 cr; S-N) Strehler, Katzmann
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 5350s. HORMONES AND CANCER. (1 cr; S-N; offered even years) Tindall, Datta
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. The course is expected to give students a basic knowledge on the hormonal aspects of cancer, as well as stimulate new ideas in students currently working on a specific field of hormone-related cancers.

BMB 5400s. DEVELOPMENTAL BIOLOGY. (2 cr; A-F) Fernandez-Zapico
Model organisms: Drosophila melanogaster, Caenorhabdtitis elegans, Mus Musculus, Brachydanio rerio and Xenopus laevis. 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: Homeobox. Sex development pathways. Teratogenesis. Regeneration and aging.

BMB 8000f. BIOLOGICAL MACROMOLECULES. (3 cr; A-F; offered odd years; prereq Core 6100 or equiv; Core 6300) Owen, Ramirez-Alvarado
Learn how to avoid mistakes in the interpretation of experimental results involving your

favorite macromolecule. This intermediate level course builds on CORE 6100, exploring quantitative methods to study proteins and nucleic acids. Topics include the physical principles and measurements of photonics, hydrodynamics and spectroscopy, as well as case studies.

BMB 8030f. DATA ANALYSIS AND MATHEMATICAL MODELING IN BIOMEDICAL RESEARCH. (3 cr; A-F; offered even years; prereq linear algebra, calculus, basic computer skills or consent of instructor) Bajzer
An introduction to the art of mathematical modeling and to methods for data fitting with applications to biomedical sciences. Theoretical knowledge along with data reduction practice are offered to provide sufficient skills in using data fitting procedures. Students are encouraged to apply acquired knowledge to their own research projects.

BMB 8040s. FRACTALS AND CHAOS IN BIOSCIENCES. (2 cr; A-F; prereq college calculus) Bajzer
An overview of applications of fractals and chaos in biosciences. The emphasis is on general understanding of basic concepts (self-similarity, scaling, dimension, sensitivity to initial conditions, bifurcations, chaotic data, control of chaos, etc.) and their applications (protein backbone, neurons, ion channel kinetics, glycolysis, allosteric enzymes, pulmonary hypertension, tumor growth, etc.). Mathematical aspects and technical details are reduced to a minimum.

BMB 8050f. BIOLOGICAL KINETICS. (3 cr; S-N; prereq college level biochemistry or biophysics, college calculus, college chemistry, basic computer skills) Bajzer, Caride
An overview of applications of kinetic analysis to various biological problems including complex steady-state and pre-steady-state enzyme kinetics, kinetics of protein folding, ion pumps, calcium signaling, oscillatory biochemical reactions, neurotransmitter release and tumor growth. Experimental, theoretical and practical aspects are covered in sufficient detail to allow participants to approach their kinetic problems with an adequate background.

BMB 8070w. CANCER BIOLOGY II: MOLECULAR MECHANISMS OF CANCER: SIGNAL TRANSDUCTION PATHWAYS AND NETWORKS. (3 cr; A-F; offered even years; prereq BMB 5000) Billadeau, 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 8075s. EPIGENETICS OF CANCER AND ADDICTION. (3 cr; A-F; offered even years; prereq Core 6150) Ekker
This course is designed to provide the student with an understanding of how epigenetics

plays a central role in cancer but is also involved in a range of other disease states, such as addiction.

BMB 8300f,w,s,su. MASTER'S PROJECT IN BIOCHEMISTRY AND MOLECULAR BIOLOGY. (3 cr; S-N) Staff
Critical review article of an area of biochemistry and molecular biology submitted as Employee Master's project. Topic is chosen by student in consultation with the advisor and an advisory committee. May be taken only once for credit. Register in the quarter in which you present your final project to the advisory committee; and register with your advisor as course director.

BMB 8320s. SPECIAL TOPICS IN CANCER BIOLOGY. (1 cr; S-N) Salisbury
This course will present a comprehensive discussion of the origin and maintenance of embryonic, adult (somatic) and cancer stem cells; stem cell self-renewal vs. asymmetric division and differentiation; genes that determine stemness; cancer stem cells and the origin of tumor cell heterogeneity and cancer progression; epigenetics and the cancer stem cell niche; and cancer stem cells as therapeutic targets in cancer treatment.

BMB 8350f. INTRODUCTION TO BIOINFORMATICS. (2 cr; A-F; prereq Core 6150 or Core 6250) Kocher, P. Li, Leontovich
This course introduces theoretical concepts and practical applications of bioinformatics methods in biomedical research. "Omics" technologies became major tools and motive force in the development of new diagnostics, prognostics and therapies for various diseases. Analysis of the data generated by these technologies also helps to understand molecular mechanisms of diseases. Both the application of the technologies and data analysis rely on the understanding of bioinformatics concepts and analytical methods.

The course will give students a basic knowledge of the high throughput technologies as well as principles of data analysis. Bioinformatics databases and data mining tools will be reviewed. Topics to be covered include: Sequence analysis, gene transcription regulation, gene expression analysis, mutation and genotype analysis, biomarker discovery, study design, bioinformatics resources, proteomics, drug targets and drug design, future high throughput technologies.

BMB 8390f,w,s,su. INDEPENDENT STUDY IN BIOCHEMISTRY AND MOLECULAR BIOLOGY. (1-2 cr; A-F) Staff
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 8500f. BMB JOURNAL CLUB. (1 cr; S-N) Ekker, Mer
Students of the Biochemistry and Molecular Biology program present a paper authored by the BMB Seminar presenter for the following week in partnership with the faculty inviting the seminar speaker.
Register in fall quarter only (1 cr./yr.). 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 8510f,w. CANCER BIOLOGY JOURNAL CLUB. (1 cr/qt; S-N) Billadeau
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, retroviruses.

BMB 8520f,w,s,su. CURRENT TOPICS IN AGING RESEARCH. (1 cr., S-N) Scrable
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 8650s. RECEPTOR TRAFFICKING AND SIGNALING TUTORIAL. (2 cr; A-F; offered odd years; prereq core courses 6100, 6150 and 6250) Katzmann, 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 8660f. TRANSCRIPTION, CHROMATIN, AND EPIGENETICS. (2 cr; A-F; offered even years; prereq core courses 6100, 6150 and 6250) Urrutia, Lomberk
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 8665w. DNA/PROTEIN INTERACTIONS, REPAIR, REPLICATION, AND RECOMBINATION. (2 cr; A-F; offered even years; prereq core courses 6100, 6150 and 6250 or consent of instructor) Maher, McMurray
This tutorial begins with a study of the fundamental physical and chemical principles of DNA recognition by proteins. Subsequent topics focus on key characteristics of the major classes of DNA binding proteins. The second half of the tutorial concerns basic mechanisms of DNA repair processes emphasizing the roles of DNA repair processes in human diseases.

BMB 8675w. PROTEIN STRUCTURE AND DYNAMICS. (2 cr; A-F; offered odd years; prereq core courses 6100 and 6150 or consent of instructor) Mer, Thompson
This tutorial discusses various models of protein folding including the experimental approaches and computational methods for predicting and determining structure.

Examples from the current literature highlight protein structure, proteomics and functional proteomics.

BMB 8801f,w,s. CONCEPTS OF VESICULAR TRAFFICKING JOURNAL CLUB. (1 cr/qt; S-N; prereq Core 6250) McNiven
Study of the basic mechanisms by which cells package, process, and transport synthesized and/or endocytosed proteins.

BMB 8900f,w,s,su. BMB THESIS PROPOSAL. (2 cr; S-N) Katzmann
Thesis proposal: The written thesis proposal matches the new format of NIH R01 grants and, hence, is limited to 14 pages, including illustrations but not including references. In the students 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).
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 (2-3 pages).
Innovation: How is the project you are proposing novel and groundbreaking (~1 page).
Approach: Describes 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 (8-10 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 Dr. Katzmann indicating that your thesis proposal was satisfactory.

Research

BMB 8840f,w,s,su. RESEARCH IN BIOCHEMISTRY AND MOLECULAR BIOLOGY. (6 cr/qtr; S-N) Staff
Graduate thesis research for Basic Science and Clinical Master's students under supervision of staff.

BMB 8890f,w,s,su. RESEARCH IN BIOCHEMISTRY AND MOLECULAR BIOLOGY. (S-N) Staff
Graduate thesis research for Ph.D. students under supervision of staff.

BIOMEDICAL ENGINEERING

BME 5000f. PRINCIPLES OF BIOMEDICAL ENGINEERING I. (3 cr; A-F) Prakash
This course and BME 5050 are problem-based courses focusing on the application of biomedical engineering principles to address physiological principles. Problems will be broadly defined, and students will be given considerable independence in the approach to the problem, with encouragement to perform independent literature reviews, mathematical analyses, simulations, programming and presentation. Team approach with equitable distribution of effort is critical. Didactic sessions will focus on addressing alternative approaches to a problem, and understanding limitations and applicability of

specific approaches.

BME 5050w. PRINCIPLES OF BIOMEDICAL ENGINEERING II. (3 cr; A-F) Daniel, Mantilla
BME5050 is a problem based course that introduces basic principles in biomedical engineering together with BME5000. In BME5050, students will explore the interface between physiology and electrical engineering focusing on the restoration of respiratory function through phrenic pacing or related techniques. The course provides an introduction to respiratory physiology, basic engineering/mathematics of signal processing with a focus on analog techniques as well as electronic techniques and circuits for signal acquisition, processing, and electrical stimulation. Students will demonstrate teamwork, basic project management skills and ability to assess the state-of-the art in a given topical area through research and analyses of relevant published literature.

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

BME 5160f. INTRODUCTION TO RADIATION PHYSICS. (3 cr; A-F; offered every other year {2011}, prereq calculus, atomic or modern physics) McGee, Antolak, Kruse
This is an introductory graduate course designed for those interested in the radiation sciences. The course will cover ionizing radiation, interactions, cavity theory, dosimetry fundamentals, and measurements. The course will also include material describing the fundamentals of projection reconstruction, the quantification of imaging systems performance and the application of projection imaging in both diagnostic and therapeutic radiology.

BME 5200su. ADVANCED ENGINEERING MATHEMATICS. (4 cr; A-F) Manduca, Bajzer
This course will include a short recapitulation of calculus and vector algebra (which are prerequisites), and then cover a variety of advanced engineering math topics: linear algebra, vector analysis, complex variables and functions, Fourier series and transforms, dimensional analysis, Laplace transforms, ordinary differential equations, calculus of variations, and a brief introduction to partial differential equations.

BME 5225i. TUTORIAL IN NEURAL NETWORKS. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration; prerequisites background of computer science, engineering) Manduca
This course will provide a theoretical and practical understanding of the most important artificial neural network models. The focus will be on practical applications of the technology.

BME 5250w. ANATOMY FOR BIOMEDICAL ENGINEERS. (2 cr; S-N; offered odd years {2011) 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.

BME 5300f. CELL AND NEUROPHYSIOLOGY. (3 cr; A-F) Mantilla
This course will provide an understanding of basic concepts in cell and neurophysiology. The course will start with an introduction to cell physiology, electrophysiology and cell signaling. The focus will then move more specifically into sensory and motor systems.

BME 5450f. LABORATORY METHODS IN BIOMEDICAL IMAGE PROCESSING. (3 cr; A-F) Robb
Provides 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.

BME 5453w,su. FUNDAMENTAL CONCEPTS IN BIOMECHANICS. (3 cr; A-F) Kaufman
This course is an introduction to biomechanics and addresses the fundamental topics of force, movement, statics, geometric properties, kinematics and kinetics.

BME 5460f. FINITE ELEMENT METHODS. (3 cr; A-F; offered odd years (2011); contact Dr. Sieck prior to registering for this course) Staff
This course introduces the fundamental concepts of the finite element methods and its major applications in biomechanics research.

BME 5505s. PHYSIOLOGICAL CONTROL SYSTEMS I – MODELING AND SIMULATION. (3 cr; A-F) Roy
This course covers dynamic system modeling, control, and simulation of some physiological systems. It uses MathWorks, Inc.'s Simulink package for simulation of the different open-and closed-loop physiological systems under study. Prerequisites are basic courses in physiology and differential equations.

BME 5550s. IMAGE GUIDED PROCEDURES IN BIOMEDICAL APPLICATIONS. (4 cr; A-F; prereq BME 5450 or equivalent) Robb, 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.

BME 5740f. MAGNETIC RESONANCE IMAGING SYSTEMS.
(3 cr; A-F; offered odd years) (2011); prereq advanced calculus, Fourier analysis, and a course in modern physics) Riederer
Introduction to physics and engineering aspects of modern diagnostic magnetic resonance imaging (MRI).

BME 5800w. PHYSICS AND TECHNICAL PRINCIPLES OF MEDICAL IMAGING. (3 cr;

A-F; prereq general and modern physics, calculus, and Fourier analysis or consent of instructor) McCollough
An introduction to the fundamental principles of medical image formation. Diagnostic imaging modalities to be covered include: radiographic x-ray imaging, x-ray computed tomography, digital radiography, and nuclear medicine.

BME 5802f,s. PRINCIPLES OF BIOMECHANICS. (3 cr; A-F; prereq BME 5453) An Advanced concepts of orthopedic biomechanics, including kinematics and kinetics, mechanics of deformable bodies, stress analysis, tissue engineering and fluid mechanics.

BME 8000i. TUTORIAL IN EXERCISE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) 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.

BME 8100s. MEDICAL HEALTH PHYSICS. (2 cr; A-F; prereq BME 5100 or equivalent, or consent of instructor) 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.

BME 8151w. RADIATION ONCOLOGY PHYSICS. (3 cr, A-F; prereq BME 5160) Herman, Kline
Physics principles and application in radiation therapy, including dose calculation, treatment planning/dosimetry, brachytherapy and quality assurance.

BME 8300s. TUTORIAL IN NEUROPHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) 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.

BME 8302i. TUTORIAL IN ULTRASONIC IMAGING. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Fatemi
Principles and methods of imaging tissue, using ultrasound, and related parameters.

BME 8304i. TUTORIAL IN PHYSIOLOGICAL IMAGING. (2 cr; A-F; consent of instructor required prior to registration) Ritman
X ray imaging of physiological systems and analysis of resulting data.

BME 8350s. ADVANCED CONCEPTS IN MOLECULAR BIOPHYSICS. (4 cr; A-F;

offered even years (2012) Sine
This course focuses on the biophysics of ion channels, solute transporters, molecular motors, elastic proteins, molecular recognition, protein dynamics and enzyme kinetics. A set of technical lectures will cover patch clamp recording, single channel kinetic analysis, x-ray crystallography, mass spectrometry and fluorescence spectroscopy. Didactic lectures are complemented by student presentations of a corresponding scientific paper.

BME 8400f,w,s,su. MASTER'S PROJECT in BIOMEDICAL ENGINEERING. (3 cr; S-N) Staff
Requires paper or equivalent in the area of biomedical engineering submitted as Employee's Master's Project. Topic is chosen by student with guidance from the advisor. May be taken only once for credit.

BME 8420s. WAVE PROPAGATIONS AND BIOMEDICAL APPLICATIONS. (2 cr; A-F; prereq college physics) Fatemi
Wave propagation is a fundamental phenomenon of acoustics, electromagnetics, and optics. This course will emphasize the wave propagation of ultrasound and their applications to medical imaging and tissue property identification. In addition to linear wave propagation, nonlinear wave propagation and their potential medical applications will be studied.

BME 8470f. TWO-DIMENSIONAL DIGITAL SIGNAL PROCESSING. (4 cr; A-F; prereq BME 8704 or working knowledge of linear system theory and one-dimensional digital signal processing) Ottesen
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.

BME 8490s. ADVANCED TOPICS IN BIOMEDICAL IMAGE PROCESSING. (3 cr; A-F; offered even years; prereq BME 5450, Core 6750 or equivalent experience/coursework) Manduca
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.

BME 8500i. SPECIAL TOPICS IN IMAGING SCIENCE. (2 cr; A-F; prereq BME 5450, Core 6750; consent of instructor required prior to registration) Robb
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.

BME 8600i. BIOMEDICAL ENGINEERING SEMINARS. (1 cr.; S-N; consent of instructor required prior to registration) Manduca, Sieck

Presentations of research topics related to biomedical engineering. First and second year students are REQUIRED to attend all 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 3rd year and the second in their 5th year. Students should register in the quarter in which they give their second presentation; and register with your advisor as course director.

BME 8650i. BME JOURNAL CLUB. (1 cr; A-F) Holmes
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 to attend for 3 consecutive quarters in a given year - fall, winter and spring (register for course in spring.)

BME 8704s. DIGITAL SIGNAL PROCESSING I. (4 cr; A-F, offered annually) Ottesen
First of a two-part series starts with one-dimensional (1D) discrete time signals and systems, and the effects of sampling. It moves into the areas of 1D Discrete Fourier Transforms (DFT), Z-transforms, linear and circular convolutions and signal flow-graphs. Various methods for design of common analog filters and their conversion to 1D digital Infinite Impulse Response (IIR) digital filters. Also covered are 1D digital Finite Impulse Response (FIR) filters with linear phase characteristics. There will be homework, class projects, and an in-class final exam.

BME 8705f. DIGITAL SIGNAL PROCESSING II. (4 cr; A-F; offered 2011; prereq BME 8704 or consent of instructor) Ottesen
Topics covered are special 1D analog filters and their conversion to 1D digital equivalent filters; Advanced designs and structures of optimal FIR digital filters; spectral and cepstral analysis, and parametric and non-parametric estimation of signals; the effects and filtering techniques for different types of noise and introduction to discrete 1D ordered-statistic, homomorphic, Wiener, Golay-Savitzky and fuzzy logic filters. There will be homework, case studies and class projects.

BME 8710w. NUMERICAL METHODS IN BIOMEDICAL RESEARCH. (3 cr; A-F) Bajzer, Manduca
This course provides an overview of numerical methods commonly used in biomedical research including: solving of ordinary and partial differential equations, random systems, common transforms, function fitting, optimization and search algorithms, and filtering and time series analysis.

BME 8730w. LABORATORY METHODS IN MAGNETIC RESONANCE IMAGING. (2 cr; S-N; offered even years (2012); prereq BME 5740, previous or concurrent registration) Edmonson
Introduction to MRI laboratory methods. Firsthand experience in basic and advanced MR image acquisition strategies, experimental tradeoffs, image reconstruction, and data interpretation.

BME 8740w. ADVANCED TOPICS IN MAGNETIC RESONANCE IMAGING SYSTEMS. (3 cr; S-N; offered even years (2012); prereq BME 5740) 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, cardiac imaging, and neuro-functional MRI.

BME 8750f,s. MAGNETIC RESONANCE TECHNICAL SEMINAR. (1 cr; S-N; offered odd years (2011); consent of instructor required prior to registration) Riederer
Seminar held weekly consisting of a presentation of some contemporary technical research topic in magnetic resonance.

BME 8770f. FUZZY LOGIC THEORY AND APPLICATIONS. (4 cr, A-F; prereq BME 8704 and an interest in intelligent systems and decision and control) Ottesen
Fuzzy Logic Theory and Applications is intended for students and practicing scientists and engineers. It covers the applied concepts of fuzzy logic to several application areas. There will be homework, case studies, and class projects.

BME 8830w. LABORATORY METHODS IN PHYSIOLOGY. (2 cr; A-F) Blanco
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.

BME 8853i. READINGS IN BIOMEDICAL ENGINEERING. (2 cr; S-N; consent of instructor required prior to registration) Sieck
Review of contemporary topics in Biomedical Engineering literature to be arranged with individual staff members.

BME 8855i. TUTORIAL IN CARDIOVASCULAR PHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) 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.

BME 8856i. TUTORIAL IN RESPIRATORY PHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) 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.

BME 8857i. TUTORIAL IN CELLULAR MECHANICS. (2 cr; A-F; consent of instructor required prior to registration) Hubmayr
Detailed review of cellular structure and function relationships, diffusion, micro-

mechanics, mechano-chemical signal transduction.

BME 8858i. TUTORIAL IN SMOOTH MUSCLE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Qian, Gibbons
Students will be exposed to advanced topics related to smooth muscle signaling pathways, intracellular calcium regulation, pharmaco-mechanical coupling, etc.

BME 8859i. TUTORIAL IN RENAL PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Romero
Renal hemodynamics, glomerular function, mechanisms and regulation of electrolyte transport. Two laboratory sessions demonstrating basic renal function and the effects of diuretics.

BME 8860su. TUTORIAL IN ENDOCRINE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Eberhardt
This course focuses on several aspects of endocrine physiology, including mechanisms of hormone action, calcium homeostasis, glucose, and fatty acid metabolism, pituitary, thyroid and adrenal physiology, immunologic aspects of endocrinology, and endocrine effects on bone biology.

BME 8861su. TUTORIAL IN SKELETAL MUSCLE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) 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.

BME 8870f. SYSTEMS PHYSIOLOGY I. (3 cr; A-F) 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.

BME 8871w. SYSTEMS PHYSIOLOGY II. (3 cr; A-F) Sieck
Development, Growth and Regeneration – concepts of intracellular communications as taught in Systems Physiology I will be reinforced, and the concept of intercellular communication will be introduced as they relate to the development, growth, and regeneration of issues. Roles of stem and progenitor cells along with contributions from various model systems will be incorporated.

BME 8872s. SYSTEMS PHYSIOLOGY III. (3 cr; A-F) Ordog
The students will focus on the role of biological oscillators in higher-order physiological functions including circadian rhythms, neuroendocrine control of reproduction and metabolism, as well as gastrointestinal and urogenital motor physiology. Topics discussed will include the role of transcriptional/epigenetic regulators, metabolic factors, and cellular signaling pathways in rhythm generations at the molecular and cellular level, interactions between oscillators to control complex organ and organismal functions, and

quantitative models. This course builds on, reinforces, and extends concepts of intra- and intercellular communication discussed in the preceding Systems Physiology courses.

BME 8875su. PHYSIOLOGICAL CONTROL SYSTEMS II – STABILITY AND OPTIMIZATION. (3 cr; A-F; prereq BME 5505 or a basic course in control systems or dynamic system modeling) Staff
The course covers stability, identification, and optimization of some physiological systems. It uses Matlab and Simulink to analyze the physiological systems under study. A laboratory session is included to prove identification and estimation concepts.

BME 8876w. ADAPTIVE AND NONLINEAR PHYSIOLOGICAL SYSTEMS. (3 cr; A-F; prereq BME 8875) Sieck
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.

BME 8878su. TUTORIAL IN BONE PHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) Oursler
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.

Research

BME 8890f,w,s,su. RESEARCH IN BIOMEDICAL ENGINEERING. (S-N) Staff
Opportunities in research for Ph.D. students to be arranged with individual staff members.

CLINICAL AND TRANSLATIONAL SCIENCE

CTSC 5000su. INTRODUCTION TO CLINICAL RESEARCH. (1 cr; S-N; self-paced on-line course) Huskins
This lecture series is an introduction to the principles and practice of designing, conducting, and reporting clinical research and how to best utilize resources that support research at Mayo Clinic. The course is targeted toward persons who are beginning their research careers or who want to develop additional research skills. The course will cover the following topics: choosing a research question and mentor; writing a research proposal; obtaining consultation on study design and methods; protecting human subjects; utilizing research resources at Mayo; managing data; and reporting the results of a study.

CTSC 5010f. CLINICAL RESEARCH PROTOCOL DEVELOPMENT. (2 cr; A-F; prereq CTSC 5000, CTSC 5300, CTSC 5600; limited to scholars admitted to CTS programs and T32 trainees with faculty approval; course content is delivered in a classroom setting utilizing Blackboard) Huskins

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. Students will use their own research question to build a proposal for a research project that they intend to conduct in the future. Key elements of clinical research design, such as articulation of testable hypotheses and specific aims, selection of study subjects, measurement techniques, analytic approaches, sample size and power will be reinforced throughout the course. Students will also develop expertise in critiquing other students' proposals and in responding to critique of their own proposal as a key skill in fostering effective proposal writing. 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 Masters thesis research project or a research grant application.

CTSC 5020w. REGULATORY ISSUES IN CLINICAL RESEARCH. (1 cr; S-N; course content is delivered either in a classroom setting or via lectures on Blackboard) Ehman

This course, comprised of 12 lectures and one "practicum," is designed to introduce students to regulatory issues pertaining to clinical research. Lecture topics will focus on the investigators' responsibilities with respect to extramural review by the Office for Human Research Protections, HIPAA, and the Food and Drug Administration, as well as a review of state and federal legislation regarding clinical research. Emphasis will be given to the importance of inclusion of minorities in clinical research, opportunities in Federal and Foundation Research, legal responsibilities, and interaction with institutional offices and technology transfer. Responsibilities in the implementation of clinical trials, potential conflict of interest issues, the role of the research pharmacist and Good Clinical Practice will be presented. A practical session will expose students to intramural review by the Mayo Institutional Review Board. Evaluation is based on successful and timely completion of test questions for each lecture, participation in an IRB meeting, and a written review of an IRB protocol.

CTSC 5080w. ELIMINATING HEALTH DISPARITIES. (1 cr; A-F; course content is delivered in a classroom setting utilizing Blackboard) Greene

The major purpose is to create a heightened awareness amongst clinical researchers and investigators (active and prospective) that the racial, ethical, ethnic, cultural, and socioeconomic dimensions of clinical research are important metrics that should be considered in all phases of clinical research study design, development, execution, analysis and reporting. Successful grant funding includes the ability to write proposals that will address these disparities.

CTSC 5081f,w,s,su. HEALTH DISPARITIES FIELD EXPERIENCE. (1 cr; A-F) Huskins

This course is an on-site field experience in community-based research that addresses disparities in health and healthcare that affect underserved populations. Participants are strongly encouraged to have completed CTSC 5000, CTSC 5300, and CTSC 5080 or equivalent courses prior to enrolling in this course. Consent of instructor required prior to

registration.

CTSC 5090w. LEADERSHIP PRINCIPLES FOR CLINICAL RESEARCHERS IN THE 21ST CENTURY. (1 cr; S-N; limited to KL2 and Career Development scholars only; course content is delivered in a classroom setting) G. Smith
Research in the 21st century will be accomplished through effective research teams. Important to the development of future leaders of the clinical research enterprise and these research teams is the knowledge of leadership competencies, principles, characteristics and career activities that lay the pathway to leadership of a research team. Through interactive seminars this course will identify the leadership principles, characteristics and career activities that are critical to the development of the clinical researcher. (Career Development Scholars are those funded by NIH K awards, foundation and intramural Mayo awards).

CTSC 5130f. IMMUNE SIGNATURES IN DISEASE OUTCOME AND RESPONSE TO THERAPY. (1 cr; A-F; course content is delivered in a classroom setting) Knutson
This course will focus on methods of discovery of immune signatures of disease and their use in evaluating disease risk and response to therapy. This is a 1-credit course that emphasizes the utility of immune biomarkers in various disease settings and includes analysis of different types of biomarkers and their clinical applications.

CTSC 5190s. COMPLEMENTARY AND ALTERNATIVE MEDICINE RESEARCH. (1 cr; A-F; course content is delivered in a classroom setting) Sood
To provide a broad overview of complementary and alternative medicine (CAM) research and introduce participants to unique aspects of CAM practice. Written brief research proposal developed by the participants will be critiqued and examples of proposals that have succeeded at the level of NIH or foundation grants will be presented.

CTSC 5201f,w,s,su. INDEPENDENT STUDY FOR CLINICAL PRACTICE ISSUES. (1-2 cr; S-N; approval by CTSA Curriculum Committee required prior to registration; limited to scholars admitted to CTS programs) Beebe
The purpose of this course is to provide needed training in clinical practice for non-MD/non-biology scholars in the Mentored Clinical Research Program (formerly K12 Award) in concert with the scholar's career development and research plan. Tutorials are arranged on an individual basis in selected advanced topics in clinical practice. Students are expected to define an objective and specific reading list in consultation with a member of the faculty.

CTSC 5202f,w,s,su. INDEPENDENT STUDY OF LABORATORY METHODS. (1-2 cr; S-N; approval by CTSA Curriculum Committee required prior to registration; limited to scholars admitted to CTS programs) Beebe
The purpose of this course is to provide hands-on experience in specific laboratory methods and techniques for MD and non-research scholars in the Mentored Clinical Research Program (formerly K12 Award) in concert with the scholar's career development and research plan. Scholars are expected to define their objectives and specific techniques/skills to be learned in consultation with a member of the faculty

CTSC 5230f,w,s. CARDIOVASCULAR RESEARCH SEMINAR. (1 cr; S-N) Chen
This course is designed to introduce students to a broad range of cardiovascular research topics. The lecture topics will focus on bench to bedside translational research in the broad area of cardiovascular diseases. Lectures will be given by expert faculty in cardiovascular sciences within the Mayo faculty as well as invited speakers. Special emphasis will be given to the research of mentors with the Clinical Research Training Program as well as an emphasis in the broad area of outcome based cardiovascular sciences. Requirements: 1) Attendance: mandatory at 80% of seminars, 2) a 2-page paper on the aspect of cardiovascular science discussed in one or multiple seminars. The paper should highlight the relevance of the seminar(s) to the area of research or clinical practice in which you are involved. The paper should demonstrate an understanding of the seminar and its relevance. The paper should include up to 5 references from the speaker or others. The paper is due one week following the last speaker.

CTSC 5240w,s. PRINCIPLES AND PRACTICES OF PEDIATRIC RESEARCH. (2 cr; A-F; class extends over two quarters; course content is delivered in a classroom setting) Jacobson
This course addresses the special concerns and challenges faced by clinical investigators when conducting clinical research involving infants, children, and teens. Topics include ethics, federal regulation, consent and assent, funding, recruitment, retention, remuneration, data collection, and analytic issues.

CTSC 5270s. HEPATOBILIARY PATHOBIOLOGY. (1 cr; A-F; offered even years; course content is delivered in a classroom setting) Lazaridis
The purpose of this course is to teach hepatobiliary pathobiology through a series of 12 interactive lectures covering a broad range of topics within the field. Students will be expected to have completed the pre-assigned reading prior to each lecture. The course will emphasize basic hepatobiliary pathophysiology with clinical and clinical research correlations whenever possible.

CTSC 5271su. GI CELLULAR AND MOLECULAR PHYSIOLOGY. (1 cr; A-F; offered odd years; course content is delivered in a classroom setting) Loftus, Lazaridis
The purpose of this course is to teach gastrointestinal/hepatobiliary physiology and discourse through a series of 12 interactive lectures covering a broad range of topics within the field. The course will emphasize basic cellular and molecular concepts with clinical and clinical research correlations whenever possible. There are no prerequisites.

CTSC 5280su. APPLIED ENTERIC NEUROSCIENCES IN HEALTH AND DISEASE. (1 cr; A-F; offered odd years; course content is delivered in a classroom setting) Camilleri
This course provides information of the mechanisms, diagnosis, and management of gastrointestinal diseases that affect motor and sensory functions of the digestive tract. Topics covered will include genetic and molecular basis of motility disorders, antroduodenal manometry, sensitivity testing, gastroduodenal motility disorders, diabetes and the gut, colonic motility testing and management of constipation, dyspepsia, irritable bowel syndrome, current and emerging therapies for IBS, motility problems in the elderly, motility disorders, and pharmacogenomics. Evaluation will be based on class participation and a final exam.

CTSC 5290f. GI POPULATION SCIENCES. (1 cr; A-F; course content is delivered in a classroom setting) Saito-Loftus, Kane

The purpose of this course is to teach clinical epidemiology and methodology as applied to, or specific to, gastrointestinal diseases. The course will show what has been learned from epidemiology in GI diseases from gastrointestinal research and contributed to our clinical understanding of gastrointestinal diseases.

During 12 interactive sessions with pre-assigned reading, this course will cover current knowledge and approaches to studying the epidemiology of a wide span of gastrointestinal disorders. Broadly, course topics will be divided into those with a clinical focus and those with a methodological focus. Topics will include the clinical epidemiology of esophageal reflux and Barrett's esophagus, inflammatory bowel disease, functional gastrointestinal disorders, celiac disease, pancreatic cancer, and chronic liver disease as well as questionnaire development/assessment, health economics/decision analysis, meta-analyses, clinical trials, molecular epidemiology, and genetic epidemiology as applied to GI diseases.

CTSC 5300su,w. INTRODUCTION TO CLINICAL EPIDEMIOLOGY. (1 cr; A-F; self-paced on-line course) J. Olson

This course is the first in a series of three epidemiology methods courses. This first course presents an overview of epidemiology; the second gives students the opportunity to plan five studies of various designs; and the third concentrates on the application of these methods based on published epidemiologic studies. Thus, the three courses together equate a typical 4-credit introductory epidemiology course. As the first in this series, this course addresses basic terminology and methodological concepts in epidemiology from a clinical perspective. Topics will include issues related to measurement (reliability, validity), testing (sensitivity, specificity), prevalence, incidence, causation, study design (ecologic studies, cohort studies, case-control studies, clinical trials, cross-sectional studies), bias, and confounding.

All course content is delivered in a web-based learning environment using the Blackboard learning management system. This course is self-paced and all course requirements must be completed by the last day of the class. If you have not utilized a web-based learning environment it is highly recommended that you complete the online orientation prior to enrolling in the class.

CTSC 5310f,su. CLINICAL EPIDEMIOLOGY II. (1 cr; A-F; prereq CTSC 5300, priority given to CTS scholars; on-line course with weekly assignments) J. Olson

This course is the second in a series of three epidemiology methods courses. The goal of this course is to guide students through the thought processes necessary to design methodologically sound studies. Students will design five different studies; each one will include elements of hypothesis specification, study design, study populations, measurement of important study variables, quality assurance/quality control, and internal and external validity. The first session will be an in-person overview of the course and small group review of an existing study. Subsequently, students will work together in assigned online groups to discuss and complete four study proposals (cross-sectional, clinical trial, prognostic cohort, etiologic cohort) based upon given clinical scenarios.

These assignments will provide the opportunity to work in various study team member roles, be accountable to study team members, and adhere to short timelines. The final study design (case-control) will be completed independently. Students will also review the final study proposal of two fellow students. Unlike CTSC 5300 Introduction to Clinical Epidemiology, this course is highly collaborative from the first day of class and requires daily online interaction with fellow class members and has weekly assignment deadlines. The class will be entirely online except for the first day of the course. Statistics in Clinical Research I (CTSC 5600) is *highly* recommended as a pre-requisite to this course.

CTSC 5390w. ADVANCED APPLIED EPIDEMIOLOGIC METHODS. (2 cr; A-F; prereq CTSC 5300, CTSC 5310; course content is delivered in classroom setting utilizing Blackboard) LeBlanc, Rocca

This course will increase the ability of students to interpret and criticize research articles in the medical literature. One or more articles for each of the following major types of epidemiological studies will be discussed: 1) prevalence study; 2) incidence study; 3) case-control study; 4) cohort study; and 5) clinical trial. Two sessions will be allocated to each of prevalence studies, incidence studies, and clinical trials. Three sessions will be allocated to each of case-control studies and cohort studies. For each type of study, the instructor will explain the general terminology and give guidelines on how to read the articles in the first session. The students will then be assigned to read an article (or two articles) and to write a summary report for each article following a standardized format (article abstracting form). The instructor and the students will jointly interpret and discuss each article in the following session. All students are expected to participate in the discussion. Three additional lectures will be an introduction, a discussion of bias, and a discussion of confounding and interaction. Even though most of the articles used as examples will be derived from the neurological literature, the course focuses on methodological issues that apply to any medical specialty.

CTSC 5500s. INTRODUCTION TO GENETIC EPIDEMIOLOGY. (1 cr; A-F; prereq CTSC 5300 or equivalent; course content is delivered in a classroom setting utilizing Blackboard) Odd years: Bielinski; Even years: de Andrade, P. Yang

Genetic epidemiology is the important interaction of two parent disciplines, genetics and epidemiology. Genetic epidemiology focuses on genetic factors and family resemblance related to disease in the population. This is an introductory course designed to introduce fundamental concepts of genetic epidemiology including population genetics, genetic transmission patterns, familial aggregation and heritability, family based and non-family based study designs, and ethical issues related to genetic studies.

CTSC 5510s. GENETIC EPIDEMIOLOGY II: ASSOCIATION STUDIES. (1 cr; A-F; prereq CTSC 5310, CTSC 5500, CTSC 5610; a minimum of 4 students and maximum of 10 students is required course content is delivered in a classroom setting utilizing Blackboard) Slager, Pankratz; Vachon, Biernacka

To provide in-depth detail of study design, data collection, basic data analysis, and quality control of genetic association studies. The knowledge gained from this class will be integrated with the knowledge gained from the first genetic epidemiology class, as

well as the clinical epidemiology and biostatistics classes. Upon completion, students will be able to critically appraise articles from the current genetic epidemiology literature.

CTSC 5600su. STATISTICS IN CLINICAL RESEARCH. (2 cr; A-F; on-line course with weekly assignments; students seeking a Master's degree in CTSC must also complete CTSC 5601) Enders

This 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. Course material is presented through on-line interactive lectures. Evaluation includes individual homework assignments, group assignments, and midterm and final examinations.

CTSC 5601su. UTILIZING STATISTICS IN CLINICAL RESEARCH. (1 cr; A-F; prereq CTSC 5600 taken concurrently or prior; limited to 30 students at MCR campus; course content is delivered in a classroom setting utilizing Blackboard) Enders

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 JMP statistical software, and correctly interpreting the results of the JMP analysis. Must be taken concurrently with or following CTSC 5600.

CTSC 5610f. INTRODUCTORY STATISTICAL METHODS II. (3 cr; A-F; prereq CTSC 5600 and CTSC 5601; limited to 28 students with preference given to those admitted to the CTSA program; course content is delivered in classroom setting utilizing Blackboard) Enders

This course provides an introduction to methods for statistical modeling. Specific topics covered include simple linear regression and multiple linear regression and introduces some extensions of these methods such as logistic regression and Cox 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. The course is a combination of lectures and computer labs; assignments require the use of statistical software (JMP). Evaluation includes homework assignments and midterm and final examinations.

CTSC 5640w. LOGISTIC REGRESSION. (1 cr; A-F; prereq CTSC 5600, CTSC 5610; course content is delivered in a classroom setting utilizing Blackboard) Ryu

Logistic regression is often used as an analytic tool for medical studies with binary outcomes, such as case-control studies. The goals of this course are: 1) to demonstrate how logistic regression may be used to estimate the magnitude of association between a risk variable and disease, in terms of an odds ratio (OR), to estimate a confidence interval for this OR, and to test hypotheses regarding the OR; 2) to demonstrate how the OR 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 interactions; 3) to illustrate how variable selection methods may be used to build a multiple logistic regression model when several risk variables are of interest; 4) to demonstrate the analyses of matched data and correlated data by logistic regression. In addition commonly used measures for assessing fit of the model and advanced topics such as multi-category logistic regressions for ordinal and nominal outcomes will be covered.

Since the theme of this course is appropriate analysis and interpretation of clinical data, computer printouts of analyses of medical research data will be reviewed. An understanding of basic statistics and linear regression is required.

CTSC 5650w. SURVIVAL ANALYSIS. (1 cr; A-F; prereq CTSC 5600, CTSC 5601, CTSC 5610; course content is delivered in a classroom setting utilizing Blackboard) Qin
This course examines methods for summarizing and analyzing time- event data generated from clinical trials and epidemiologic studies. Non-parametric approaches such as the Kaplan-Meier and actuarial methods for estimating the distributions of event times will be covered. A family of non-parametric tests (including the log-rank and Generalized Wilcoxon) to compare event distributions will be discussed. Parametric distributions for survival times and accelerated failure models will be covered. The semi-parametric Cox proportional hazards regression model will be introduced and methods for variable selection (model building) and assessing model assumptions will be discussed. Advanced topics of time dependent covariates, competing risks, and multivariate survival models will be covered as time permits. All concepts will be illustrated using examples and relevant output from appropriate statistical software, with no specific demonstration in JMP due to its limitations in performing survival analysis. The emphasis in this course will be to provide an understanding of the theory and concepts involved in gathering, summarizing and analyzing time to event data.

CTSC 5660s. Bioinformatics: Statistical Design & Analysis. (1 cr; A-F; prereq CTSC 5600 or CORE 6650; course content is delivered in classroom setting utilizing Blackboard) Oberg, Eckel-Passow
This course provides an introduction of concepts to consider when designing and analyzing high-dimensional 'omics data such as gene, copy number and protein expression data. Concepts that are covered include variability, bias, appropriate study designs, sample selections, data quality control, pre-processing and statistical analysis. The course consists of a series of lectures that include case studies and interactive discussions.

CTSC 5690w. CRITICAL APPRAISAL OF STATISTICAL METHODS IN THE MEDICAL LITERATURE. (1 cr; A-F; prereq CTSC 5600, CTSC 5610; priority to CTS scholars; course content is delivered in a classroom setting utilizing Blackboard) Bailey
This module will be concerned with reading papers in the medical literature with a view towards understanding the statistical aspects. There will be 12 sessions: an introductory session, 10 one-hour sessions each involving either the review of one paper or of general concepts and discussion, and a two-hour in-class exam involving review of a paper. For

paper review sessions, all students will be required to prepare a written review of each paper prior to the start of class on a form distributed. All students will participate in the discussion of each paper. Evaluation will be based on participation, completion of forms, and the final exam.

CTSC 5710f. MANAGING AND DISPLAYING DATA. (1 cr; A-F; prerequisite CTSC 5600 or equivalent; limited to 40, priority given to CTS scholars; course content is delivered in a classroom setting utilizing Blackboard) Shi

This course introduces the general guidelines of data management including data entry and cleaning, quality control and quality assurance, locking studies, transferring data, controlling access and security, and regulatory requirements. Detailed discussions cover major areas of data management in medical research and clinical trials: case report form design, survey, and database design. In addition, the design consideration for lab data is also discussed. The second half of the course is devoted to presenting data. Particular attention is paid to graphical methods and principles that show the structure of data and aid in data communication. Evaluation will be based primarily on four assignments.

CTSC 5720w. CLINICAL TRIALS DESIGN AND CONDUCT. (1 cr; A-F; prereq CTSC 5600 or equivalent; course content is delivered in a classroom setting utilizing Blackboard) Wu

This course will focus on the statistical considerations and practical issues involved in the design and conduct of clinical trials. One of the lecturers will discuss the foundations of and practical considerations involved in drug development in humans. The Phase I-III paradigm for clinical trials will be discussed including issues about aims, endpoints, trial designs, interim analysis, final decision rules, and analytic techniques. The other lecturer will focus on several case studies of Phase III clinical trials, the use of surrogate outcome measures, goals (i.e. symptomatic versus disease modification), and post hoc analyses.

CTSC 5740w. SYSTEMATIC REVIEWS AND META-ANALYSES. (2 cr; A-F; prereq CTSC 5600, CTSC 5300, CTSC 5310; limited to 8 students, Rochester campus only, priority given to CTS scholars at end of their program; discussion of the selected topic with course faculty is required prior to registration; course content is delivered in a classroom setting) Montori, West, Murad

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 course will consist of 12 weekly two-hour small group tutorials with expert faculty to discuss key concepts and troubleshoot the scholars' 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. Students will drive their own learning agenda; there will be no lectures. There will be two practical sessions: one for developing thorough and systematic search strategies, in coordination with Mayo Library; the other for learning how to use meta-analysis software. Evaluation will be based on the methodological quality of the final systematic review/meta-analysis manuscript.

CTSC 5760w. MEDICAL DECISION MAKING. (1 cr; A-F; prereq CTSC 5600 or equivalent;

limited to 22; priority to CTS scholars; course is delivered in a classroom setting) Bundrick, Liebow
This course is intended to provide a sound, thorough introduction to the principles of clinical decision making in the areas of basic medical decision psychology and quantitative decision analysis. Specific learning objectives include: 1) to describe the major cognitive factors involved in medical decision making (e.g., heuristics, biases, and principles of valid clinical reasoning), 2) to improve clinical reasoning skills, 3) to develop a framework for analyzing and improving medical decision making skills, and 4) to describe the components of formal decision and cost-effectiveness analysis and understand the strengths and limitations of the technique. Evaluation will be based on two written exams, one mostly centered on analyzing the approach of clinicians on realistic cases and on a realistic clinical dilemma and one on utilizing the formal techniques of decision and cost-effectiveness analysis. In addition, a small portion of the grade will be based on a short critique of a cost-effectiveness article in the medical literature.

CTSC 5761f. EVIDENCE-BASED MEDICINE FOR CLINICAL RESEARCHERS. (1 cr; S-N; prereq CTSC 5600, CTSC 5300, CTSC 5310; course is delivered in a classroom setting) Montori, Murad
This course addresses a critical need of clinical researchers seeking an easier translation of their research findings into improved quality of care and patient outcomes. That is, an understanding of how the users of research need to know to translate clinical research evidence into practice. Students will benefit the most from this course if they have conducted research and have completed the design of one or more studies. Preference is given to students admitted in the CTSA program and limited to 12.

CTSC 5770s. DIAGNOSTIC TESTING STRATEGIES. (1 cr; S-N; prereq CTSC 5600 or equivalent, CTSC 5760 highly recommended; limited to 12; priority to CTS scholars and those completing CTSC 5760; course content is delivered in a classroom setting utilizing Blackboard) 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 four sessions will introduce material in a discussion format. Subsequent sessions will be organized around student presentations on self-selected clinical topics. Students will review the relevant background for the clinical problem, the prevalence of the disease in question, the operating characteristics (sensitivity/specificity, etc.) of the pertinent history and exam components and diagnostic tests, and the range of post-test probabilities that might be expected to result from the application of various diagnostic strategies. Discussion will be initiated by presenting a hypothetical case and requesting input as to suggested plans for diagnostic testing. The instructor will provide a brief summary of learning points at the end of each session. The course grade will be based on the presentation and a take-home examination.

CTSC 5810s. QUALITATIVE RESEARCH DESIGN, METHODS, AND ANALYSIS. (1 cr; A-F; course content is delivered in classroom setting utilizing Blackboard) Frimannsdottir

Qualitative data allows for in-depth understanding of complex phenomena, including an understanding of processes as well as outcome variables. In this class, students will: 1) be introduced to the theoretical foundations of qualitative methods, including grounded theory, and ethnography; 2) explore the strengths and limitations of a variety of qualitative methods, such as focus groups, interviewing, observational analysis, and document analysis; 3) examine research that utilizes multiple methods of qualitative and quantitative data; 4) review various computer systems used for analyzing qualitative data; and 5) develop skills for performing qualitative research by engaging in hands-on experiences.

CTSC 5820s. INTRODUCTION TO SURVEY RESEARCH. (1 cr; A-F; offered even years course content is delivered in a classroom setting) Yost, Ziegenfuss
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. 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. (Recommended that students have previously taken CTSC 5600 or CORE 6650).

CTSC 5850f. INTRODUCTION TO PSYCHOLOGICAL AND BEHAVIORAL MEASUREMENT. (1 cr; A-F; prereq CTSC 5600, CTSC 5601, CTSC 5610; limited to 20; offered odd years; course content is delivered in a classroom setting) G. Smith
This course will focus on the special application of concepts of reliability, validity, and norms to psychological and behavioral variables. Prevailing methods for assessing various behavioral constructs such as aptitude, attitude, emotion, personality and overt behavior will be reviewed. Advanced techniques such as item response theory, construct validation via confirmatory factor analysis and structural equation modeling will be introduced.

CTSC 5860f. BEHAVIORAL INTERVENTIONS IN CLINICAL TRIALS. (1 cr; A-F; offered even years; course content is delivered in a classroom setting) G. Smith
This course will focus on techniques for operationalizing, implementing, and monitoring the fidelity of behavioral interventions in clinical trials. Topics will include treatment development, assessing feasibility and acceptability of treatments, study design, recruitment and retention, rationale and techniques for assessing treatment fidelity, participant adherence, and dissemination of results.

CTSC 5910w. ECONOMIC EVALUATION IN HEALTH CARE. (1 cr; A-F; prereq CTSC 5600, CTSC 5601, CTSC 5010; offered odd years; limited to 10; priority given to CTS scholars with instructor's approval; course content is delivered in a classroom setting) Shah
In a world of rising healthcare 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: cost-effectiveness analysis, cost-utility analysis, issues related to study design (trial-based, model-based, and observational administrative claims-based economic evaluation), outcomes measurement and analysis (clinical

outcomes, costs, patient-reported outcomes), guidelines and reference standards, and the use of economic data in decision-making. This course will be presented in the form of lectures supported by presentation of case studies demonstrating these methods applied to specific clinical topics. Class discussion/interaction will be encouraged.

CTSC 5920s. INTRODUCTION TO HEALTH SYSTEMS ENGINEERING. (1 cr; A-F; prereq: CTSC 5600; course content is delivered in a classroom setting) Rohleder
This course introduces systems engineering methods and their emerging applications to medical decision making. The use of these methods for medical decision making has recently become an active and growing area of research in contexts such as organ transplant decisions, sequencing and timing of drug therapy, evaluation of cost effectiveness of preventive screening, and the coordination of resources for elective and emergency services. This course will cover the most important systems engineering methods for modeling disease treatment and health care delivery decisions including: queuing systems, simulation, and optimization. Specific learning objectives include 1) the development of an engineering framework for analyzing medical decisions; 2) understanding the strengths and limitations of the methods for medical decision making; and 3) recognition of opportunities for their application to research in medical decision making. This course is a combination of lectures and labs. Students will be evaluated based on weekly assignments, and either an independent project report or a take-home final examination.

CTSC 5930f. A TOOLKIT TO ANALYZE THE US HEALTHCARE SYSTEM. (1 cr; A-F; course content is delivered in a classroom setting) Shah, Ziegenfuss
The US health care system is the most complex and expensive system in the world. This is largely due to the number of different stakeholders that are involved in delivering and financing health care. This course covers the theoretical and historical foundations underlying health care delivery and organization along with practical concepts applicable to the health care system. This background is used to evaluate current and historical health policy issues and the alternatives implemented to address these issues. A thorough understanding of this system provides scholars with the required underpinnings to engage in and conduct T2 translational research.

CTSC 5960s. MEDICAL INFORMATICS FOR THE CLINICAL RESEARCHER. (2 cr; A-F; course content is delivered in a classroom setting utilizing Blackboard) Pathak, Li
This course is intended to provide a sound, thorough introduction to the principles of informatics in the context of clinical research. Specific learning objectives include: to describe basic principles and practices within the discipline of informatics; understand the motivations for informatics in clinical research; apply informatics principles and practices to clinical research; and identify and access relevant informatics resources and infrastructures.

CTSC 8110f,w,s,su. CTSA Grand Rounds (1 cr; S-N; registration limited to CTS PhD students only) Windebank
CTSA Grand Rounds provides a forum for clinical research presentations from Mayo Faculty, students in the CTS Ph.D., Master's program and trainees in the KL2 program.

Attendance is required for CTS Ph.D. students. In addition to attending seminars, CTS Ph.D. students are required to give a presentation related to their own research project beginning in year 2. Students should register in the quarter in which they present (1cr./yr.).

CTSC 8120w. CASE STUDIES IN TRANSLATION. (2 cr; A-F; course content is delivered in a classroom setting utilizing Blackboard) 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.

Research

CTSC 8890f,w,s,su. RESEARCH IN CLINICAL AND TRANSLATIONAL SCIENCE. (S-N) Staff
Graduate thesis research for Ph.D. students under supervision of staff.

CORE

Core 6000su. RESPONSIBLE CONDUCT OF RESEARCH. (1 cr; S-N) Windebank
A series of presentations on various aspects of biomedical ethics.

Core 6050s. CRITICAL THINKING AND SCIENTIFIC WRITING. (2 cr; S-N) Bieber, Hedin
This course is intended for first year graduate students across all tracks. The course will involve two components. The first will be a didactic element that introduces the scientific method, techniques and tools for searching and organizing the scientific literature, practical bioinformatics approaches, applied biostatistical analysis, scientific manuscript writing, and grant preparation. In parallel, students will choose a topic of interest and will prepare an NIH-style small grant proposal (e.g. 6-page R21 format) that will be critiqued by the course directors, the instructors, and by the other students in the class in a "study section" setting. Via a series of weekly roundtable forums discussing the merits and faults of each proposal throughout the writing process the students will learn to craft a coherent and well-reasoned grant.

Core 6100f. CHEMICAL PRINCIPLES OF BIOLOGICAL SYSTEMS. (3 cr; A-F; prereq calculus, organic chemistry, quantitative analytical chemistry, or consent of instructor)
Odd years: Strehler; Even years: Maher
An introduction to the fundamental principles of biomacromolecular structure and function, including nucleic acids, proteins, and biomembranes. The course also provides a survey of methods of structure determination and analysis, principles of catalysis, kinetics and bioenergetics.
Course URL:mayoweb.mayo.edu/mgs/core/6100/6100-intro.html

Core 6150su. GENOME BIOLOGY. (3 cr; A-F) Horazdovsky
This course will explore the organization and function of the genome, with an emphasis on the features that are critical for the regulation of gene expression mammalian systems. Topics to be examined include genome packaging and replication, as well as transcription, RNA processing, translation, and protein processing.

Core 6200f. BASIC GRADUATE IMMUNOLOGY. (3 cr; A-F) Hedin
Structure, genetics, and function of immunoglobulins; biosynthesis of antibody; cellular regulation of immune response; tumor and transplantation immunology; immune response to infectious agents; autoimmunity and immune deficiencies.

Core 6250w. MOLECULAR CELL BIOLOGY. (3 cr; A-F) Anastasiadis, Salisbury
Class is designed to convey the central principles of how eukaryotic cells function at the structural and biochemical level. Emphasis of topics is on: the cytoskeleton, extracellular matrix and cell-cell interactions, protein transport in the secretory and endocytic pathways, and cell cycle, mitosis, programmed cell death. Course format utilizes didactic lectures combined with student presentations and interactive problem

sets.

Core 6300s. MOLECULAR BIOPHYSICS. (3 cr; A-F) Sine, Burghardt
This course is an introduction to the molecular organization, dynamics and intermolecular interactions of biologically important macro-molecules with emphasis on proteins. Introductory courses in organic chemistry, biochemistry and calculus are recommended prerequisites.

Core 6400w. MOLECULAR GENETICS. (3 cr; A-F) Isaya, Harris, Xu
Overview of topics in genetics of general importance to biomedical research with emphasis on molecular aspects.

Core 6450s. MOLECULAR PHARMACOLOGY AND RECEPTOR SIGNALING. (2 cr; A-F) Brimijoin
A chief aim of modern life science is to understand the biological mechanisms of living systems and to apply this knowledge in discovering cures for disease. This course will provide a comprehensive introduction to receptors and downstream signaling pathways important in disease and the science underlying the use of chemical agents, proteins, nucleic acids, and genes to influence these pathways and biological outcomes. The course will also survey computer-aided drug discovery, gene therapy, pharmacogenomics, and the basic principles of modern molecular pharmacology. Carefully constructed problem sets will enable students to master practical issues in designing and interpreting experiments on drug-receptor interactions.

Core 6510s. MOLECULAR MECHANISMS OF HUMAN DISEASE. (3 cr; A-F) Windebank, Mukhopadhyay
This course is designed to introduce students to the basic organization, histology, and function of major organ systems and provide an appreciation for pathophysiological conditions leading to disease and therapeutic intervention. Lecture topics will focus on a new system each week. Systems discussed include skin, bone, hematopoiesis, vascular, cardiac, pulmonary, gastroenterology, kidney, and metabolic. This course is intended for students with no medical training.

Core 6650s. BIOSTATISTICS. (2 cr; A-F) Brisbin, Wu
Didactic classroom presentations, basic statistical terms and concepts with examples (using JMP software) will be presented, including: mean, median, percentiles, range, standard deviation, proportions; graphical displays of different data types; evaluating a diagnostic test in terms of sensitivity, specificity, prevalence, positive and negative predictive value; distributions for discrete and continuous random variables; confidence intervals, two sample hypothesis tests (both parametric and non-parametric), ANOVA; sample size and power; correlation and simple linear regression. Additional laboratory sessions will be arranged during the first week of class.

Core 6700w. INTEGRATED SYSTEMS PHYSIOLOGY. (3 cr; A-F) Sieck
The goal of this course will be an emphasis on the importance of integrative physiology in the evolving area of functional genomics. Laboratory demonstrations will provide exposure to state-of-the-art physiological techniques with applications from cell physiology to human disease.

Core 6770s. VIROLOGY AND GENE THERAPY. (3 cr; A-F) Cattaneo
The Virology and gene Therapy core course is the sum of three one-credit courses that will be held consecutively during the spring quarter: Molecular Virology, From Viruses to Vectors, and Gene Therapy.

DENTISTRY

Dentistry - Orthodontics

Didactic

Odon 8806f,w,s,su. ORTHODONTIC SEMINAR: TECHNIQUE.
(1 cr; A -F) Staff
Seminar on technical orthodontic procedures.

Odon 8807f,w,s,su. ORTHODONTIC SEMINAR: LITERATURE REVIEW. (1 cr; A-F) Staff
Classical orthodontic literature as well as current literature review.

Odon 8808f,w,s,su. ORTHODONTIC SEMINAR: CASE PRESENTATION. (1 cr; A-F) Staff
Cases with complete records reviewed and new patient treatment plans discussed.

Odon 8809f,w,s. SURGICAL ORTHODONTIC SEMINAR. (1 cr; A-F) Viozzi
Case presentation, illustration, diagnostic and treatment procedures that encompass the various dental specialties.

Odon 8810s. CLINICAL ORO-FACIAL PATHOLOGY AND DEVELOPMENTAL DISORDERS. (1 cr; A-F; prereq D.D.S., D.M.D., M.D. or equivalent required) Staff
A review of the clinical presentations of many congenital and acquired pathological disorders, developmental deficiencies, and malformations important to the dental specialist.

Research

Odon 8857f,w,s,su. RESEARCH IN SELECTED PROBLEMS. (1 cr/qtr; A-F) Staff
Arrangements for research in selected areas related to minor.

Clinical

Odon 8800f,w,s,su. ADVANCED ORTHODONTIC TECHNIQUES.
(3 cr; A-F) Staff
Initial technical procedures in preparation for clinical patient care. Technical procedures on the typodont, model preparation, photography, metallurgy, and cephalometrics.

Odon 8802f,w,s,su. ORTHODONTIC CASE ANALYSIS. (6 cr; A-F) Staff
First phase involves complete review of previously treated cases. Second phase is application of basic analytic principles to clinical patients.

Odon 8803f,w,s,su. ORTHODONTIC TREATMENT PLANNING. (6 cr; A-F) Staff
Mechanical principles coordinated with case analyses to provide the treatment plan. Force analysis and biomechanics of tooth movement.

Odon 8804f,w,s,su. CLINICAL ORTHODONTICS. (6 cr; A-F) Staff
Individual treatment care and clinical observation. Treatment care coordinated with other services in selected instances in the hospital.

Odon 8805f,w,s,su. ADVANCED CLINICAL ORTHODONTICS.
(6 cr; A-F) Staff
Final treatment care of individual patients.

Odon 8851f,w,s,su. DENTAL ROENTGENOLOGY. (1 cr; A-F) Staff
Includes x ray diagnosis and techniques.

Odon 8852f,w,s,su. ORAL DIAGNOSIS. (5 cr; A-F) Staff
Clinical course in diagnosis related to dental problems.

Dentistry - Periodontics

Didactic

Pdon 8883f,w,s,su. PERIODONTIC SEMINAR. (1 cr; A-F) Sheridan, Assad
Literature review and discussion.

Pdon 8884su. PERIDONTICS/ORTHODONTICS SEMINAR. (1 cr; A-F; offered odd years) Volz
Histopathology of periodontal disease. Oral mucous membrane; calcified tissues. Interdisciplinary case reviews.

Pdon 8886f,w. CLASSIC LITERATURE IN PERIODONTICS. (2 cr/qtr; A-F; offered even years; two quarters required;) Sheridan, Assad
Review of 55 years of classic literature from the Journal of Periodontology. Two one hour sessions per week x 26 weeks.

Research

Pdon 8857f,w,s,su. RESEARCH IN SELECTED PROBLEMS.
(2 cr; A-F) Assad

Clinical

Pdon 8851f,w,s,su. DENTAL ROENTGENOLOGY. (1 cr; A-F) Sheridan, Assad
X ray diagnosis and technique.

Pdon 8852f,w,s,su. ORAL DIAGNOSIS. (5 cr; A-F) Sheridan, Assad
Clinical diagnosis related to dental problems.

Pdon 8880f,w,s,su. CLINICAL PERIODONTICS. (6 cr; A-F) Sheridan, Assad
Etiology, diagnosis, and treatment of periodontal disease.

Dentistry - Prosthodontics

Didactic

Pros 8841f. COMPLETE DENTURE PROSTHODONTIC SEMINAR.
(1 cr; A-F; offered every fourth year {2013}) Carr
Literature review and discussion of past and current concepts and practices of complete denture prosthesis.

Pros 8843w. REMOVABLE PARTIAL PROSTHODONTIC SEMINAR. (1 cr; A-F; offered every fourth year {2014}) Carr
Literature review and discussion of past and current concepts and practices of removable partial denture prosthesis.

Pros 8845s. FIXED PROSTHODONTIC SEMINAR. (1 cr; A-F; offered every fourth year {2013}) Koka, Salinas
Principles, practices, and concepts related to clinical and laboratory phases of fixed prosthodontics.

Pros 8847w. SEMINAR: MAXILLOFACIAL PROSTHETICS (INTRAORAL) ADVANCED PROSTHODONTICS. (1 cr; A-F; offered every fourth year {2014}) Salinas
Literature review and discussion of past and current concepts and practices of implant prosthodontics and maxillofacial prosthetics.

Pros 8848f,w,s. SEMINAR: CURRENT LITERATURE. (1 cr; A-F) Carr, Koka, Salinas
Review and discussion of practical, clinical, or laboratory applications of current literature in prosthodontics and related fields, with an emphasis on evidence-based appraisal of the literature.

Pros 8849s. SEMINAR: MAXILLOFACIAL PROSTHETICS (EXTRAORAL) ADVANCED PROSTHODONTICS. (1 cr; A-F; offered every fourth year {2014}) Salinas
Literature review and discussions on clinical and laboratory procedures involved in fabrication of extraoral prostheses.

Pros 8850f. IMPLANT PROSTHODONTICS. (1 cr; A-F; offered every fourth year {2013}) Salinas
Literature review and discussion of past and present concepts and practices of implant prosthodontics.

Pros 8859f,w,s. PERIODONTAL AND PROSTHODONTIC CONSIDERATIONS IN DENTISTRY. (1 cr; A-F) Salinas
This course is designed to promote in-depth discussions of subjects of interest in the areas of orthodontics, periodontology and prosthodontics. The interrelationship of the three fields is stressed.

Pros 8862s. DENTAL MATERIALS. (1 cr; A-F offered every fourth year {2014}) Salinas
Discussion of physical properties, mechanical properties, technical procedures and the interrelationship of these with clinical procedures related to dental materials most commonly used in prosthodontics.

Pros 8870f. OCCLUSION. (1 cr; A-F; offered every fourth year {2012}) Salinas
A series of detailed discussions of the principles, practices, and concepts of occlusion.

Pros 8871f. PHYSIOLOGY, PHARMACOLOGY AND PRE-PROSTHETIC SURGERY. (1 cr; A-F; offered every fourth year {2012}) Salinas
Discussion of physiology of major organ systems in conjunction with pharmacologic management of disorders of these systems. Pre-prosthetic surgery is discussed and reviewed through an evaluation of the literature.

Pros 8872su. PROSTHODONTIC PRACTICE MANAGEMENT. (1 cr/yr; S-N) Carr
Discussion of topics related to the management of a prosthodontic practice.

Pros 8873f. CRANIO-MANDIBULAR DISORDERS AND FACIAL PAIN. (1 cr; A-F; offered every fourth year {2012}; prereq Pros 8870) Reid
Literature review and discussion of past and current concepts and practices in the management of patients with cranio-mandibular disorders including myofacial pain dysfunction, temperomandibular disorders and atypical face pain.

Pros 8874f. PROSTHODONTIC MANAGEMENT OF THE GERIATRIC PATIENT. (1 cr; A-F; offered every fourth year {2012}) Salinas
Literature review and discussion of medical complications found in the geriatric patient with emphasis placed on special considerations made during prosthodontic treatment.

Pros 8878f,w,s. DENTAL AND MEDICAL ETHICS. (1 cr; S-N) Salinas
This course is a review and discussion of the Ethics Educational Videorecording available at the Mayo Library System.

Research

Pros 8857f,w,s,su. RESEARCH IN SELECTED PROBLEMS. (2 cr; A-F; offered 6 quarters during program, including all of final year) Carr, Koka, Salinas

Clinical

Pros 8840f,w,s,su. CLINICAL PROSTHODONTICS: COMPLETE DENTURES. (6 cr; A-F)

Carr, Salinas, Koka
Orientation and introduction to clinical and laboratory phases of prosthodontics in the medical center with emphasis on principles, concepts, and practices related to complete denture prosthesis.

Pros 8842f,w,s,su. CLINICAL PROSTHODONTICS: PARTIAL DENTURES. (6 cr; A-F) Carr, Salinas, Koka
Orientation and introduction to clinical and laboratory phases of prosthodontics in the medical center with emphasis on principles, concepts, and practices related to removable and fixed partial denture prosthesis.

Pros 8844f,w,s,su. MAXILLOFACIAL PROSTHETICS (INTRAORAL) IMPLANT PROSTHODONTICS ADVANCED PROSTHODONTICS. (6 cr; A-F) Carr, Salinas
Clinical and laboratory procedures involved in management of patients with acquired, congenital, and developmental intraoral defects.

Pros 8846f,w,s,su. MAXILLOFACIAL PROSTHETICS (EXTRAORAL) ADVANCED PROSTHODONTICS. (6 cr; A-F) Carr, Salinas
Clinical and laboratory procedures involved in management of patients with acquired and congenital extraoral defects.

Pros 8851f,w,s,su. DENTAL ROENTGENOLOGY. (1 cr; A-F) Reid
X ray diagnosis and technique.

Pros 8852f,w,s,su. ORAL DIAGNOSIS AND TREATMENT OF CRANIO-MANDIBULAR DISORDERS. (2 cr; A-F) Salinas
Clinical diagnosis and treatment related to dental problems, including craniomandibular disorders and facial pain.

Pros 8854f,w,s,su. IMPLANT PROSTHODONTICS. (6 cr; A-F) Carr, Salinas
Clinical and laboratory procedures involved in the management of patients who receive prostheses supported and retained by endosseous implants.

Pros 8876f,w,s,su. CLINICAL PROSTHODONTICS; FIXED PARTIAL DENTURES. (6 cr; A-F) Carr, Salinas
Presentation and introduction to clinical and laboratory phases of prosthodontics in the medical center with emphasis on principles, concepts and practices related to fixed partial denture prostheses.

Pros 8880f. DENTAL LABORATORY TECHNOLOGY. (6 cr; A-F) Salinas
A full time clinical assignment to familiarize the resident with all aspects of laboratory technology used in the fabrication of removable and fixed partial and maxillofacial prostheses.

DERMATOLOGY*

Derm 8870w. ORAL MUCOUS AND MEMBRANE DISEASE. (1 cr; S-N; offered even years) Bruce, Torgerson
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 8400f,w,s,su. MASTER'S PROJECT IN IMMUNOLOGY. (3 cr; A-F) Staff
The Employee Master's project will consist of a scholarly written review of an important area of immunology. Topics will be chosen by the student in consultation with the advisor and the student's advisory committee. The written review will describe the current state of understanding in the area, identify outstanding questions and controversies, and describe potential future directions for research that will address these questions. The final document and an oral defense of the document must be of sufficient merit to satisfy all members of a four-member advisory committee, to be selected and approved by the Immunology Graduate Program Director prior to beginning work on the Employee Master's project. Register in the quarter in which you present your final project to the advisory committee; and register with your advisor as course director.

IMM 8862f. CURRENT TOPICS IN CELL ACTIVATION AND SIGNALING. (1 cr; S-N) Billadeau (f), Hedin (w), Bram (s)
Weekly discussions of recent scientific literature on topics related to receptors, transmembrane signaling mechanisms, and gene expression.

IMM 8863f. CURRENT TOPICS IN IMMUNOLOGY. (1 cr; A-F; prerequisite Core 6200 or equivalent) Schrum, Gil Pages
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, winter and spring.

IMM 8867f,w,s. CURRENT TOPICS IN HYPERSENSITIVITY REACTIONS. (1 cr; A-F; consent of instructor is required) Kita
This is a series of seminars on hypersensitivity with particular emphasis on immediate type reactions, immune regulation, and cells and mediators in hypersensitivity. Students are evaluated by their performance of a seminar during the course.

IMM 8877w. TUTORIAL IN MOLECULAR BASIS OF IMMUNE RECOGNITION. (2 cr; A-F; offered odd years; prereq Core 6200 or equivalent) Pease, David, Lustgarten, Schrum, Rajagopalan, Taneja
Regulation and structure of genes and proteins that function in specific immune recognition. Genes of the MHC, T cell receptors, and immunoglobulins will be featured.

IMM 8879w. TUTORIAL IN CELLULAR ACTIVATION. (2 cr; A-F; offered even years; prereq Core 6200 or equivalent, basic knowledge of receptor pharmacology is desirable but not a requisite) Hedin, Billadeau, Medina, Gil Pages, Howe, Shapiro
This course focuses on the intracellular signaling pathways which regulate the activation, growth, and differentiation of lymphoid cells. Additional emphasis is placed on molecular mechanism of immunosuppression by cyclosporine, FK506, and related compounds.

IMM 8880s. TUTORIAL IN IMMUNOPATHOLOGY. (2 cr; A-F; offered odd years) Barry, Plager, Weaver
Concepts in the immunopathology of virus and bacterial infection, autoimmunity, tumor immunology, and transplantation. Emphasis will be on immune mechanisms that the host uses to respond against pathologic agents, how disregulation of these responses lead to autoimmunity, and adaptative stategies infectious agents use to evade immunity.

IMM 8882w. TUTORIAL IN INNATE IMMUNITY AND INFLAMATION. (2 cr; A-F; offered odd years; prereq Core 6200) Kita, Wettstein, Faubion, Mangalam
The course will review the biology of NK cells, macrophages, and other major cellular components in the innate immunity. The current knowledge on the receptors and molecules, which are used by these cell types to recognize microorganisms and self- and non-self antigens, will be discussed. The molecular and cellular mechanisms involved in inflammation, host defense, and mucosal and other organ-specific immunity will be discussed.

IMM 8884w. TUTORIAL IN TUMOR IMMUNOLOGY. (2 cr; A-F; offered even years; prereq Core 6200 or equivalent) Vile, Kwon, Lustgarten, Markovic, Dong, Knutson
Concepts in tumor immunology. This course is based on the current literature with heavy emphasis on student/faculty discussion.

IMM 8885s. THE GENERATION AND FUNCTION OF B CELLS. (2 cr; A-F; offered even years; prereq Core 6200 or equivalent) Medina, Pease, Jelinek, Howe, Novak, Shapiro
This course is designed to provide an in depth understanding of the generation and function of B lymphocytes in health and disease. The prerequisites are successful completion of Immunology Core 6200 or Mayo Medical School, Block V, Normal Function, Immunology course. The final grade will be based on class preparation, class participation, and the grade achieved on the comprehensive final exam.

Research

IMM 8840f,w,s,su. RESEARCH IN IMMUNOLOGY. (6 cr/qtr; S-N) Staff

Graduate thesis research for Basic Science and Clinical Master's students under supervision of staff.

IMM 8852f,w,s,su. RESEARCH IN IMMUNOLOGY. (S-N) Staff
Graduate thesis research for Ph.D. students under supervision of staff.

M.D.-PH.D.

MDPD 5000f,w,s,su. LABORATORY ROTATIONS FOR M.D.-Ph.D. STUDENTS. (1 cr; S-N) Staff
Three one-month rotations required.

MDPD 5100w. BIOINFORMATICS SELECTIVE. (1 cr; S-N; offered odd years) Isaya
This two-week colloquium will survey information management, specifically examining the best tools available to acquire, organize and utilize information in research. The course will also provide an overview of the practical uses of bioinformatics techniques in medical research, with an opportunity to interact with some of the leading experts in microarray analysis and proteomics at Mayo Clinic.

MDPD 5150w. MEDICAL SCIENTIST SURVIVAL SKILLS. (1 cr; S-N; offered even years) Isaya, Huskins
This two-week colloquium will cover grant writing and clinical study protocol development. Working in small groups, students will be required to produce a complete grant application (F30 format) and a complete clinical study protocol by the end of the two-week period. Students will receive written critiques and a score for their work. Limited to 18 students.

MAYO GRADUATE SCHOOL

MGS 5100su. SURF ROTATION AND SEMINAR SERIES. (2 cr; S-N) Staff
During this 10-week fellowship students will attend a weekly SURF seminar, other seminars and journal clubs within Mayo Graduate School and present at an end-of-the year event hosted by their program. Students will receive hands-on research training during the 10-week full-time fellowship.

MGS 5102f,w,s,su. Ph.D. LABORATORY ROTATION. (2 cr; S-N) Staff
Graduate thesis research (8 weeks) under supervision of staff.

MICROBIOLOGY*

M 5805f,w,s,su. MICROBIOLOGY OF THE MUSCULOSKELETAL SYSTEM. (1 cr) Hanssen
Lectures in pathophysiology of musculoskeletal infections (bacterial) and mechanisms of action of antimicrobials.

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

MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS

MPET 5808w. INTRODUCTION OF MOLECULAR PHARMACOLOGY. (4 cr; A-F) Olson
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 5850w. METABOLOMICS AND PHARMACOMETABOLOMICS. (1 cr; A-F) Dzeja
The course is designed to introduce graduate students to the concepts, technologies and applications of new "omic" science - metabolomics, highlighting significance in system and metabolic network biology, disease diagnostics, drug discovery, pharmacology and toxicology.

MPET 8000w. ESSENTIALS IN PATCH CLAMP TECHNIQUE. (2 cr; A-F) Terzic, Alekseev
An introduction to patch clamp electronics and ion channel measurements. A limited number of students pursuing research with patch clamp techniques will be accepted.

MPET 8100w,f,s. MASTER'S PROJECT. (3 cr; S-N) Staff
The Employee Master's project will consist of a scholarly written review of a topical area in pharmacology. The review will describe the current state of understanding of the topic, identify an important question related to the topic, and describe potential future directions and experimental strategies to address the question. The topic will be chosen by the student in consultation with a faculty advisor with full or associate graduate privileges and the student's Advisory Committee. The student's committee will evaluate the scope and content of the Employee Master's Project. Register in the quarter in which you present your final project to the advisory committee; and register with your advisor as course director.

MPET 8205f. CLINICAL PHARMACOLOGY JOURNAL CLUB. (1 cr; S-N) Weinshilboum
This journal club meets once monthly. At each meeting, one participant chooses, along with his/her 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.

MPET 8400su. INTRODUCTION TO PRINCIPLES OF PHARMACOKINETICS. (1 cr; A-F) 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 8655f. MECHANISMS OF CELL GROWTH AND DEATH. (2 cr; A-F; offered even years; prereq Core 6100, 6150 and 6250 or consent of instructor) Karnitz, 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 8700f. APOPTOSIS JOURNAL CLUB. (1 cr; S-N) Kaufmann
The course is a journal club reviewing recent articles on the cellular mechanisms of apoptosis. An emphasis is placed on reviewing articles describing new, universal molecular and biochemical pathways of apoptosis. The course meets monthly throughout the year. No prerequisites are required.
Register in fall quarter only (1 cr./yr.). Attendance required fall, winter and spring.

MPET 8800s. RESEARCH SEMINARS IN PHARMACOLOGY. (1 cr; S-N) Choi
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 spring quarter only (1 cr./yr.) Attendance required fall, winter and spring.

MPET 8802w. CARDIOVASCULAR BIOLOGY AND MOLECULAR PHARMACOLOGY. (2 cr; A-F; consent of instructor is required; offered odd years) Terzic
Lectures, discussions, and demonstrations on the cellular basis of action of drugs on heart muscle.

MPET 8805s. DRUG METABOLISM, PHARMACOGENOMICS AND CARCINOGENESIS. (2 cr; A-F) Weinshilboum, Ames
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.

MPET 8812s. TUTORIAL IN RECEPTOR BIOLOGY. (2 cr; S-N) Brimijoin
Student-led discussions and presentations on current topics in receptor biology (runs concurrently with Core 6450).

MPET 8814w. CELLULAR PHARMACOLOGY OF AGENTS THAT TARGET CANCER AND AIDS. (2 cr; A-F; offered even years) Kaufmann
This tutorial will examine the mechanisms of action of selected pharmacological agents at the cellular and subcellular level. Drug targets to be examined during the quarter will include plasma membrane receptors, receptor tyrosine kinases, Janus kinases, protein farnesyl transferase, other enzymes involved in signal transduction and intermediary metabolism, microtubules, HIV transcriptase and the proteasome. 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 8815s. NEUROBEHAVIORAL PHARMACOLOGY. (2 cr; A-F) Choi
This course will cover the most recent neuropharmacological aspects of behavior disorders. The emphasis will be on understanding the advancement of neurogenetics, neurobiology, neuroimaging, and human genomics, which are enabling us to decipher behavioral disorders in molecular levels, and thereby to develop more precise pharmacological treatment methods.

MPET 8820f. REGENERATIVE MEDICINE. (2 cr; AF) Terzic
This graduate course is designed to introduce principles and practice of stem cell biology and regenerative medicine. 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. Prerequisites for this course include proficiency in fundamental cell biology, genomics, and pharmacology.

Research

MPET 8801f,w,s,su. RESEARCH IN MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS. (S-N) Staff
Directed research projects for Ph.D. students under the supervision of a faculty advisor.

MPET 8840f,w,s,su. RESEARCH IN MOLECULAR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS. (6 cr/qtr; S-N) Staff
Directed research projects for Basic Science and Clinical Master's students under the supervision of a faculty advisor.

NEUROBIOLOGY OF DISEASE

NSCI 5600w,s. BEHAVIORAL NEUROLOGY. (2 cr; S-N; offered odd years) Graff-Radford
Students will learn about the neuropathological, genetic, and clinical characteristics of neurodegenerative diseases such as Alzheimer's disease. The course will feature the most current knowledge about each disease, including therapies available or ongoing research on the causes of the disorder.

NSCI 8100f,w,s,su. MASTER'S PROJECT IN NEUROSCIENCE. (3 cr; A-F) Howe, Windebank

The Employee Master's project will consist of a scholarly written review of an important area of molecular neuroscience. The student will identify an area of active neuroscience research, describe the current state of understanding in the area, identify fundamental outstanding questions and controversies, and describe potential future directions for research that will address these questions. The final document, and an oral defense of the document, must be of sufficient merit to satisfy all members of a four member advisory committee, to be selected by the student and approved by the Molecular Neuroscience Graduate Program Director prior to beginning work on the Employee Master's project. Register in the quarter in which you present your final project to the advisory committee; and register with your advisor as course director.

NSCI 8210s. NEUROBIOLOGY OF DISEASE. (4 cr; A-F; prereq consent of course director) Howe

This course is designed for graduate students (PhD and Msc), 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 pathological and cell biological basis of important neurological diseases and syndromes. While the course will demonstrate clinical relevance, the primary goal is to provide deep insight into the mechanisms of pathogenesis. The scientific background and context for each disease will also be provided and therapeutic rationales will be discussed. The focus will be on research-oriented students, but this course will also provide a mechanistic understanding for clinically-oriented students. The didactic aspects of this course will be provided by basic science and clinical experts from all three Mayo campuses. In addition, a reading and discussion component will provide students with access to cutting edge research relevant to key neurological diseases and syndromes.

NSCI 8401f. NEUROANATOMY. (1 cr; A-F; prereq first year neuroscience student or consent of course director) Scarisbrick

This course is designed to provide a fundamental understanding of neuroanatomical nomenclature and the structure and function of the human and rodent nervous systems. The emphasis is on practical application of neuroanatomical knowledge for research-oriented students.

NSCI 8500f,w,s,su. NEUROSCIENCE SEMINAR. (1 cr; S-N) Howe

Seminar series by Mayo faculty and visiting faculty covering advanced topics in neuroscience research.

Register for this course fall quarter only (1 cr./yr.). Attendance required fall, winter and spring.

NSCI 8600f,w,s,su. SPECIAL TOPICS IN NEUROSCIENCE. (1 cr; A-F) Howe

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 of didactic lectures by the faculty and literature reviews and presentations by the students. One credit will be given per year and every student will be expected to present and participate throughout each quarter.

Students will be required to attend and participate for 9 quarters (first three years in the program, excluding summer quarter).
Register for this course fall quarter only (1 cr./yr.). Attendance required fall, winter and spring.

NSCI 8650su. NEUROBIOLOGY OF DISEASE WORKS IN PROGRESS. (1 cr; S-N) Howe
Presentation of ongoing research projects by graduate students in the Neurobiology of Disease Ph.D. Program.

NSCI 8700f,w,s,su. INDEPENDENT STUDY IN NEUROSCIENCE. (1-2 cr; A-F) Staff
Tutorials arranged on an individual basis in selected advanced topics in neuroscience. Students will define a topic and a specific high-level reading list in consultation with a faculty member. Subject mastery will be assessed by a formal written review of the subject area.

NSCI 8850f. PRINCIPLES OF NEUROSCIENCE. (3 cr; A-F) Bieber
This course will consist of a series of didactic presentations that will introduce students to the molecular biology of neurons and glia, and to the structure and function of the nervous system. Broad areas of consideration will include the cellular and molecular biology of neurons, glia, and muscle, electrical and chemical signaling in the nervous system, neuronal development, and the complex interactions between neurons and the processing and integration of neural activity. The course will also consider how the functions of the individual cellular components of the nervous system are integrated in the brain and nervous system to produce behavior and higher mental functions, and in doing so will address the structure and function of specific neural systems such as the motor systems, somatosensory systems, visual and auditory systems, learning and memory, and higher cortical function.

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. Concomitant registration in Topics in Neuroscience Research (NSCI 8852) is required for all students in the Neurobiology of Disease track.

NSCI 8852f. TOPICS IN NEUROSCIENCE RESEARCH. (1 cr/yr; A-F) Bieber
This course will introduce graduate students to the primary research literature in basic neuroscience. The emphasis will be on developing the ability to read the research literature efficiently, identifying the key points in otherwise complex papers. Emphasis will also be placed on the critical evaluation of experimental data and on the basic technical approaches that are commonly used in neuroscience research. It is intended that students enrolled in Principles of Neuroscience (Nsci 8850) will also enroll in this course.

NSCI 8854w. BASIC CLINICAL NEUROSCIENCE. (5 cr; A-F) Benarroch
The Basic Clinical 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.

NSCI 8855s. CONCEPTS OF CELL GROWTH AND REGENERATION. (1 cr/yr.; A-F; prerequisites NSCI 8600, NSCI 8850 recommended) Henley
The course will explore the processes by which developing neurons grow and establish functional connections during embryonic development, intrinsic and extrinsic growth inhibitors, and potential strategies for enhancing neuroregeneration in the adult peripheral and central nervous systems. Papers will be chosen to represent fundamental discoveries and the most current findings.

NSCI 8860s. ADVANCED TOPICS IN CELLULAR, MOLECULAR, AND SYSTEMS NEUROSCIENCE. (3 cr; A–F; prerequisites NSCI 8854, NSCI 8400; second year Neuroscience student, others only by permission of instructor) Howe
This course is intended for second year students in the Neuroscience track and will be structured as a small group didactic discussion of advanced topics in neuroscience. The course will use the analysis of both primary historical and current research articles to more thoroughly develop critical topics introduced in NSCI 8850/8852 and NSCI 8600.

Research

NSCI 8840f,w,s,su. RESEARCH IN THE NEUROBIOLOGY OF DISEASE.
(6 cr/qtr; S-N) Staff
Graduate thesis research for Basic Science and Clinical Master's students under supervision of staff.

NSCI 8900f,w,s,su. RESEARCH IN THE NEUROBIOLOGY OF DISEASE. (S-N) Staff
Graduate thesis research for Ph.D. students under supervision of staff.

OBSTETRICS AND GYNECOLOGY

Didactic

ObG 5803su. INTRODUCTION TO SURGICAL GYNECOLOGY. (4 cr; A-F) Cliby, Gebhart
Didactic sessions presented weekly. Student preparation and participation is required.
Register once for four consecutive quarters.

ObG 5804su. INTRODUCTION TO MATERNAL FETAL MEDICINE. (4 cr; A-F) Brost

Didactic sessions presented weekly. Student preparation and participation is required.
Register once for four consecutive quarters.

ObG 5805su. INTRODUCTION TO REPRODUCTIVE INDOCRINOLOGY AND INFERTILITY. (1 cr; A-F) Daftary and Staff
Didactic sessions presented weekly. Student preparation and participation is required.
Register once for five consecutive quarters.

ObG 8840f,w,s,su. RESEARCH IN OBSTETRICS GYNECOLOGY. (6 cr; A-F) Staff
Graduate thesis research under supervision of staff.

Clinical

ObG 8857f,w,s,su. GYNECOLOGIC ONCOLOGY. (6 cr; A-F; prereq 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) Cliby 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.
Register once for five consecutive quarters.

ObG 8865f,w,s,su. REPRODUCTIVE ENDOCRINOLOGY AND INFERTILITY. (6 cr; A-F; prereq satisfactory completion of an obstetrics and gynecology residency training program at an accredited institution and maintenance of satisfactory status within the Reproductive Endocrinology & Infertility Fellowship Program) Daftary and Staff
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.
Register once for five consecutive quarters

ObG 8870f,w,s,su. ADVANCED UROGYNECOLOGIC OPERATIVE SURGERY. (6 cr; A-F; prereq 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) Gebhart and staff
The preoperative, intra operative and postoperative management of gynecological patients.
Register once for four consecutive quarters.

ObG 8875f,w,s,su. MATERNAL FETAL MEDICINE. (6 cr; A-F; prereq 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) Brost
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 & 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.

ORTHOPEDICS

Didactic

Or 5803f,s. PROSTHETICS FOR ORTHOPEDICS. (1 cr; A-F) Shives
Lectures and discussions regarding upper and lower extremity prosthetics for amputations at various levels, includes class participation in the application of immediate-type pylons.

Or 8550f,w,s,su. NONSTRUCTURED MICROVASCULAR ANASTOMOSIS. (2 cr; S-N; prereq 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.) Anding
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.

Or 8860f,w,s,su. BASIC KNOWLEDGE AND MOTOR SKILLS OF ORTHOPEDIC SPECIALTIES. (3 cr; A-F; consent of instructor is required) Rose
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

Or 8851f,w,s,su. ORTHOPEDIC DIAGNOSIS. (6 cr; A-F) Staff
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 disease processes. Included are experiences in outpatient, inpatient and operating room settings. The didactic program includes clinical conferences, lectures and journal clubs.

Or 8852f,w,s,su. ADULT RECONSTRUCTION. (6 cr; A-F) Lewallen and staff
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.

Or 8853f,w,s,su. SURGERY OF THE HAND. (6 cr; A-F) Berger and staff
Supervised exposure to clinical hand surgery with weekly teaching conference and monthly journal club.

Or 8854f,w,s,su. PEDIATRIC ORTHOPEDICS. (6 cr; A-F) Stans and staff
Incidence, etiology, evaluation and treatment of congenital developmental, metabolic, and post-traumatic orthopedic conditions from birth to physiologic maturity.

Or 8855f,w,s,su. ORTHOPEDIC ONCOLOGY. (6 cr; A-F) Rock and staff
Orthopedic oncology residents participate in evaluation and management of patients with various musculoskeletal neoplasms. The surgical experience includes modern limb salvage procedures.

Or 8856f,w,s,su. FRACTURES AND RELATED INJURIES.
(6 cr; A-F) Sems and staff
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.

Or 8890f,w,s,su. RESEARCH IN ORTHOPEDICS. (6 cr; S-N) Staff
Graduate thesis research for Master's students under supervision of staff.

OTORHINOLARYNGOLOGY

Didactic

ENT 5150f,w,s,su. CORE CURRICULUM. (2 cr; S-N) Staff
This series of lectures rotates systematically every two years through basic and advanced

discussions of topics in the various aspects of the field of otorhinolaryngology. The lectures are presented by the staff and are divided into segments covering otology/audiology, rhinology, head and neck, pedicatric ORL, general ORL, and plastic/reconstructive.

ENT 5300f,w,s,su. CORE COLLOQUIUM. (1 cr; S-N) Price and staff
Course is designed for open discussion among staff and participants regarding surgical indications and management and prevention of complications in patients with medical and surgical problems in otorhinolaryngology-head and neck surgery.

ENT 8100f,w,s,su. PROBLEMS IN CLINICAL DIAGNOSIS. (4 cr; A-F) Price and staff
Presentations by resident and consulting staff of representative diagnostic and management problems in otorhinolaryngology.

ENT 8300s. SOFT TISSUE AND PLASTIC RECONSTRUCTION.
(1 cr; A-F; offered even years) Moore
The purpose of this course is to acquaint the resident with the basic principles of soft tissue surgery. Local skin flaps including advancement, rotation, transposition and island flaps will be discussed. The techniques of scar revision will be demonstrated.

ENT 8500f. RHINOLOGY AND RHINOLOGIC SURGERY DISSECTION. (3 cr; A-F; offered odd years) Staff
This rhinology dissection course is given with fresh frozen cadavers. The basic purpose of this course is to acquaint the resident with the surgical anatomy and basic operative procedures of the nasal septal and external nose, including nasal septal reconstruction, sinus surgery, and rhinoplasty. There are dissections assigned and didactic material presented.

ENT 8800f,w,s,su. SEMINAR: OTORHINOLARYNGOLOGY. (1 cr/yr; S-N) Price
Review, presentation and discussion of current literature in otorhinolaryngology head and neck surgery.

ENT 8857s. TEMPORAL BONE ANATOMY AND SURGERY OF THE TEMPORAL BONE. (3 cr; A-F) Driscoll and staff
This course is designed to present the basic anatomy of the temporal bone, surgical landmarks, and to familiarize the resident with the surgical techniques of temporal bone surgery and the appropriate anatomy.

Research

ENT 8890f,w,s,su. GRADUATE RESEARCH. (6 cr; A-F; consent of instructor is required) Neff
Graduate thesis research under staff supervision.

Clinical

ENT 8851f,w,s,su. CLINICAL OTORHINOLARYNGOLOGY.

(6 cr; A-F) Staff
Theory and practice with differential diagnosis and treatment of diseases of the ear, nose, paranasal sinuses, pharynx, larynx, head, and neck; their relation to general diagnosis.

ENT 8852f,w,s,su. PREOPERATIVE AND POSTOPERATIVE CARE OF PATIENTS. (6 cr; A-F) Staff
Junior residency service. Care of the pre- and postoperative in-hospital management of patients with diseases associated with the ears, nose and throat. Initial assessment of trauma involving head and neck as well as emergency room management of those patients.

ENT 8853f,w,s,su. OPERATIVE OTORHINOLARYNGOLOGY.
(6 cr; A-F) Staff
Senior residency service. Senior surgical residency with the teaching staff. Management of the patient during entire hospital stay. Surgery performed under direction of faculty by the resident when properly qualified.

ENT 8854f,w,s,su. OPERATIVE OTORHINOLARYNGOLOGY - CHIEF RESIDENT ASSOCIATE. (6 cr; A-F) Staff
The chief resident manages the pre-operative, surgical and postoperative care of the patient. Faculty are available for supervision and consultation.

PATHOLOGY*

Didactic

Path 8872w,su. BONE AND SOFT TISSUE PATHOLOGY. (3 cr; A-F) Staff
Discussion of the gross and microscopic appearances of tumors and tumor-like conditions of bone and joints.

Path 8873f,w,s,su. ORAL PATHOLOGY. (2 cr/yr; A-F) Staff

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

RADIOLOGY*

R 8854f,w,s,su. Radiology of the Musculoskeletal System (1 cr; S-N) Wenger

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

SPEECH PATHOLOGY*

SpPa 8861f,w,s,su. SPEECH PATHOLOGY. (2 cr.; A-F; consent of instructor is required; credits arranged in consultation with instructor) Strand
This is a clinical, independent study course open to medical and dental residents and to postdoctoral fellows, consisting of participation in clinical rounds, observation of clinical diagnosis, and independent study.

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

VIROLOGY AND GENE THERAPY

VGT 5300s. GENE THERAPY LECTURE COURSE. (1 cr; A-F) Russell
After attending this course the student will have gained an appreciation of the broad potential scope of gene therapy and should understand 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 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 5500s. FROM VIRUSES TO VECTORS LECTURE COURSE. (1 cr; A-F) Vile
This course will cover the structure of viruses from which vectors are commonly derived and will describe the modifications made to the wild-type vectors which ensures the production of safe, efficient, targeted vectors for gene therapy.

VGT 5600s. MOLECULAR VIROLOGY LECTURE COURSE. (1 cr; A-F) Cattaneo
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 8740f. VIRUSES AND VECTORS JOURNAL CLUB. (1 cr; A-F) 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 required fall, winter and spring.

VGT 8745f. CURRENT TOPICS IN VIROLOGY AND GENE THERAPY. (1 cr; A-F) Russell
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 required fall, winter and spring.

VGT 8884s. VIRAL DISEASE TUTORIAL. (2 cr; offered odd years; A-F) Poeschla
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. (1) e.g., cytomegalovirus, Ebola, EBV, dengue & yellow fever, hepatitis C, HIV, herpes simplex 1 and 2, influenza, lassa & other arenaviruses, measles and mumps, RSV, papillomaviruses, rhinoviruses, smallpox, viral diagnosis. (2) e.g., avian influenza, Nipah, SARS, Sin Nombre (Hanta) virus, West Nile virus.

VGT 8886s. MOLECULAR VIROLOGY TUTORIAL. (2 cr; offered odd years; A-F) Ikeda
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 8888s. GENE THERAPY TUTORIAL. (2 cr; offered even years; A-F) Dingli
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.

Research

VGT 8890f,w,s,su. RESEARCH IN VIROLOGY AND GENE THERAPY.
(S-N) Staff
Graduate thesis research for Ph.D. students under supervision of staff.

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