# 2019-2020 CWRU SCHOOL OF MEDICINE BULLETIN

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SCHOOL OF MEDICINE

Since its founding in 1843 Case Western Reserve University School of Medicine has been a national leader in health care education, biomedical research, and commitment to its community, creating an intellectually sophisticated, service-oriented culture that enables bold ideas and new ways of thinking to take root and flourish.

Building on a stellar legacy, including praise in the seminal 1910 Flexner Report, today the School of Medicine is consistently ranked among the top-25 medical schools in the United States as well as earning distinction as the #1 medical school and largest biomedical research institution in Ohio. It also regularly places in the top tier of U.S. medical schools for NIH research funding.

Our educational offerings comprise nearly two dozen programs and degree options for prospective students, including the MD degree, the PhD, the joint MD-PhD, numerous MS degrees, and our physician assistant program. All are led by nationally recognized experts in their fields and feature faculties of wide-ranging distinction.

Continuing to steer the conversation in biomedical education, we have opened the doors of a new 485,000 square foot, high-tech Health Education Campus developed in collaboration with the Cleveland Clinic. The facility takes our longstanding emphasis on interprofessional education to the next level by bringing together under one roof medical students from our various programs (described below), CWRU’s School of Dental Medicine, the Frances Payne Bolton School of Nursing, and the Jack, Joseph and Morton Mandel School of Applied Social Sciences, as well as the medical school’s physician assistant program.

EDUCATION

MD Programs

The School of Medicine offers three outstanding programs leading to the MD degree: the University program, Cleveland Clinic Lerner College of Medicine at Case Western Reserve University, known as the College program, and the Medical Scientist Training Program, the nation’s oldest MD-PhD track.

Our students learn and practice in a wide range of clinical settings at some of the best teaching hospitals in the region and country:

- Cleveland Clinic – consistently chosen one of the nation’s best hospitals
- University Hospitals Cleveland Medical Center (including UH Rainbow Babies & Children’s Hospital, and UH Seidman Cancer Center) – one of the nation’s leading academic medical centers
- MetroHealth – a nationwide leader among public hospital systems
- Louis Stokes Cleveland VA Medical Center – one of the U. S.’s largest veterans’ health care facilities

The University Program

The University Program (four-year MD), our largest MD course of study, trains well-rounded physicians by emphasizing four cornerstones: clinical mastery, research and scholarship, leadership, and civic professionalism. It features our innovative Western Reserve2 (WR2) curriculum, which integrates medicine and public health – emphasizing the relationship between health and social and behavioral factors. Learn more about the University Program at https://case.edu/medicine/admissions-programs/md-programs.

Case Inquiry (IQ)

Case Inquiry (IQ), a student-centered learning approach, is a foundation of the WR2 curriculum. Small groups of students join with a faculty facilitator to examine specially chosen medical cases – jointly developing learning objectives and carrying out pertinent reading and research. As with other components of WR2, IQ promotes deep-concept learning, enabling students to gain superb skills and a life-long orientation towards teamwork, professionalism, critical thinking, and wide exposure to primary literature. Learn more about IQ at http://casemed.case.edu/curriculum/education/iq-program.cfm.

Pathways

Our Pathway programs are health care concentrations for medical students seeking to gain extra knowledge in special aspects of health and patient care. Examples include the Jack, Joseph and Morton Mandel Wellness and Preventive Care Pathway, Andrew B. Kaufman World Health Pathway, and pathways in the humanities, health innovation and entrepreneurship, and urban health. Learn more about Pathways at https://case.edu/medicine/admissions-programs/ pathways-programs.

The College Program

The Cleveland Clinic Lerner College of Medicine of Case Western Reserve University (five-year MD), is a research-focused curriculum that prepares students for careers as physician-investigators. Students graduate with an MD with special qualifications in biomedical research. Learn more about the College program at https://portals.clevelandclinic.org/cclcm/.

MD/PhD Program

The Medical Scientist Training Program – our MD/PhD track – develops physician-scientists who will spend most of their time doing research while still caring for patients. Established in 1956, this was the first MD/PhD program in the country, created nearly a decade before the NIH developed the Medical Scientist Training Program to similar training. Learn more about the MD/PhD program at https://case.edu/medicine/admissions-programs/md-phd-program.

Graduate Education

The School of Medicine partners with the Case Western Reserve University School of Graduate Studies to offer many high-quality programs leading to PhD and MS degrees, such as the physician assistant program and master of science in anesthesia, as well as certificates in a number of disciplines and sub-fields in the School of Medicine. Learn more about the medical school’s graduate education offers at https://case.edu/medicine/admissions-programs/graduate-programs.

RESEARCH

The School of Medicine has earned a sterling record of national leadership as a research institution, consistently ranking in the top tier of U. S. medical schools for federal research funding from the National Institutes of Health. A recent Academic Medicine study placed the School in the top 15 medical schools nationally based on the achievements of its graduates. Faculty and trainee research is routinely reported in the top journals of all fields.

Within a wide and interdisciplinary research portfolio, the School has special strengths in the areas of cancer, big data, imaging, regenerative medicine, and brain health. We are home to more than 30 highly regarded research and teaching institutes and centers ranging from the Center for AIDS Research and Center for Global Health and Diseases (http://
case.edu/orgs/cghd) to the Digestive Health Research Institute (https://case.edu/medicine/dhin) and Stem Cell Ethics Center (https://case.edu/medicine/bioethics).

The School is a foundational partner in the Case Comprehensive Cancer Center, which links the cancer research activities of CWRU, Cleveland Clinic, and University Hospitals. Our researchers are supported by eight core facilities such as translational research and clinical trials, computational analysis, and omics and sequencing. We house two highly competitive Specialized Programs of Research Excellence (SPOR) programs – gastrointestinal and cancer disparities – established by the National Cancer Institute. We are the organizing partner for the Cleveland Brain Health Initiative (https://case.edu/medicine/neurosciences/cleveland-brain-health-initiative), which includes all of our hospital affiliates and draws on our internationally recognized brain experts to address brain-based diseases such as stroke and Alzheimer's disease.

Among numerous research-centered awards, we have earned a highly competitive Clinical Translational Service Award in partnership with our hospital affiliates – testimony of our entrepreneurial and team-oriented view of science and scholarship.

On the international setting our Center for Global Health and Diseases focuses on AIDS, tuberculosis, malaria, and other serious medical conditions that threaten world health and quality of life. Our Uganda-CWRU Research Collaboration, began in 1986 to assist with the HIV/AIDS epidemic, has expanded its remit to include building capacity and providing training through research on such topics as epidemiology, clinical trials, nursing, anthropology, bioethics, biomedical engineering, cancer, and cardiovascular disease. Our collaboration with Taipei Medical University includes exchange programs and joint research efforts in the areas of cancer, brain science, biomedical engineering, medical device and drug development, geriatrics, and long-term care.

We also partner with the business community on technology development and transfer, helping our researchers develop ideas, secure funding, and commercialize their technology – in the process transforming Cleveland into an “ideapolis.” A growing number of faculty-founded start-up companies have emerged from this effort – with many more in the pipeline.

COMMITMENT TO COMMUNITY

The School of Medicine demonstrates our commitment to the community in many ways. We have many programs aimed at improving the health of the community, ranging from healthy-eating initiatives to partnered projects to reduce infant mortality. Our Prevention Research Center for Healthy Neighborhoods (https://www.prchn.org) fosters partnerships in Cleveland’s urban neighborhoods to prevent and reduce rates of chronic diseases such as diabetes and cardiovascular problems – including culturally appropriate interventions as well as evaluating and strengthening existing community programs. The Office of Cancer Disparities Research in the Case Comprehensive Cancer Center works to reduce the disproportionate burden of cancer on minority populations by promoting health equity-focused research and outreach. Our Youth Enjoy Science (YES) program brings diversity to cancer research by engaging underrepresented minorities in Cleveland-area schools in cancer investigation and study.

History

Since our founding in 1843 Case Western Reserve University School of Medicine has been widely recognized for innovative, inclusive medical education and pioneering biomedical research.

We were one of the first medical schools in the country to employ instructors devoted to full-time teaching and research. Six of the first seven women to receive medical degrees from accredited American medical schools graduated from Western Reserve College (as it was then called) between 1850 and 1856.

Already a leading educational institution for more than a century, in 1952 the School of Medicine initiated the most advanced medical curriculum in the country, pioneering integrated education, a focus on organ systems, and team teaching in the preclinical curriculum. This curriculum instituted a pass/fail grading system for the first two years of medical school to promote cooperation among students instead of competitiveness, introduced students to clinical work and patients almost as soon as they arrived on campus, and provided free, unscheduled time for our students in an era when doing so seemed unthinkable. Many other medical schools followed suit on all of these fronts, and these components remain at the core of medical school curriculums everywhere.

In 1971 the Health Sciences Center was completed to house the university’s medical, dental, and nursing schools, as well as the Health Center Library. The proximity of these research and educational centers to other university departments, including the sciences, engineering, and social sciences, stimulates creative interaction between researchers and educators. We expand on this emphasis on intellectual cross-fertilization in our brand new Health Education Campus described above.

Another leap in research capabilities came in the early 1990s with the Richard F. Celeste Biomedical Research Building, which added 154,000 square feet of cutting-edge research space. In 2002 the University and Cleveland Clinic entered into an agreement to form the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University, with the first class matriculating in 2004. The subsequent years saw additional new research space added, resulting in a complex of facilities on par with the best anywhere.

As described above, in 2006 the School of Medicine launched Western Reserve2, the latest evolution in our medical school curriculum. That same year we partnered with the Cleveland Municipal School District to create the School of Science and Medicine at John Hay High School, the first such school in the nation. That partnership lives on today in the form of numerous initiatives aimed at exposing Cleveland’s young people to careers in science and healing. Our medical and graduate students play vital roles in these initiatives, including mentoring, teaching, and providing shadowing opportunities. The next historical highlight came in 2007 when Pamela B. Davis was appointed the School’s first woman dean of the medical school.

Curricular advancements continued throughout the next decade. For example, in 2015 CWRU and Cleveland Clinic partnered with Microsoft to develop medical and engineering platforms as part of the new HoloAnatomy curriculum – a revolutionary way of learning the intricacies and cross-connections of the human body and its workings. HoloAnatomy plays a central role in the interprofessional education featured at our Health Education Campus. And our physician assistant program, begun in 2016, is fast becoming a national destination for those interested in this popular field.
A Rich Legacy

Eleven Nobel Prize holders have had ties to Case Western Reserve University School of Medicine:

- John J.R. Macleod, a Physiology Professor, shared the 1923 Nobel Prize in Physiology or Medicine for the discovery of insulin. Dr. Macleod completed much of his groundwork on diabetes in Cleveland.
- Corneille J.F. Heymans, a Visiting Scientist in the Department of Physiology, received the Nobel Prize in Physiology or Medicine in 1938 for work on carotid sinus reflexes.
- Frederick C. Robbins, a Pediatrics and Virology Professor, shared the 1954 Nobel Prize in Physiology or Medicine for his pioneering work on the polio virus, which led to the development of polio vaccines.
- Earl W. Sutherland Jr., Professor of Pharmacology, won the 1971 Nobel Prize in Physiology or Medicine for establishing the identity and importance of cyclic adenosine monophosphate (AMP) in the regulation of cell metabolism.
- Paul Berg, who earned his Biochemistry degree from CWRU, received the 1980 Nobel Prize in Chemistry for groundbreaking research in recombinant DNA technology.
- H. Jack Geiger, an alumnus of the medical school, is a founding member and past President of Physicians for Social Responsibility, which shared the 1985 Nobel Peace Prize as part of the international campaign to ban landmines.
- George H. Hitchings, an Oncology Professor, shared the 1988 Nobel Prize in Physiology or Medicine for pathbreaking research leading to the development of drugs to treat leukemia, organ transplant rejection, gout, herpes virus, and AIDS-related bacterial and pulmonary infections.
- Alfred G. Gilman, a graduate of the medical school, shared the 1994 Nobel Prize in Physiology or Medicine for identifying the role of G proteins in cell communication.
- Ferid Murad, a graduate of the medical school, shared the 1998 Nobel Prize in Physiology or Medicine for novel discoveries concerning nitric oxide as a signaling molecule in the cardiovascular system.
- Paul C. Lauterbur, PhD, a Visiting Professor of Radiology, shared the 2003 Nobel Prize in Chemistry for pioneering work in the development of magnetic resonance imaging.
- Peter C. Agre, who completed a Fellowship in Hematology at CWRU, shared the 2003 Nobel Prize in Chemistry for major discoveries that clarified how salts and water are transported out of and into the cells of the body, leading to a better understanding of diseases of the kidneys, heart, muscles, and nervous system.

Two other distinguished alumni have served as U.S. Surgeon General: Jesse Steinfeld, from 1969 to 1973, and David Satcher, from 1998 to 2002. Dr. Satcher also served as Director of the Centers for Disease Control and Prevention from 1993 to 1998. Another medical school graduate, Julie Gerberding, MD, MPH, followed in his footsteps in 2002 becoming the first woman to be named CDC director.

Administration

Pamela B. Davis, MD, PhD
Dean, School of Medicine, and Senior Vice President for Medical Affairs

Carol L. Moss, MS
Vice Dean for External Affairs, and VP for Medical Development

Sana Loue, PhD, JD
Vice Dean for Faculty Development and Diversity

Patricia Thomas, MD
Vice Dean for Medical Education

Mukesh Jain, MD
Vice Dean for Medical Sciences

Stanton Gerson, MD
Vice Dean for Oncology

Mark Chance, PhD
Vice Dean for Research

Michael W. Konstan, MD
Vice Dean for Translational Research

Lisa M. Mencini, CPA, MBA
Senior Associate Dean, and Chief of Staff

Matthew J. Lester, MBA, MHA
Senior Associate Dean for Finance

Brian Cmolik, MD
Senior Associate Dean for Louis Stokes Cleveland Veterans Affairs Medical Center

Bernard Boulanger, MD
Senior Associate Dean for the MetroHealth System

C. Kent Smith, MD
Senior Associate Dean for Students, and Assistant Dean for Student Societies

J. Harry Isaacson, MD
Executive Dean for Cleveland Clinic Lerner College of Medicine

Lina Mehta, MD
Associate Dean for Admissions

Jeffrey L. Ponsky, MD
Associate Dean for Alumni Affairs

Neil Mehta, MBBS, MS
Associate Dean for Curricular Affairs for Cleveland Clinic Lerner College of Medicine

Amy Wilson-Delfosse, PhD
Associate Dean for Curriculum

Gene H. Barnett, MD
Associate Dean for Faculty Affairs for Cleveland Clinic Lerner College of Medicine

Paul N. MacDonald, PhD
Associate Dean for Graduate Education

Susan Nedorost, MD
Associate Dean for Graduate Medical Education

Marc Kaplan
Associate Dean of Marketing and Strategic Communications

Fabio Cominelli, MD
Associate Dean for Program Development
Outstanding teaching site for all medical students in the School of Medicine. Cleveland Clinic serves as an affiliate hospital of Case Western Reserve University, with the first students matriculating in 2002. In 2004, the university and Cleveland Clinic entered into a landmark agreement to form the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University, with the first students matriculating in 2004. The "College Program" is a program within the Case Western Reserve University School of Medicine. Cleveland Clinic serves as an outstanding teaching site for all medical students in the School of Medicine, in addition to being the site for pre-clerkship education in the College Program.

Cleveland Clinic was founded in 1921 by four Case Western Reserve faculty members, three of whom are counted among the alumni of the Case School of Medicine. Cleveland Clinic’s main campus, where much of the activity associated with the program occurs, is located on 180 acres near the Case Western Reserve campus.

Occupying 44 buildings on 167 acres, Cleveland Clinic main campus includes a hospital, an outpatient clinic, a children’s hospital, specific buildings for cancer, eye, heart and urologic care, a research institute with supporting labs and facilities, and an education institute. To better serve the Cleveland suburbs with quality healthcare, Cleveland Clinic operates 18 family health centers, three health and wellness centers, 10 regional hospitals and numerous urgent care and medical offices. State-of-the-art imaging services are available, and several locations contain pharmacies and outpatient surgery centers.

Cleveland Clinic also has locations in Florida, Nevada, Canada, Abu Dhabi and, beginning in 2020, London.

In 2016, Cleveland Clinic recorded more than 7.14 million outpatient visits and 220,000 hospital admissions. Among them were patients from all 50 states and 185 countries. More than 3,500 physicians and scientists, 11,800 nurses and nearly 2,000 residents and fellows provide high-quality care for patients.

Cleveland Clinic is consistently named as one of the nation’s top hospitals by U.S. News & World Report, and its heart and heart surgery program has been ranked No. 1 by U.S. News since 1995. Learn more about Cleveland Clinic (http://www.clevelandclinic.org).

**Louis Stokes Cleveland Department of Veterans Affairs Medical Center (http://www.cleveland.va.gov)**

The Louis Stokes Cleveland Department of Veterans Affairs Medical Center (VAMC) is a major teaching hospital of the School of Medicine and is an important site for the education of medical students. The Cleveland VAMC also supports more than 100 residency and fellowship training positions in medicine, surgery, and psychiatry and their subspecialties. Most VAMC physicians hold faculty appointments within the School of Medicine. The affiliation is overseen by the Deans Committee, consisting of the dean, department chairpersons from the School of Medicine, and key VAMC officials.

The Cleveland VAMC is a part of the VA Healthcare System of Ohio, linking VA health care facilities in Ohio in an integrated service network. Inpatient care is provided at the Wade Park location and includes medicine, surgery, psychiatry, spinal cord injury, neurology, and rehabilitation medicine as well as a nursing home and a domiciliary. Outpatient care is delivered in primary and specialty care clinics located at Wade Park, Akron, Canton, Cleveland, East Liverpool, Lorain, Mansfield, New Philadelphia, Painesville, Ravenna, Sandusky, Warren, and Youngstown. The medical center serves more than 100,000 individual veterans annually through approximately 11,600 hospital admissions and 1,884,000 outpatient visits.

An active research program includes activities funded through the Department of Veterans Affairs and other governmental and private funding sources. Total funding of approximately $21.5 million annually (from all sources) supports more than 50 principal investigators in a broad range of research endeavors.
MetroHealth System (http://metrohealth.org)
The MetroHealth System is one of the largest, most comprehensive health care providers in Northeast Ohio, caring for people in and around Greater Cleveland for more than 170 years. This academic health care system is committed to the communities it serves by saving lives, restoring health, promoting wellness, and providing outstanding, lifelong care that is accessible to all.

Affiliated with Case Western Reserve University School of Medicine since 1914, MetroHealth is a center for medical research and education, with all active staff physicians holding CWRU faculty appointments. More than 400 primary care and specialty care physicians practice within The MetroHealth System. At the core of the MetroHealth system, is the MetroHealth Medical Center. The system’s main health care provider, research facility, and teaching hospital is also home to the region’s only Level 1 trauma and burn center. However, The MetroHealth System also serves Greater Cleveland with more than a dozen urban and suburban primary and specialty healthcare centers in Cleveland, Strongsville, Westlake, Lakewood, Pepper Pike, and Beachwood.

MetroHealth has received many accolades for its high level of care and the innovation of its physicians. Surgeons at MetroHealth are pioneering new techniques in minimally-invasive surgery for faster recoveries, while its primary care physicians are developing cutting-edge ways to manage common and chronic diseases through the use of electronic medical records and a patient-centered medical home model called Partners in Care. Its maternal-fetal medicine specialists are successfully managing the riskiest of pregnancies and saving the tiniest of lives. In addition, MetroHealth is nationally recognized by the American Heart Association for cardiac and stroke care and the cancer center has earned outstanding achievement awards for the treatment of cancer patients. Every year, MetroHealth provides care to more than 28,000 inpatients and delivers approximately 3,000 newborns. More than 790,000 visits are recorded each year in the medical center’s outpatient centers, and patient visits to the emergency department exceed 99,000.

University Hospitals (http://www.uhhospitals.org)
University Hospitals serves the needs of patients through an integrated network of hospitals, outpatient centers, and primary care physicians. At the core of the health system is University Hospitals Cleveland Medical Center. University Hospitals Cleveland Medical Center is home to some of the most prestigious clinical centers of excellence in the nation and the world, including cancer, pediatrics, women’s health, orthopedics and spine, radiology and radiation oncology, neurosurgery and neuroscience, cardiology and cardiovascular surgery, organ transplantation and human genetics. Its main campus includes the internationally celebrated UH Rainbow Babies & Children’s Hospital, ranked among the top children’s hospitals in the nation; UH MacDonald Women’s Hospital, Ohio’s only hospital for women; and UH Seidman Cancer Center, part of the NCI-designated Case Comprehensive Cancer Center.

Advanced Platform Technology Research Center
216.707.6421
Ronald J. Triolo, PhD, Executive Director
Clay Kelly, MD, Medical Director
https://www.aptcenter.research.va.gov/

The Advanced Platform Technology (APT) Center (https://www.aptcenter.research.va.gov) at the Louis Stokes Cleveland VA Medical Center (LSCVAMC) is one of 13 designated Centers in the Rehabilitation Research and Development Service. The APT Center focuses on serving veterans with sensorimotor dysfunction, cognitive impairment, or limb-loss using cutting edge technologies and rehabilitation techniques, translating them from proof of concept to viable clinical options. Advances in material science, microfabrication and microsystem design, neural engineering, mechanics, and communications are captured and integrated for applications in prosthetics/orthotics, neural interfacing, wireless health monitoring and maintenance and all forms of enabling and emerging technologies. The APT Center is able to provide or facilitate access to the following resources:

- Neural modeling and analysis of interface designs
- Polymer and bioactive material development
- Microelectromechanical (MEMS) systems design and fabrication
- 3-D and laser printing/prototyping, mechanical testing and dynamic simulation
- Pre-clinical in vitro and in vivo verification of device performance
- Circuit, sensor and software design and fabrication
- System validation and design control documentation
- Professional engineering support and project management
- Administrative support for intellectual property protection, regulatory affairs, and quality systems.

The APT Center was established in 2005 as a collaboration between the LSCVAMC and Case Western Reserve University (CWRU). Over 50 Engineers and Clinician Scientists at the LSCVAMC, CWRU, Cleveland Clinic, University Hospitals, Cleveland State University, Kent State University, University of Michigan, and Cornell University are affiliated with the APT Center and contribute to its mission.

Case Comprehensive Cancer Center
216.368.1122
Stanton L. Gerson, MD, Director, Case Comprehensive Cancer Center
http://cancer.case.edu

The Case Comprehensive Cancer Center (Case CCC) (http://cancer.case.edu) based at Case Western Reserve University (CWRU) is a partnership organization supporting cancer-related research efforts at CWRU, University Hospitals Cleveland Medical Center, and Cleveland Clinic. Located in Cleveland, Ohio, the Case CCC serves the cancer research and clinical needs of an urban manufacturing and rural agricultural region containing over 4 million people in Northern Ohio.

The Case CCC provides a unique forum and academic network for cancer researchers across our community to accomplish more than they may individually. Through the Case CCC, our medical institutions are linked in a stronger and more unified effort to understand the causes and progression of cancer and to use that understanding to develop treatments and to reduce the likelihood that our population will develop cancer and suffer from its consequences. The Cancer Center advocates for cancer research support across the institutions; provides funding for promising pilot grants, shared resource development, training programs, and recruitments; and catalyzes multidisciplinary and transdisciplinary
cancer research across institutions, emphasizing innovative discovery that will have an impact on cancer patients.

The mission of the Case CCC is to:

- Improve the prevention, diagnosis and therapy of cancer through discovery, evaluation and dissemination.
- Stimulate and support innovative, coordinated interdisciplinary clinical research on cancer diagnosis, treatment, prevention and control.
- Develop clinical applications of discovery and make these available to Northern Ohio residents as quickly as possible through the integrated efforts of the major health systems in the region.
- Develop cancer prevention and control activities that build on the expertise of the Center and result in a reduction of cancer morbidity and mortality in Northern Ohio and the nation.

The research efforts of the Case CCC members are organized into seven interdisciplinary scientific programs. The clinical research effort is supported by 12 Clinical Trials Disease Teams that develop and prioritize clinical trials, and a single Protocol Review and Monitoring System, Data Safety and Monitoring Plan integrate cancer research, cancer therapeutics, and prevention services at the partner institutions and throughout the region.

Research programs of the Case CCC are also extending into community medical centers operated by University Hospitals and Cleveland Clinic. Outreach programs for clinical practice-based prevention and screening initiatives, educational programs, minority recruitment, and facilitation of patient referrals are also supported by the partner institutions.

In addition to successfully competing for a Cancer Center Support Grant from the National Cancer Institute, the Center must meet specific criteria for:

- Breadth and depth of basic cancer research; clinical cancer research; and prevention, control and population/behavioral sciences research in cancer; and
- Strength of interaction among these three major research areas.

The Case Comprehensive Cancer Center is one of only 50 NCI-designated Comprehensive Cancer Centers in the nation. Learn more about the National Cancer Institute’s Cancer Centers program at cancercenters.cancer.gov (http://cancercenters.cancer.gov).

**Case Cardiovascular Center**

216.368.5678
Sanjay Rajagopalan, MD, Director, Case Cardiovascular Research Institute
Aaron Proweller, MD, Associate Director, Case Cardiovascular Research Institute

https://case.edu/medicine/cvri/

The Case Cardiovascular Center (http://www.case.edu/cvri) was established in 2006 with the central mission to develop premier clinical, research, and education programs in heart and vascular disease. The structure of the Center includes clinical (University Hospitals Harrington-McLaughlin Heart & Vascular Institute—UH-HMHVI) and research (Case Cardiovascular Research Institute—CVRI) arms.

The UH-HMHVI (http://www.uhhospitals.org/services/heart-and-vascular/institute) is a multi-disciplinary team of nearly 60 full-time faculty members dedicated to (a) the prevention, diagnosis, and treatment of heart and vascular disease to both local and regional patient populations in Northeast Ohio, (b) the education and training of medical students, residents and fellows, and (c) the development of breakthrough medical advancements and practices to deliver superior clinical outcomes. These clinical services range from primary to quaternary levels of expertise and are provided at all the health are facilities within the University Hospitals healthcare system. The clinical programs are organized into 11 program centers that comprise the Institute.

The research activities of the CCC are focused on the development of premier research programs that span the full spectrum of activities from basic bench-side research to translational research (“first-in-man”) and clinical trials. The CVRI is focused on basic and translational studies. The Research & Innovation Center (RIC) of the UH-HMHVI is dedicated to innovative clinical trials and applied technology. The major areas of research focus in the CVRI include cardiovascular biology, mechanisms of gene regulation, innate immunity & inflammation, and stem cell & regenerative medicine. Investigators in the CVRI have full access to two laboratories for in vivo research in small and large animals. The RIC oversees all clinical research activities within cardiovascular medicine and surgery and is supported by a lead administrator along with nurse coordinators and staff to facilitate patient enrollment as well as regulatory/grant activities. Active areas of clinical research include interventional cardiology, vascular medicine, heart failure, electrophysiology, preventive cardiology& rehabilitative medicine, and cardiovascular imaging.

**Case Center for Imaging Research (CCIR)**

216.983.3264
James Basilion, PhD, Director - CCIR
Chris Flask, PhD, Director - Imaging Research Core

The CCIR (https://case.edu/medicine/ccir) is a joint venture between Case Western Reserve University School of Medicine and University Hospitals Cleveland Medical Center. The CCIR, through its numerous faculty members and state-of-the-art clinical and preclinical imaging capabilities, promotes interdisciplinary and translational imaging research. As the imaging research program at CWRU continues to grow, we strive to make the CCIR imaging capabilities available to the broader research community. This overriding goal has led to a strong collaborative relationship between the CCIR imaging faculty and both basic and clinical researchers in many disciplines.

Within the CCIR, the Imaging Research Core provides facilities for both preclinical and clinical imaging studies. The Imaging Research Core serves as a shared resource for CWRU’s Cystic Fibrosis Center, the Case Comprehensive Cancer Center, the Clinical and Translational Science Collaborative (CTSC), the Cleveland Digestive Diseases Research Cores Center, and the SMART Center in the School of Nursing. The preclinical facility includes two high-resolution MRI scanners, a microPET/CT scanner, an ultrasound scanner, an X-ray scanner, and three bioluminescence and fluorescence systems. Magnetic relaxometers are also available for high throughput screening of developmental MRI contrast agents. In addition, a novel cryo-imaging imaging system provides high resolution, 3D optical imaging capabilities. The Core also provides support for quantitative analysis of all imaging data.

A human 3T MRI scanner and an ultrasound scanner are also available through the Core for clinical research studies. Other clinical imaging options are also available within the Department of Radiology. The creation of a new radiopharmaceutical facility within the CCIR, together with our existing cyclotron and radioisotope delivery system, now provide
the capacity to conduct a variety of molecular PET imaging studies from preclinical animal studies all the way to routine clinical studies.

**Case Center for Synchrotron Biosciences**

216.368.4406
Mark Chance, PhD, Director
https://case.edu/medicine/(csrb/)

Many of the advances in structural molecular biology and related biosciences are the result of the rapidly occurring developments at synchrotrons. These include X-ray crystallography for protein structure determination, X-ray spectroscopy for examination of metalloprotein structure, and synchrotron footprinting technologies for examining macromolecular structure and dynamics. The Case Western Reserve University School of Medicine (http://casemed.case.edu) established the Case Center for Proteomics and Bioinformatics (https://case.edu/medicine/nutrition/case-center-proteomics-and-bioinformatics) for expanding the state-of-the-art in proteomics research. This center provides administrative oversight for the Case Center for Synchrotron Biosciences (CSB) which is funded by the National Institute of Biomedical Imaging and Bioengineering (NIBIB) (http://www.nibib.nih.gov) as a Biotechnology Research Resource to serve an international community of biomedical scientists. The CSB is catalyzing further development and application of synchrotron radiation tools through a number of multidisciplinary collaborations and partnerships. The research facility is located at the National Synchrotron Light Source II (NSLS-II) (https://www.bnl.gov/ps) at Brookhaven National Laboratory (BNL) (https://www.bnl.gov/world) in New York. NSLS-II, as a Department of Energy funded facility, has as a mission to provide academic institutions access to synchrotron light through various general user, collaboration, and consortium arrangements.

**The Center for AIDS Research**

216.368.0271
Jonathan Karn, PhD, Director
Michael Lederman, MD, Associate Director

Since its founding in 1994, the Case Western Reserve University/ University Hospitals Center for AIDS Research (CWRU CFAR (http://casemed.case.edu/cfar)) has been a center of excellence for both clinical and basic science AIDS research. Investigators participating in the CWRU CFAR draw on resources from the Case Western Reserve University School of Medicine, University Hospitals Cleveland Medical Center, MetroHealth Medical Center, the Cleveland Clinic Foundation and the Joint Clinical Research Center in Kampala Uganda. As one of only 19 CFARs nationally, the CFAR plays an important role in ensuring that cutting-edge AIDS research and well-received community outreach is supported in our region of the country. Major strengths in the CWRU CFAR include international research, especially with respect to research in tuberculosis and HIV malignancy, microbiodes, pathogenesis, virology, clinical trials, and training, at the national and international levels. As the first CFAR to make a major investment in international research, we have been able to expand a highly productive and long-standing scientific relationship with Makerere University, Kampala.

The CWRU CFAR shares and supports the mission of the National CFAR program to support a multi-disciplinary environment that promotes basic, clinical, epidemiologic, behavioral, and translational research in the prevention, detection, and treatment of HIV infection and AIDS. The CWRU CFAR provides: Leadership and strategic planning that promotes and supports outstanding HIV/AIDS research at our participating institutions, a vibrant series of seminars and meetings regularly bringing leaders in HIV research to our campus, laboratory cores with expertise, state-of-the-art instrumentation and technologies; pilot grant awards and mentoring to develop junior faculty interested in HIV, educational and training efforts which encompass the whole range of contemporary HIV/ AIDS research; community outreach programs, and the promotion of and participation in collaborative research efforts within the national CFAR network and in Uganda.

**Center for Antimicrobial Resistance and Epidemiology**

216.791.3800, ext. 4788
Louis Stokes Cleveland Department of Veterans Affairs Medical Center (VAMC)
Robert A. Bonomo (robert.bonomo@va.gov), MD Chief, Medical Service

As antibiotic resistance has become a national and global public-health problem, top academic centers are preparing to launch ambitious programs addressing research on the basic, translational and clinical aspects of antibiotic resistance. The CWRU-Cleveland VAMC Center for Antimicrobial Resistance and Epidemiology (Case VA CARES) aims to translate research findings into clinically useful tools for the diagnosis and treatment of patients infected with multidrug-resistant (MOR) Gram-negative organisms and mycobacteria. The center’s long term goals are: 1) to continue and expand this dynamic research program directed at understanding the mechanistic bases of resistance in order to develop innovative clinical and therapeutic approaches to deal with MOR organisms; 2) to develop a strong clinical research program of translational medicine on antibiotic resistance; 3) to incorporate drug discovery, whole genomic sequencing and other rapid diagnostic technologies into the management of patients infected with MOR organisms and mycobacterial pathogens, including tracking of outbreaks and molecular epidemiology of these organisms; 4) to enhance educational activities of trainees in aspects related to antibiotic resistance; and 5) work with existing services available at the School of Medicine, University Hospitals, and the Clinical and Translational Science Collaborative to disseminate research and educational activities both nationally and internationally.

**The Center for Child Health and Policy at Rainbow Babies & Children’s Hospital**

216.844.6253
Ann Nevar, MPA, Manager

Established in 2007, the Center for Child Health and Policy at Rainbow (http://www.uhospitals.org/rainbow/for-clinicians/child-health-policy) focuses on major health policy issues that are central to the well-being of children and youth. The Center recognizes that health policy forms a framework for all health care delivery and that health policy is therefore essential to improving children’s health. In this way, the Center focuses on the nexus between policy and practice of pediatric medicine.

The Center fills the need to amalgamate expertise in pediatric medicine and research with expertise in health policy. Operating as a think tank, the Center brings together experts in child health, health finance, law and policy to perform policy analyses, consultations, research, educational programming, and community outreach to advance child health through policy. Work is focused on several areas including: Maternal/Fetal/ Newborn Health; Chronic Illness; Quality; and Care Delivery Systems. The Center is the only program devoted to child health policy in Cleveland and one of few nationwide.
To date, the Center has accrued many products and achievements including: Ohio Health Policy Researcher of the Year in 2006; Ohio Health Policy Researcher of the Year for Independent Research in 2009; programs designated Centers of Excellence; multiple white papers, reports, and peer-reviewed publications; grants and awards from the National Institutes of Health, The Centers for Disease Control and Prevention, the Ohio Department of Health, the Ohio Department of Job and Family Services, and numerous foundations; and invited/elected memberships in state and national policy committees.

Center for Clinical Investigation
216.368.3286
James Spilsbury, PhD, Academic Development Core Director

The Center for Clinical Investigation (CCI) was founded in 2007 and is part of Case Western Reserve University School of Medicine's Division of General Medical Sciences. The CCI serves as the academic home of Cleveland's Clinical & Translational Science Collaborative, a partnership of 4 local institutions (Case Western Reserve University, the Cleveland Clinic Foundation, the MetroHealth System, and University Hospitals) and member of a national consortium of approximately 66 institutions funded by the National Institutes of Health to increase the efficiency and speed of clinical and translational research across the country.

The CCI's mission is to enhance clinical and translational research efforts across the Cleveland area by: (1) spurring advances in knowledge of risk factors, outcomes and treatment effectiveness in the population; (2) facilitating the transfer of scientific advances to the community; and (3) developing a new generation of clinical researchers equipped with the skills needed to efficiently design, implement and interpret novel studies that address important public health questions. To accomplish its mission, the CCI provides computer systems and applications support for basic science and clinical research activities and works closely with basic science and clinical investigators in the CWRU Schools of Medicine, Nursing, and Dental Medicine, as well as the University Hospitals Case Medical Center, Cleveland Clinic, and MetroHealth System. The CCI has supported hundreds of clinical research and epidemiology projects, including local and national multicenter, longitudinal studies. The CCI has two cores that provide research support to all investigators: the Academic Development Core and Statistical Sciences Core.

The Academic Development Core manages the newly created PhD Program in Clinical Translational Science, the Master's Degree Program in Clinical Research (Clinical Research Scholars Program - see "Clinical Research MS" tab above), and the Graduate Certificate Program in Clinical Research. The Academic Development Core also delivers seminars and short courses in clinical research and works to coordinate educational activities in interdisciplinary clinical research across the CTSC's institutional members. The programs target investigators and other key members of the research team, including data managers and study coordinators. Training efforts in research design, research data management, statistical sciences, statistical software, and scientific communication are emphasized.

The Statistical Sciences Core provides data management and statistical support for study design and data analysis. Members who provide data management consist of skilled data managers and programmers who consult and collaborate with investigators on data collection instrument development and coding, database development and administration, data cleaning and quality assurance, statistical programming, and dataset preparation. Members providing statistical support collaborate and consult with clinical investigators on proposal development, study design, study monitoring, and data analysis. "The Statistical Sciences Core currently consists of 1 PhD biostatistician and 1 MS biostatistician. Statistical software packages that are supported by the CCI Statistical Sciences Core include SAS, SPSS, R/S-Plus, NCSS PASS and Minitab. In addition, the Statistical Science core serves as a gateway for connecting investigators with the broad expertise available through the biostatistics faculty in the Department of Population and Quantitative Health Sciences.

Center for Community Health Integration
https://case.edu/medicine/healthintegration/
CHI-Information@case.edu (CHI-Information@case.edu/)
Kurt C. Stange, MD, PhD, Director

The Center for Community Health Integration (CHI) (https://case.edu/medicine/healthintegration) conducts collaborative research and development to advance community health and integrated, personalized health care. We work with colleagues across multiple levels of a complex system to develop a shared understanding of the effects of social, environmental, and human systems, and to use that understanding to improve the health of individuals, vulnerable populations, and communities.

Building on three decades of work with partners in Cleveland and around the world, this new center is in an early phase of making and reinforcing connections that challenge problems often perceived as intractable. We are investing in relationships, analytical capacity, and novel ideas. We welcome conversations to explore collaborative opportunities.

Center for Global Health and Diseases
216.368.4818
http://www.case.edu/orgs/cghd/
James W. Kazura, MD, Director

The Center for Global Health and Diseases links the numerous international health resources of the University, its affiliated institutions, and the northern Ohio community in transdisciplinary programs of research and education related to global health. The scope of the Center’s activities also includes education and service as these are related to molecular, clinical and population studies of human health and disease.

The Center is currently a national leader in National Institutes of Health-supported studies of the major infectious diseases of developing countries. Cutting-edge approaches are implemented in order to examine the molecular, genetic and immunologic basis of susceptibility to infectious diseases of public health significance - malaria, river blindness, lymphatic filariasis, schistosomiasis, HIV and other viral diseases such as Rift Valley fever. Clinical research in endemic countries is concerned with testing and implementing cost-effective public health interventions that are aimed at the control of malaria and Neglected Tropical Diseases (worm infections of children, elimination of lymphatic filariasis). The Center has ongoing research and educational collaborations with academic and governmental institutions in Papua New Guinea, Brazil, Kenya, Uganda, and several other countries in Sub-Saharan Africa. Educational programs sponsored by the Center include electives in international health, population biology, and genetics of infectious diseases (available to undergraduate, graduate and professional school students), a weekly World Health Interest Group (WHIG) seminar series, overseas rotations for graduate and professional school students, and training programs at the university and abroad for scholars from...
developing countries (with support from the Fogarty International Center at NIH).

A certificate in Global Health is available (see Certificates).

**Center for Health Care Research & Policy**
216.778.3902
Randall D. Cebul, MD, Director

The mission of the Center for Health Care Research & Policy (http://www.chrp.org) is to: 1) improve the health of the public by conducting research that improves access to health care, increases the quality and value of healthcare services, and informs health policy and practice; and 2) lead education and training programs that promote these goals. Formally established in 1994, the Center's mission is carried out by a cross-disciplinary faculty who both lead and collaborate with other scholars in Northeast Ohio and beyond. A core faculty of 17 is extended by affiliated Senior Scholars throughout the university, assisted by an able staff and over 30 grant-supported research associates. The Center's home at MetroHealth's Rammelkamp Research and Education Building is an outstanding venue for collaborative research, mentoring of students and junior faculty, and cross-disciplinary seminars.

The Center's research and training focus in programmatic areas that reflect national health care priorities as well as high impact problems in adults. Center Programs pertain to chronic conditions, especially stroke, obesity and diabetes, and kidney disease. Programs are supported by methods units, including biostatistics and evaluation, health care decision making, and health economics and health policy. Research using clinical informatics capitalizes on growing institutional capacities in electronic medical records (EMR) and clinical decision support. Center faculty view Northeast Ohio as a laboratory for research, recognizing the national relevance of regional challenges and opportunities. For over four years, the Center has served as the administrative home for Better Health Greater Cleveland, an EMR-catalyzed initiative to measure, publicly report, and improve health outcomes for the region's residents with chronic medical problems. Center faculty also assume leadership roles in federally-supported degree programs in Health Services Research and Clinical Investigation and teach in the core curriculum of the School of Medicine.

**Center for Medical Education**
216.368.1948
Patricia A. Thomas, MD, FACP, Director
Klara Papp, PhD, Director, CAML

The Center for Medical Education, established in 2010, provides an organizational home for teaching and learning programs in the School of Medicine and a supportive environment for those who want to develop special skills in medical education.

The Center also sponsors faculty appointments, both full- and part-time, for faculty whose roles are predominantly focused on teaching medical students and physician assistant students. These include community clinicians who welcome medical students into their clinics and practices.

The Center for the Advancement of Medical Learning (https://case.edu/medicine/caml) ("CAML") operates its programs under the auspices of the CMEd. CAML supports and promotes the development of teaching and lifelong-learning skills among students, faculty, staff, residents, and alumni. CAML pursues research into educational innovations to advance our knowledge of medical learning and teaching. The Center offers workshops to faculty locally, regionally, and nationally to enhance faculty teaching, research and evaluation skills.

**Center for Proteomics and Bioinformatics**
216.368.0291
http://proteomics.case.edu/index.html
Biomedical Research Building, Ninth Floor
Mark R. Chance, PhD, Director

The Case Center for Proteomics and Bioinformatics was created, in part, to strengthen Cleveland's presence in modern proteomics and bioinformatics research to make the region a leader in the field. The vision for the Center has been shaped over the past several years by the leadership of the Center's Director, Mark Chance, PhD, with over $120 million in grants awarded to the Center and its collaborators since its inception in February 2006. One of the primary goals of the CPB is to develop an infrastructure of sophisticated equipment that facilitates and maximizes shared equipment usage, as well as to offer a wide array of proteomics, and metabolomic services including protein and small molecule mass spectrometry, protein expression/interactions, systems biology, and biostatistical analyses.

The CPB has expanded its vision to include education of graduate students in systems biology and bioinformatics. The Center for Proteomics and Bioinformatics developed a graduate program in Systems Biology and Bioinformatics in collaboration with Schools and Departments across the campus. For more information regarding the SYBB graduate program please see "Systems/Bioinformatics” tab above. You may also visit http://bioinformatics.case.edu/.

In studying proteins and metabolites, bioinformatics analysis enables researchers to take an integrated pan-omics approach for discovering networks involved in human disease. The School of Medicine has established the Center for Proteomics and Bioinformatics to perform research to better understand the genetic and environmental bases of disease as well as provide new technologies to diagnose diseases such as cancer, heart disease, and diabetes. Utilizing bioinformatics enables researchers to take an integrated-omics approach for discovering networks involved in human disease.

New technologies in mass spectrometry are also allowing protein expression, localization, structure, post-translational modifications, and interactions to be studied in increasing detail and on a genome-wide scale. The Center is also developing and applying state-of-the-art-structural proteomics technology, metabolomic and small molecule analysis, especially for pharmacokinetic (PK) studies to support clinical, translational, and structural research.

The CPB has three major research areas: Proteomics and Bioinformatics, Metabolomics, and Macromolecular Structure.

**Proteomics and Bioinformatics** faculty and staff support research in protein expression analysis, protein modifications, and protein interactions in a wide variety of biological contexts as well as develops new bioinformatics tools in Proteomics research. This includes multiple Proteomics Cores to support these activities.

**Metabolomics** faculty and staff support metabolite small molecule quantification research in the CWRU community. The services provided range from drug PK studies to quantification of endogenous metabolites in clinical and preclinical samples.
Macromolecular Structure faculty and staff support interdisciplinary research in new methods of structure determination, the combination of computational and experimental structural biology approaches and developing and maintaining the infrastructure for macromolecular structure determination.

The CPB also offers a wide range of seminars, workshops, and possibilities for individual training. These activities are posted on the CPB Web site. For a list of services and to explore opportunities to collaborate, please visit the Web site: https://case.edu/medicine/nutrition/case-center-proteomics-and-bioinformatics

**Center for Psychoanalytic Child Development**

Kimberly Bell, PhD; John A. Hadden Jr. Assistant Professor of Psychoanalytic Child Development
Email: kmb207@case.edu
216.991.4472

The Center for Psychoanalytic Child Development was established in 2001 in memorial to John A. Hadden Jr., past President of the Board of Trustees of the Cleveland Center for Research in Child Development and of the Hanna Perkins School. The mission of the center is to advance the science of psychoanalytic child development at the School of Medicine.

The Center offers medical students and residents who are interested in working with children the opportunity for observational learning in the Hanna Perkins school. In addition, didactic courses, case conferences, and supervision are available to deepen students’ understanding of the relationship between physical and psychological development in the first 5 years of life.

**The Center for RNA Science and Therapeutics**

216.368.0299
http://www.case.edu/med/rncenter/home.htm
Jeffery M. Collier, PhD, Director

The Center for RNA Science and Therapeutics is a free-standing academic unit in the basic sciences within the School of Medicine at Case Western Reserve University. The RNA Center was established in the mid-nineties as a core entity in recognition of the strong cadre of research laboratories devoted to studying post-transcriptional mechanisms of gene expression focusing on various aspects of RNA Biology. The current mission of the RNA Center is to parlay the strengths of RNA Center scientists towards the development of unique therapeutic initiatives. The RNA Center is combining the usage of nanoparticle technology with RNA science to develop new classes of drugs, leading towards the amelioration of a variety of diseases. Current efforts are focused on metabolic disorders, cancer immunotherapies, immunity, and protein replacement. In addition, we are developing new technologies that promise to improve diagnostics, allowing for earlier detection of a variety of human diseases, especially cancer.

The RNA Center contains one of the largest concentrations of RNA scientists in the nation. The faculty of the RNA Center cover nearly every aspect of RNA research. Current research in the Center focuses on several problems ranging from extremely basic questions such as the mechanism of RNA catalysis and how proteins interact with RNA to the roles of RNA processing in disease. Specific research interests include splicing and its regulation, RNA editing, tRNA maturation, mechanisms of translation regulation, RNA degradation, RNA trafficking, RNA interference and regulation of gene expression by microRNAs and non-coding RNAs.

Collectively, the RNA Center provides a valuable resource for collaborative efforts within the University and its affiliated institutions: the Cleveland Clinic Foundation, MetroHealth Medical Center, the Cleveland VA Medical Center, and University Hospitals Cleveland Medical Center. In addition, the official journal of the RNA Society “RNA” was founded and continues to be housed in the RNA Center. The members of the RNA Center have an excellent funding record and the research performed is regularly published in highly visible journals such as Science, Nature, Molecular Cell, NSMB, Molecular Cell, etc.

**Center for Science, Health and Society**

216.368.2059
http://casemed.case.edu/cshs/
Nathan A. Berger, MD, Director

Recognizing that the successful futures of Case Western Reserve University, the City of Cleveland, and Cuyahoga County are integrally related, the Center for Science, Health and Society (C SHS) was created in 2002 to focus the efforts of the University and the community in a significant new collaboration to impact the areas of health and healthcare delivery systems through community outreach, education, and health policy. The Center, based in the School of Medicine, with university-wide associations, is engaging the many strengths of the University and the community to improve the health of the community.

The Center has engaged the community at the level of the individual and the neighborhood, in public and private schools, at civic and faith-based organizations, and at the level of governmental agencies and community leadership to identify community problems, perceptions, assets, and resources; advise the community of faculty skills, assets and expertise; and, catalyze that community service based scholarship that benefits community interests and promotes mutual enhancement. The Center coordinates the Scientific Enrichment Opportunity outreach program that brings Cleveland high school students on to the medical school campus in the summer to work along with our distinguished faculty in their research labs, to introduce and stimulate the students and help prepare them to enter careers in the health care professions and biomedical workforce. The Center also coordinates the Mini Medical School Program presented every Spring and Fall to educate the community about the latest developments in healthcare, particularly those developed at CWRU. The overall goal of these programs is to educate and empower the community to become better consumers of healthcare and more informed and stronger advocates for healthcare policy and legislation in their own interests.

**Center for the Study of Kidney Biology and Disease**

John R. Sedor, MD, Director
Thomas H. Hostetter, MD, Co-director
Jeffrey Garvin, MD, PhD, Co-director
Jeffrey Schelling, MD, Co-director

Chronic Kidney Disease (CKD) is a growing public health problem in the United States. More than seventeen percent of US adults—more than 40 million Americans—have CKD. CKD generally progresses over time and can cause cardiovascular disease, anemia, bone disease, fluid overload, and eventually end-stage kidney disease (ESKD). Patients with...
ESKD need renal replacement therapy, either from dialysis or a kidney transplant, to live. The risk of death for patients receiving dialysis is nearly eight times higher than the non-ESRD population, leading to a 20% annual probability of death. Kidney disease disproportionately affects minorities and vulnerable populations. Kidney disease treatment is expensive and uniquely tied to federal expenditures through the Medicare entitlement program. The cost of care for ~550,000 ESKD patients is nearly $34 billion annually, exceeding the total NIH budget. Treating all health conditions of CKD and ESRD patients consumes nearly 25% of the Medicare's budget.

The Center's mission is to accelerate discovery and its translation for treatment and care of kidney diseases in an interdisciplinary environment within the rich, research environment of the CWRU School of Medicine. The faculty is an accomplished and highly interactive group of investigators, based in the adult or pediatric Divisions of Nephrology in CWRU-affiliated hospitals (Cleveland Clinic, MetroHealth, Stokes VAMC, University Hospitals) as well as other clinical and basic science departments at the School of Medicine and Lerner Research Institute. Research interests of the faculty include digital pathology image analysis using machine learning tools, glomerular diseases, diabetic and other chronic kidney diseases, epithelial cell biology and ion transport, tubular physiology, genetic epidemiology, health services research, renal transplantation, health disparities research and clinical trials. Center faculty are members of the NIDDK-funded Kidney Precision Medicine Project and the APOLLO, NEPTUNE and CureGN consortia, all of which use “omics” tools to generate deep molecular phenotypes for discovery of new treatment targets and biomarkers. Research projects use cellular, molecular biological, computational, genetic, genomic and epidemiological methods to study in vitro and animal models and/or patients. Projects by Center investigators use health data, culled from electronic health records, and biological samples from patients with kidney diseases in order to generate novel hypotheses, which can then tested with animal models and cell lines. Training opportunities are available for undergraduate, pre- and post-doctoral students.

Cleveland Functional Electrical Stimulation (FES) Center
216.231.3257
Robert F. Kirsch, PhD, Executive Director
Robert Ruff, MD, PhD, Medical Director

The Cleveland Functional Electrical Stimulation (FES) Center (http://fescenter.org) is a consortium of three nationally recognized institutions: Department of Veterans Affairs, MetroHealth Medical Center, and Case Western Reserve University. Through the support of these partners, the Cleveland FES Center is able to provide a continuum of advancement. Created in 1991 with a grant from the Department of Veterans Affairs, the FES Center currently has research funding at the federal, state and local levels and additional industry and foundation funding in excess of $17M in order to achieve its mission.

The Center focuses on the application of electrical currents to either generate or suppress activity in the nervous system. This technique is known as functional electrical stimulation (FES). FES can produce and control the movement of otherwise paralyzed limbs for standing and hand grasp, activate visceral bodily functions such as bladder control or respiration, create perceptions such as skin sensibility, arrest undesired activity such as pain or spasm, and facilitate natural recovery and accelerate motor relearning.

Founded to introduce FES into clinical practice, the Center provides innovative options for restoring neurological health and function by developing advanced technologies and integrating them into clinical care.

Institute for Transformative Molecular Medicine
216.368.5725
Jonathan S. Stamler, MD, Director

The Institute for Transformative Molecular Medicine (ITMM), which operates under the combined aegis of Case Western Reserve University and University Hospitals, is composed of physician-scientists and basic discovery researchers who work to acquire fundamental scientific knowledge within the field of molecular medicine. Founded in 2010, the ITMM provides physician-scientists with the opportunity for professional advancement based on their contributions to life sciences, protected from demanding clinical schedules or administrative responsibilities. The mission of the ITMM is to foster the unrestricted pursuit of new knowledge that can be cultivated as the basis for therapeutic innovation and to inspire new generations of physician-scientists.

The operation of the ITMM is based on a new model that unites academic medical centers, physician- and discovery-scientists and commercial partners to maximize the conversion of basic science discoveries into novel, high-value therapeutics. Thus, the ITMM facilitates connectivity between medical disciplines and the basic research community in order to catalyze fundamental discovery and its transformation into therapies that benefit humankind. Creativity and innovation are highly valued in the culture fostered by the ITMM. Expertise in interdisciplinary science is prioritized, including signal transduction, receptor biology, regenerative medicine, RNA biology and chemical biology, in the pursuit of cutting-edge advances that can impact human disease.

The Mt. Sinai Skills and Simulation Center
216.368.0064
Ellen Luebbers, MD, Interim Medical Director

The Mt. Sinai Skills and Simulation Center (MSSSC) (http://casemed.case.edu/simcenter) was initially conceived in response to common concerns over the nationwide increased incidence of medical errors, the rising costs of healthcare, and the need for improved patient-caregiver communication. Since its founding in 2006, the MSSSC continues to work with an ever-expanding list of healthcare partners to become an integral resource for the education of healthcare students and professionals in the Northeastern Ohio region and throughout Ohio.

Simulation develops confident practitioners who can significantly contribute to the goal of improved patient outcomes. By providing a variety of simulation tools, such as life-like computerized manikins and standardized professionals performing within carefully crafted scenarios, we can replicate the complex environment of the clinical setting. Participation in these specially designed scenarios allows learners to practice the critical skills needed to provide safe, quality care to patients, including communication, technique development, decision making and data analysis. These models have allowed us to have ongoing research projects in education development and intervention and advanced our partnership for the development of new techniques and materials.

The MSSSC has all the tools available for simulation training, including Standardized patients – individuals trained to portray situations or conditions; Task trainers – devices used to teach individual techniques; High fidelity trainers – manikins with programming...
capabilities; Virtual reality — real-life interactive trainers for surgery, cardiology and other disciplines; and Hybrid combinations of the above.

During the past five years, the Center has provided educational opportunities and course for learners at all levels from high school students, medical, physician assistant, dental and nursing students at Case Western Reserve University and The Lerner College of Medicine, residents and fellows from training programs at University Hospitals Case Medical Center, The Cleveland Clinic and VA Medical Center, graduate education for practicing physicians and surgeons, nursing and other healthcare providers at all levels.

**National Center for Regenerative Medicine**

216.368.3614  
http://ncrm.us  
Stanton L. Gerson, MD, Director  
Jeremy Rich, MD, PhD, Co-Director  
Mariesa Malinowski, Executive Director

The Center for Regenerative Medicine (http://ncrm.us) is a multi-institutional center composed of investigators from Case Western Reserve University, University Hospitals Case Medical Center, the Cleveland Clinic, Athersys, Inc., and The Ohio State University. Building on over 30 years of experience in adult stem cell research in northeast Ohio, the Center was created in 2003 with a $19.4 million award from the State of Ohio as a Wright Center of Innovation. An additional $8M award in 2006 from the State of Ohio's Biomedical Research and Commercialization Program (BRCP) was successfully completed and enabled 3 new clinical trials to enroll patients. In 2009, $5M was awarded by the Ohio Third Frontier (OTF) Research Commercialization Program (RCP) which further validated the Center’s ability to achieve its mission to utilize human stem cell and tissue engineering technologies to treat human disease. In 2010, $1M was awarded to the NCRM by the OTF Biomedical Program (OTFBP) to advance the clinical treatment of spinal cord injury, and a $2.1M OTF Wright Program Project (WPP) award was made to create a consortium of quantitative analysis imaging systems for stem cells.

**Neural Engineering Center**

216.368.3978  
Dominique M. Durand, PhD, Director  
Kenneth Gustafson, PhD, Associate Director

The Neural Engineering Center (NEC) (http://www.case.edu/cse/nec) is a coordinated group of scientists and engineers dedicated to research and education in an area at the interface between neuroscience and engineering. They share the common goal of analyzing the function of the nervous system, developing methods to restore damaged neurological function, and creating artificial neuronal systems by integrating physical, chemical, mathematical, biological and engineering tools.

The center was started in 2001 and replaced the Applied Neural Control Laboratory (ANCL) started in 1972. The center offers breadth and depth in Neural Engineering research and education in a highly ranked biomedical engineering department and medical school. The center is located on the campus of Case Western Reserve University and its members collaborate with four major hospitals in the Cleveland area.

The center provides core facilities in tissue culture, microscopy and histology. The center facilities also include an electrode fabrication laboratory, surgical suite for acute and sterile surgery, staffed by two full-time animal technicians. The center also holds several laboratories in neural regeneration, neural interfacing, neural prosthetics, materials for neural interfacing computer modeling and in-vitro electromyobiology. The students, research associates, and faculty can carry out research at many levels starting from cellular and molecular to animal experimentation and into the clinic. Many other facilities such as electronic design, microfabrication, and rapid prototyping are also available in collaboration with other closely related centers, the Functional Stimulation Center (FES) and the Advanced Platform development Laboratory (APT). Center members work closely with the partner hospitals and the technology transfer office of CWRU for translation and clinical implementation of solutions restore neural function such as development of electrodes for communication with the nervous system, regenerating neural tissue, restoring function in paralyzed patients, preventing seizures, motor disorders, incontinence aspiration or obstructive sleep apnea.

The center provides financial support for students through research and training grants. The graduates of this program have made significant contributions to the development and the growth of this fast-growing area of neural engineering in academic, industrial and federal institutions.

**Prevention Research Center for Healthy Neighborhoods**

216.368.1918  
Elaine A. Borawski, PhD, Director

The Prevention Research Center for Healthy Neighborhoods (PRCHN) (http://casemed.case.edu/ctsc/community/prevention.cfm) at Case Western Reserve University was established in 2009 with funding from the Centers for Disease Control and Prevention (CDC). Built upon the foundation of two previous centers that merged to become the PRCHN - the Center for Health Promotion Research and the Center for Adolescent Health - the PRCHN seeks to foster partnerships within Cleveland’s neighborhoods for developing, testing, and implementing research strategies to prevent and reduce the burden of chronic disease. The PRCHN, midway into its second 5-year cycle of CDC funding, is a highly responsive and collaborative community-based research center that partners with public health agencies, community organizations, neighborhood leaders and residents to address significant environmental and lifestyle issues strongly linked to chronic disease and influenced by the conditions, disparities and resources of the neighborhood itself. Its faculty and staff have also served as an active partner and leader in the transformative process occurring in Cleveland around the concepts of health equity, collective action, and the understanding of multiple determinants of health.

The PRCHN supports a comprehensive research agenda that centers around food access and community nutrition, tobacco prevention, and cessation, environments supporting healthy eating and active living, place-based health and health behavior surveillance, and community-clinical linkages and chronic disease management research. This includes core research project, Freshlink, that aims to increase nutritional food access (NFA) in low-income neighborhoods throughout Cleveland. A goal of the PRCHN is to build capacity for community-based research among University and community partners by offering formal training programs (i.e., PEER Program, PRCHN Student Internship Program) monthly seminars, workshops and webinars, and by providing technical assistance, evaluation services and subject matter expertise to its community partners.

The PRCHN partners include experienced community based researchers, heads of local boards of health, more than 50 community and health organizations, neighborhood leaders and residents, and Affiliated Faculty
The center places special emphasis on investigating the environmental issues. It is to study the complex interplay between the environment and health. The mission of the Mary Ann Swetland Center for Environmental Health continues Mary Ann Swetland's legacy, promoting awareness of the environment's disparate impact on disadvantaged populations. The strategic vision of the Swetland Center is:

- Promoting translational environmental health research
- Integrating environmental health science into medical education
- Engaging the community in environmental health sciences

Skin Cancer Research Institute
216.368.0324
Kevin D. Cooper, MD, Director

The Skin Cancer Research Institute (http://mediswww.case.edu/dept/dermatology/Centers/SCRI.html) engages the foremost experts in dermatology and oncology to work collaboratively across disciplines to discover causes of skin cancers, prevent skin cancers more effectively, and to develop new therapies for skin cancer treatment.

The Department of Dermatology is poised to create a research institute unique in scope on a national scale. Its efforts are validated by generous grant funding from the National Institutes of Health as well as through its continuous stream of groundbreaking discoveries over the past decade. What exists now within this rich infrastructure is an opportunity to transform discovery in skin cancer research. CWRU plans four new centers exclusively dedicated to the study of skin cancer, which will complement existing centers of excellence in the Department. The emerging centers will include a melanoma center, a basal/squamous cell carcinoma center, a photo medicine center, and an environmental agent center.

The Skin Cancer Research Institute has an opportunity to be unique in the nation in its capacity to bring new therapies "from lab to life" by aligning specialized skills and catalyzing new knowledge through these centers.

The Stem Cell Ethics Center
216.368.0881
Insoo Hyun, PhD, Director

The CWRU Stem Cell Ethics Center (https://case.edu/medicine/bioethics) serves as a focal point for campus-wide and international interdisciplinary scholarship and education. Housed in the Department of Bioethics, the Stem Cell Ethics Center provides an avenue to educate policymakers, regulators, and the general public about stem cell research of all forms and their translation to clinical practice. The Stem Cell Ethics Center bridges ethics and biotechnology by providing ethical and technical support, as well as a forum for directed application of stem cell ethics in the complex array of cultural, social, political, and economic issues.

The Swetland Center for Environmental Health
216.368.5437
http://casemed.case.edu/swetland/
Li Li (li.li@case.edu), MD, PhD, Director

The mission of the Mary Ann Swetland Center for Environmental Health is to study the complex interplay between the environment and health. The center places special emphasis on investigating the environmental determinants of health disparity and translating the findings into practices and programs that promote community and population health.

The environments in which we live, work and play have a great impact on our health. Environmental health embraces all the physical, psychosocial, and biological factors that affect health. Today, the Swetland Center continues Mary Ann Swetland's legacy, promoting awareness of the environment's disparate impact on disadvantaged populations.
genotyping, DNA cloning, paraffin or cryostat sections and slides, histological stains, high-quality images, microscopy training, image analysis, maintenance and breeding of mice as well as in vivo eye imaging and testing. Each Core manager is very knowledgeable in his/her respective field. The P30 grant Core facilities provide first-rate service with quick turnaround times. Individual consultations are also available.

The T32 training grant offers the graduate course 'Biochemical and molecular aspects of vision' facilitated by Dr. Paul Park (http://case.edu/med/ophthalmology/BasicResearch/PaulParkResearchPage2.html). This course, listed under the graduate program of three VSRC basic science departments - Pharmacology (PHRM 432), Neurosciences (NEUR 432) and Pathology (PATH 432), is taught by VSRC investigators, and covers the major components of the eye, visual processing and disease conditions. The course is open to all students, although VSTP Training Grant awardees take this course in their first or second year of training. Together with the Core Grant facilities, the T32 Training grant has had the most profound influence on the development and growth of the VSRC by bringing young investigators into the field that have full access to Core Grant facilities for pre- and post-doctoral training.

The VSRC coordinates an annual seminar series (http://case.edu/med/ophthalmology/Seminars/2016SeminarSeries.html), which brings to campus renowned vision researchers on a regular basis during the academic year. An all-day annual symposium, held on the Medical School Campus, comprises an external keynote speaker, talks from the faculty, post-docs, ophthalmology residents and training grant awardees as well as poster presentations. In addition, monthly VSRC Primary Investigator meetings are a forum for the VSRC members to discuss science on a regular basis. Also, members from each Ophthalmology research lab take turns presenting their research at monthly Departmental Ophthalmology Research meetings. These three seminar series and the symposium foster a multitude of opportunities for collaboration, in addition to bringing non-vision investigators into the field.

**Willard A. Bernbaum Cystic Fibrosis Research Center**

216.368.6896
Mitchell Drumm, PhD and Michael Konstan, MD, Co-Directors
Constance May, Administrative Assistant

The Cystic Fibrosis Research Center is a translational center composed of investigators from Case Western Reserve University and University Hospitals of Cleveland. The Center's research is supported annually by funds from the National Institutes of Health, the Cystic Fibrosis Foundation and other sources. The Center provides core facilities and services for investigators carrying out research related to cystic fibrosis, including a Clinical Studies core that provides clinical data for research studies and aids in IRB generation and study design, an Animal Models core that maintains the world's largest assortment of CF mouse models, a Bioanalyte core that measures a range of biomolecules (proteins, lipids, mRNA) from blood, tissues or cell culture, an Animal Imaging core that uses such technologies as MRI, PET and SECT to generate high resolution images of rodents, a Biostatistical core to carry out complex statistical analyses of CF-related studies, a Histology core that generates slide-mounted and stained sections of tissues from animal or human samples and a Cell Culture core that provides facilities and media for cultured cells. These cores facilitate translational, or "bench to bedside" projects that take very mechanistic, basic research on CF-related biochemistry and cell biology to in vivo studies in animal models and on to humans. Center members have access to all the cores as well as involvement in the weekly seminar series focused on CF or pediatric pulmonary research.

**Doctor of Medicine (MD) Programs Leading to MD**

Today, applicants can choose from three programs to obtain a medical degree at Case Western Reserve University: the University Program, the College Program (Cleveland Clinic Lerner College of Medicine at Case Western Reserve University), and the Medical Scientist Training Program (https://case.edu/medicine/admissions-programs/md-phd-program). Students in all three programs:

- are introduced to clinical work and patients almost as soon as they arrive on campus.
- learn medicine using an integrated, systems-based approach.
- are treated as junior colleagues by faculty members.
- are taught the science of medicine infused with the skills of communication and compassion.
- learn how to learn- a skill they will call on throughout their careers in the quickly changing field of medicine.

**Educational Authority**

Governance of the educational programs leading to the medical degree resides in the Faculty of Medicine. Each class of students selects representatives who become voting members of the Faculty of Medicine. The faculty of the School of Medicine is responsible for the content, implementation, and evaluation of the curriculum. The Dean of the School of Medicine serves as its chief academic officer, with overall responsibility to the university for the entire academic program. The Vice Dean for Medical Education carries the Dean's academic and administrative authority and has direct supervisory responsibility for the units that lead and support the curriculum.

The faculty's Committee on Medical Education (CME) evaluates, reviews and makes recommendations concerning overall goals and policies of the School's medical education program, which includes the University and College programs. Acting for the faculty, the Committee on Medical Education is responsible for: 1) the formal approval and adoption of the School's educational program objectives and ongoing monitoring to ensure that the objectives serve as guides for establishing curriculum and provide the basis for evaluating program effectiveness, 2) the review of performance in each program's competencies, and 3) the evaluation of the overall content and appropriateness of the educational programs and curricula leading to the MD degree. The faculty elects the majority of the members of the Committee on Medical Education. Student representatives also serve on this committee and its curriculum councils.

The operational responsibility for the medical curriculum is invested in curriculum committees that report to the Committee on Medical Education. There are four curriculum committees: (a) the WR2 Curriculum Committee (University Program), (b) the Program Evaluation and Assessment Committee (University Program), (c) the Curriculum Steering Council (College Program), and (d) the Joint Clinical Oversight Group. These committees are responsible for the strategic planning, content, design, selection of teaching leadership, oversight of the curriculum, student assessment, and program evaluation.
Expectations for Personal and Professional Characteristics

Students are evaluated on their knowledge base, clinical skills, and professional behavior and attitudes. The following characteristics are evaluated throughout the medical curriculum, and students are expected to adhere to these standards in both their academic and personal pursuits:

**Interpersonal relationships:** Provide supportive, educational and empathetic interactions with patients and families, and is able to interact effectively with "difficult" patients. Demonstrates respect for and complements roles of other professionals, and is cooperative, easy to work with, commanding respect of the health care team.

**Initiative:** Independently identifies tasks to be performed and makes sure that tasks are completed. Performs duties promptly and efficiently, and is willing to spend additional time, assume new responsibilities, and able to recognize the need for help and ask for guidance when appropriate.

**Dependability:** Complete tasks promptly and well. Present on time and actively participates in clinical and didactic activities. Always follows through and is exceptionally reliable.

**Attitude:** Are actively concerned for others. Maintain a positive outlook toward assigned tasks. Recognizes and admits mistakes. Seeks and accepts criticism, using it to improve performance.

**Integrity and honesty:** Demonstrate integrity. Is honest in professional encounters. Adheres to professional ethical standards.

**Tolerance:** Demonstrate exceptional ability to accept people and situations. Acknowledges her or his biases and does not allow them to affect patient care.

**Function under stress:** Consistently maintain professional composure and exhibits good clinical judgment in stressful situations.

**Appearance:** Always display an appropriate professional appearance.

Graduation Requirement

To graduate from CWRU School of Medicine with the MD degree (or the MD degree with Special Qualifications in Biomedical Research for students in the Cleveland Clinic Lerner College of Medicine program), students must:

1. Satisfactorily complete all Program Specific Requirements and Educational Program Objectives of the School of Medicine
2. Pass the USMLE Step 1 and USMLE Step 2 CK and CS
3. Pass or remediate the School of Medicine's Clinical Skills Exam
4. Satisfactorily complete the MD Thesis
5. Meet financial obligations to the University
6. Be approved to graduate by the Committee on Students

Licensure

Licensure to practice medicine in the United States and its territories is a privilege granted by the individual licensing boards of the states and territories. Each licensing board of the individual jurisdictions establishes its policies, eligibility, and requirements for the practice of medicine within its boundaries pursuant to statutory and regulatory provisions. The degree of doctor of medicine awarded by Case Western Reserve University is an academic degree and does not provide a legal basis for the practice of medicine.

Pathways

Case Western Reserve University School of Medicine is actively developing Pathway programs, health care concentrations available to medical students who want to focus on particular aspects of health and patient care. The current Pathways are the Jack, Joseph and Morton Mandel Wellness and Preventive Care, Humanities, Urban Health, Health Innovation and Entrepreneurship, and World Medicine. Students in both University and College programs have the option of specializing in one of several longitudinal pathways:

**Urban Health Pathway:**

The Urban Health Pathway is designed to provide selected students with the opportunity to expand their knowledge and skills in caring for patients in an urban setting, and to foster a better understanding of medicine and health in urban communities by aligning students' engagement, clinical and research goals with the community's health care needs.

**The Jack, Joseph, and Morton Mandel Wellness and Preventive Care Pathway:**

The mission of this pathway is to provide participants with insight and skills in wellness and health promotion as it relates to the domain of the mind, body, and spirit, social interactions, and the community. The vision is to incorporate and advance the promotion of health and wellness at the individual, family, institutional, professional and community levels.

**Humanities Pathway:**

The vision of the Humanities Pathway is to use arts and humanities-based courses and experiences to promote the development of health care professionals who will explore the fundamental questions of what it is to be human and to be a healthcare professional. Students will think critically about the complex interplay among patients, health care professionals, and culture. They will develop innovative and informed approaches to health, well-being, and quality of life for the patients and communities they serve while developing resilience and passion to improve the culture of medicine.

**Health Innovation and Entrepreneurship Pathway:**

In today's world, innovation and aligned entrepreneurial activities are increasingly focused upon as required value-drivers in patient care, healthcare economics, and regional economic development. The goal of the Health Innovation and Entrepreneurship Pathway is to address issues relating to the commercialization of medical-related inventions by exposing students to the challenges and opportunities encountered when attempting to develop innovative concepts from the point of early discovery to the market. The students will gain insight into what constitutes innovation, the skills necessary to become successful entrepreneurs, and future approaches on how to manage their clinical practice.

**Andrew B. Kaufman World Medicine Pathway:**

The World Medicine Pathway will prepare medical students for advanced training and careers that address global health challenges. A foundational curriculum during the pre-clerkship years will focus on building knowledge, skills, and attitudes through a series of seminars, simulations, and other experiences. Students will then have a mentored experience in the clinical years focused on biomedical research, clinical
care, capacity building, or global health policy/advocacy which will include international elective time.

Medical Student Organizations
The list of organizations and activities available to medical students continually evolves to reflect the interests of current students. Visit here for the most up-to-date list of student organizations (http://www.casemed.org). (http://casemed.case.edu/admissions/studentlife/organizations.cfm)

Admission
There are three paths to a medical degree at Case Western Reserve University School of Medicine: the University Program (4 yr. MD), the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University (College Program - 5 yr. MD), and the Medical Scientist Training Program (MSTP). Inquiries about admission and application should be addressed to the appropriate office:

Office of Admissions-University Program
School of Medicine
9501 Euclid Avenue
Cleveland, Ohio 44106-4920
Phone: 216.368.3450 or admissions@case.edu

Office for Admissions and Student Affairs-College Program
Cleveland Clinic Lerner College of Medicine of Case Western Reserve University
9501 Euclid Avenue
Cleveland, Ohio 44106
Phone: 216.445.7170 or 866.735.1912 or cclcm@ccf.org (/ cclcm@ccf.org)

Medical Scientist Training Program
School of Medicine
Case Western Reserve University
10900 Euclid Avenue
Cleveland, Ohio 44106-4936
Phone: 216.368.3404 or mstp@case.edu

Getting Started
Students wishing to apply to any MD program at the School of Medicine must initiate this electronic process through the American Medical Colleges Application Service (AMCAS). Visit AMCAS (https://www.aamc.org/students/applying/amcas) to learn more about the medical school application process.

Admissions Process
After the American Medical College Application Service (https://students-residents.aamc.org/applying-medical-school/applying-medical-school-process/applying-medical-school-amcas) (AMCAS) is completed the applicant receives an e-mail directing him or her to the CWRU School of Medicine online secondary (final) application where the applicant can designate to which MD program(s) they wish to apply. Applicants can apply to both MD programs and/or the MSTP. It is possible for an applicant to be interviewed by and receive an admission offer from all three programs.

Applicants should complete this secondary application as instructed. After the applicant has submitted the secondary application and all supporting materials, the appropriate admissions subcommittee will review the information and decide whether to invite the applicant for an interview. After the interview, the Admissions Committee of the CWRU SOM will discuss each applicant and decide whether to extend an offer of admission.

Admissions Criteria
Although academic credentials are important in the admissions process, high grades and a high score on the MCAT are not the only criteria for admission. Just as important are interpersonal skills, exposures to medicine, well-roundedness and qualities such as professionalism, empathy, and leadership ability. The School of Medicine includes a widely diverse student body.

Academic Requirements
Given the variability in the way undergraduate institutions structure various courses, there is some flexibility with some of our prerequisite courses. Please closely review the prerequisite charts (http://case.edu/medicine/admissions/application-process/requirements) for each program.

If these prerequisites were not fulfilled at an accredited, four-year, degree-granting American or Canadian college or university, the applicant should be prepared to take at least 1 year of challenging, upper-level sciences at one of these institutions prior to application.

If all science prerequisites were taken at a community college, the committee strongly recommends that the applicant take at least one year of upper-level sciences from an accredited four-year degree granting university within the United States or Canada. If a few science prerequisite courses were taken at a community college, the committee will evaluate them on a case-by-case basis.

Undergraduate students should pursue a major in a subject of their own choosing; they should not structure their undergraduate experiences in an attempt to sway the medical school admissions committee but instead, base it on their own personal interests and goals.

Financial Aid
About 70 percent of the University Program’s medical students receive some financial aid based strictly on financial need. It’s impossible to provide precise figures for financial aid before each specific situation is completely analyzed, but here is a description of the general aspects of the process:

The School of Medicine adheres to the unit loan concept used by most private medical schools. Under this concept, if a student qualifies for financial aid, he or she is expected to obtain a specific portion of his or her support from outside sources such as a Federal Direct Loan, savings, and family. Once the student obtains this amount, the remaining aid would be provided through the School of Medicine resources, up to the amount determined to be his or her reasonable need. The school’s contribution would be a combination of loan and scholarship, with the exact ratio determined by the student’s particular circumstances.

All students within the College Program receive a full scholarship covering tuition and fees. Additionally, the Medical Scientist Training Program offers financial support for participants. For more information, see other entries in this publication and contact the specific program.
The University Program each year offers a number of merit scholarships to each class through its Dean's Scholars program. These scholarships, which vary in annual amounts, are awarded for up to four years for selected students. Application for the scholarships is by invitation of the Admissions Committee. Recipients are students with records of exceptional academic and personal achievement.

Overview of the University Program
The School of Medicine curriculum always has reflected the most current educational principles, practices, and knowledge. In the 1950s the School of Medicine was the first to introduce the organ systems approach to teaching the basic sciences. In July 2006, the University Program launched the Western Reserve2 Curriculum (WR2) to develop a learner-centered and self-directed curriculum framework and implement dynamic small group learning teams. Students learn in an environment that fosters scientific inquiry and excitement.

The University Program in Detail
The WR2 Curriculum has high expectations for self-directed learning, and seeks to train physician scholars who are prepared to treat disease, promote health and examine the social and behavioral context of illness. It interweaves four themes - 1) research and scholarship, 2) clinical mastery, 3) teamwork and leadership, and 4) civic professionalism and health advocacy to prepare students for the ongoing practice of evidence-based medicine in the rapidly changing healthcare environment of the 21st century.

Scholarship and clinical relevance are the benchmarks for learning, and clinical experiences and biomedical and population sciences education are integrated across the four years of the curriculum. The WR2 Curriculum also creates an independent, educational environment where learning is self-directed and where student education primarily occurs through:

1. facilitated, small-group student-centered discussions
2. large group interactive sessions such as Team-Based Learning or didactic sessions that offer a framework or synthesis
3. interactive anatomy sessions
4. clinical skills training
5. patient-based activities

Clinical experiences begin in the first week of the University Program when students participate in community-based health care field experiences. In February of the first year, the Community Patient Care Preceptorship (CPCP) rotations begin. Each student works with a community physician one afternoon a week for 10 weeks.

Research and Scholarship begin early in the curriculum with special sessions led by faculty engaged in cutting-edge research. In the summer following year one, the majority of students engage in summer research opportunities. All students participate in a mentored 16-week experience in research and scholarship and complete an MD thesis prior to graduation.

Electronic resources make the most of classroom time while improving opportunities for self-directed learning and capitalizing on the innovative technology available at Case Western Reserve University.

A key component of the University Program is the unscheduled time on some Thursday mornings and some weekday afternoons. Students use this time for self-directed learning as well as to pursue a joint degree, take electives, participate in interest groups, shadow a practicing physician, or become active in student organizations.

Each student in the University Program is a member of one of the following advising societies: Blackwell-McKinley Society, Robbins Society, Satcher Society, Geiger Society, or Wearn Society. Each society is headed by an advising dean, who helps the students navigate the curriculum, advises them on residency and career planning, and writes their dean's letters. The society deans hold regularly scheduled small group and individual meetings with the students. The society deans are all members of the faculty of the School of Medicine and participate actively in the educational programs of the school. Some aspects of the curriculum are coordinated through the societies.

Education throughout the Four Years is Centered on:
1. Fostering experiential and interactive learning in a clinical context;
2. Stimulating educational spiraling by revisiting concepts in progressively more meaningful depth and increasingly sophisticated contexts;
3. Promoting integration of the biomedical and population sciences with clinical experience;
4. Transferring concepts and principles learned in one context to other contexts;
5. Enhancing learning through deliberate practice, or providing learners with direct observation, feedback, and the opportunity to practice in both the clinical environment and in the Case Western Reserve University (CWRU) School of Medicine's Mt. Sinai Skills and Simulation Center.

The Western Reserve2 Curriculum has 10 Guiding Principles:
1. The core concepts of health and disease prevention are fully integrated into the curriculum.
2. Medical education is experiential and emphasizes the skills for scholarship, critical thinking, and lifelong learning.
3. Educational methods stimulate an active interchange of ideas among students and faculty.
4. Students and faculty are mutually respectful partners in learning.
5. Students are immersed in a graduate school educational environment characterized by flexibility and high expectations for independent study and self-directed learning.
6. Learning is fostered by weaving the scientific foundations of medicine and health with clinical experiences throughout the curriculum. These scientific foundations include basic science, clinical science, population-based science, and social and behavioral sciences.
7. Every student has an in-depth mentored experience in research and scholarship.
8. Recognizing the obligations of physicians to society, the central themes of public health, civic professionalism and teamwork & leadership are woven through the curriculum.
9. The systems issues of patient safety, quality medical care, and health care delivery are emphasized and integrated throughout the curriculum.
10. Students acquire a core set of competencies in the knowledge, mastery of clinical skills and attitudes that are pre-requisite to graduate medical education. These competencies are defined, learned and assessed and serve as a mechanism of assessment of the school’s success.
Curricular Composition

The four years of the WR2 Curriculum are divided into four major components, each of which focuses on health as well as disease.

Foundations of Medicine and Health

This component is made up of six curricular blocks.

The first block, Becoming a Doctor, is five weeks in duration and gives students an understanding of population health and the doctor’s role in society. Typically students begin their medical education by studying basic science at the molecular level and are often not fully aware of the relevance that this knowledge has in their future education as physicians or how it relates to the actual practice of medicine. This curricular block focuses on how physicians can act as advocates for their patients in the health care system; how social and environmental factors impact health; and the importance of population health. Medical students participate in an Extensive Care Unit, an experiential, longitudinal, service learning project intended to introduce them to key population health concepts including epidemiology, biostatistics, community assessment, health risk behavior, and social-environmental determinants of health.

The next five blocks in the Foundations of Medicine and Health are comprised of basic science education complemented by early contact with patients in clinical preceptorships and simulated clinical experiences. Subject matter is integrated across entire biological systems, which permits faculty in the different disciplines to leverage teaching time to convey content and concepts common to their disciplines. Content is divided into the following blocks:

- The Human Blueprint: Comprised of endocrine, reproductive development, genetics, molecular biology, and cancer biology.
- Food to Fuel: Encompasses gastro-intestinal system, nutrition, energy, metabolism, and biochemistry.
- Homeostasis: Includes cardiovascular system, pulmonary system, renal system, cell regulation, and pharmacology.
- Host Defense and Host Response: Focuses on host defense, microbiology, blood, skin, and the auto-immune system.
- Cognition, Sensation and Movement: Comprised of neurosciences, mind, and the musculoskeletal system.

Several concepts and themes stretch longitudinally across these blocks, including Structure (anatomy, histopathology, and radiology) and clinical mastery. Teamwork, interprofessional collaboration, and bioethics are likewise incorporated longitudinally.

During Block 4’s Clinical Immersion Week, students leave the classroom and enter the clinical setting to see the relevance of the basic science they have been studying as the concepts are used in the setting of patient care. The Reflection and Integration week is the final week of blocks 2-6. During this week, no new material is introduced. Learning activities are planned to help students spiral back to concepts introduced earlier in the block by presenting these concepts again, sometimes in new contexts, and now integrated with other concepts previously learned. End of block assessment takes place during the reflection and integration week.

Research and Scholarship

The WR2 Curriculum is in concert with CWRU’s emphasis on research and scholarship to encourage student career development in the areas of clinical investigation and population research. The practice of medicine is becoming increasingly evidence and science-based, and research teaches students a way of framing questions and developing an approach to answering them. The focus on research and scholarship provides medical students with opportunities to pursue individualized areas of interest in great depth. Through this 16-week, mentored experience in research and scholarship (which can be taken at any point from March of the second year onward), students acquire the intellectual tools needed to formulate research questions, critically assess scientific literature and continue the life-long pursuit of learning that is a critical aspect in the careers of all physicians and physician/scientists. The research project culminates in a thesis, which is written in the format of a manuscript of the leading journal in the particular area of interest.

Clinical Experiences

The clinical curriculum cuts across all four years of the medical school curriculum, and can be divided into three areas of involvement:

1. Foundations of Clinical Medicine

This segment of the clinical curriculum runs longitudinally through the Foundations of Medicine and Health and seeks to develop a broad range of clinical and professional capabilities. FCM develops the necessary skill sets through 4 separate, but integrated programs:

- Tuesday Seminars: Course continues the theme of “doctoring” begun in Block 1 through the Year 1 and Year 2 curriculum. Topics examined include the relationship between the physician and the patient, the family and the community; professionalism; healthcare disparities; cultural competence, quality improvement; law and medicine; medical error/patient safety, development of mindful practitioners and end of life issues.
- Communications in Medicine: Course is comprised of seven workshops running through Year 1 and Year 2 that focus on the range of skills needed for effectively talking with patients including the basic medical interview, educating patients about a disease, counseling patients for health behavior change, and presenting difficult news and diagnosis.
- Physical Diagnosis: Course runs throughout Year 1 and Year 2 and includes: Physical Diagnosis 1 introducing the basic adult exam to Year 1 students for one session per week for eight weeks, Physical Diagnosis 2 in-depth regional exams in various formats during Year 1 and Year 2, and Physical Diagnosis 3 in Year 2 where students spend five session doing complete histories, physicals and write-ups on patients they see in an in-patient setting.
- Patient-based Programs: Community Patient Care Preceptorship (CPCP) during either Year 1 or Year 2 students spend 10 afternoons in a community physician’s office developing and reinforcing medical interviewing, physical exam and presentation skills (written and oral) with ongoing mentorship from a preceptor.
- Interprofessional Education (IPE): IPE provides students from the health professions (Medical, Dental, Nursing, Social Work, Public Health, Nutrition and Physician Assistants) the opportunity to engage in a dynamic and interactive team learning environment to better understand the goals, purpose, and benefits of inter-professional collaboration.
- Procedures: Training in basic medical and surgical procedures in Years 1 and 2, including hemorrhage control, scene safety, basic airway management, sterile field, gloving and gowning, OR scrub, suturing, injections, IV placement and foley placement.

2. Core Clinical Rotations:
The Core Clinical Rotations are designed to provide students from both the University and College programs of the Medical School with both breadth and depth in clinical care. Experiences are developmental, with opportunities to reinforce, build upon, and transfer knowledge and skills from all parts of the curriculum. Clinical learning is integrated across disciplines whenever possible through a unique block structure, and important themes related to scholarship, humanism, and science are supported through specially designed weekly small group programs. A unified approach to addressing and assessing a core curriculum is utilized at all teaching sites with the flexibility to take advantage of the unique strengths of each clinical setting.

**Core Rotations:** Beginning in March of their second year, students have the opportunity to begin their core clinical rotations. These rotations are organized in blocks that integrate core specialties in at one site for 8 or 12 weeks. Core 1 combines Internal Medicine, Family Medicine, and Aging for 12 weeks, Core II combines Pediatrics and OB/Gyn for 12 weeks, Core 3 combines Neuroscience and Psychiatry for 8 weeks, and Core 4 combines Surgery and Emergency Medicine for 8 weeks. Each of these clinical rotations is offered at all of the School of Medicine’s hospital affiliates including University Hospitals of Cleveland, MetroHealth Medical Center and the Louis Stokes VA Medical Center.

**Cleveland Clinic Longitudinal Clerkship:** Students will have the option of completing their core clinical rotations as part of a 12-month longitudinal clerkship experience at the Cleveland Clinic. The educational learning objectives remain the same for all Case Western Reserve University students on their core rotations, however, the structure of this experience will offer some unique features aimed at increased learning, longitudinal experiences with faculty and creation of a learning community. Students will complete all 40 weeks of their core rotations within the Cleveland Clinic Health System and have 8 weeks of electives that can be taken at other core hospitals in Cleveland or as a visiting student at another institution. The structure of the core rotations will differ from other sites in order to integrate a longitudinal ambulatory block. The rotation structure will be as follows:

- **Longitudinal Ambulatory Block (LAB) – 12 weeks**
  - Team-Based Care 1 – Inpatient Internal Medicine/Surgery – 12 weeks
  - Team-Based Care 2 – OB, Inpatient Gynecology, Inpatient Pediatrics – 8 weeks
  - Team-Based Care 3 – Neurology/Psychiatry – 8 weeks
  - Electives (any site) – 8 weeks
  - Vacation – 4 weeks

The LAB will include outpatient components of Family Medicine, Internal Medicine, Ob/Gyn, Pediatrics, Emergency Medicine, Palliative Medicine, and Geriatrics. LAB will also provide exciting opportunities for students to explore disciplines and possible areas of career interest and establish longitudinal experiences by working a half-day a week with the same preceptor over 12 weeks. The longitudinal clerkship will also allow students to create a community of learning by participating in Longitudinal Learning Groups over the year. Topics such as quality/safety, high-value care, and palliative medicine will be covered as part of a year-long curriculum.

**The MetroHealth-CWRU Longitudinal Integrated Clerkship (MCLIC):** Students will have the option of completing their core clinical rotations as part of a 12-month longitudinal integrated clerkship experience in the MetroHealth System. The educational learning objectives remain the same for all Case Western Reserve University students on their core rotations, however, the structure of this experience will emphasize longitudinal and integrated experiences with faculty and patients in the diverse MetroHealth community. Students will complete all 40 weeks of their core rotations within the MetroHealth System and have 8 weeks of electives that can be taken at other core hospitals in Cleveland or as a visiting student at another institution.

The structure of the MCLIC is rooted in a year-long, half-day/week, outpatient mentorship with a family physician, internist, pediatrician, surgeon, and obstetrician/gynecologist. The student will work with the same attending physician in each core specialty for the entire year and become an integral member of the clinic team. They will develop longitudinal relationships with patients of all age groups who they can help care for in the inpatient and outpatient settings and across specialties. Time is set aside each outpatient week for students to do surgeries and procedures, deliver babies, work on quality improvement, attend learning sessions, address health disparities, and participate in the care of their panel of patients. On weekends and at other convenient times, the students will be able to work in the emergency department and urgent care settings.

Spread across the academic year at approximately four-week intervals, the MCLIC students will engage in their inpatient core rotations. Each inpatient burst will last 14 days and the student will be a member of the inpatient teams on the internal medicine, pediatric, obstetric, surgical, neurology, and psychiatry services. During their inpatient bursts, they will be full members of the inpatient team caring for the hospitalized and diverse, urban, and underserved community served by the MetroHealth Medical Center.

**Sciences and Art of Medicine, Integrated (SAMI)** is an undifferentiated-patient curriculum that takes place during the clerkship year. Utilizing a small group format, SAMI provides University Program medical students with an opportunity to practice patient care with direct observation and feedback from clinical facilitators. Each SAMI case incorporates healthcare disparities as well as integrates basic, health systems, and clinical sciences in order to improve students’ skills of clinical reasoning and decision making. Finally, SAMI provides students with an environment to further develop their humanism through activities like reflection and advanced communication skills.

### 3. Advanced Clinical and Scientific Studies

Advanced clinical and scientific studies provide students with flexible learning opportunities that support ongoing professional development and residency preparation and planning:

- Two Acting Internships are required: one in Internal Medicine, Surgery, Pediatrics, or Inpatient Family Medicine, and one in an area of student choice.
- One Acting Internship and all electives can potentially be done outside of the CWRU system.
- Students are encouraged to augment their interest in scholarship through rotations and activities that focus on sciences basic to medicine as well as clinical rotations.

**Evaluation and Assessment**

Student assessment in the WR2 Curriculum is designed to accomplish three goals:
1. drive the types of conceptual learning and scientific inquiry that are goals for the WR2 Curriculum
2. assess whether students have attained the level of mastery set for each phase of the curriculum
3. prepare students for medical licensure

These three goals are accomplished through multiple assessment methods.

Independent study and inquiry are hallmarks of WR2 through assessment strategies that are formative, focus on the synthesis of concepts, and promote student responsibility for the mastery of skills and material. The following assessments are used in Foundations of Medicine and Health:

1. Assessment of students' participation in weekly Case Inquiry (IQ) groups by faculty facilitators, utilizing observable behavior anchors and focusing on contributions to team process and content, critical appraisal skills, and professional behaviors.
2. Synthesis Essay Questions (SEQs). Weekly, formative, open book concept reasoning exercises in which students are given a brief written clinical scenario and asked to explain a clinical phenomenon and its basic science underpinnings. Throughout a teaching block, students complete SEQs at the end of each week. They compare their own answers to an 'ideal' answer and receive feedback from their IQ group facilitator.
3. Summative Synthesis Essay Questions (SSEQs), or exercises that measure what students know at specific points in their education, are closed book exercises with approximately 5 clinical vignettes that take an estimated 3-4 hours to complete. These SSEQs are based on the synthesis essays students have been assigned throughout the block. In the final week of the block SSEQs present concepts from previous exercises in new contexts and require concept integration. These summative exercises are scheduled at the end of each large teaching module (every 3-4 months) and are graded by faculty.
4. Structure Practical Exercises. These assessments occur in the final week of blocks 2-6 and assess anatomy, histo-pathology and radiology through clinical scenarios and questions that require anatomic localization and histo-pathologic identification.
5. Self-Assessment Multiple Choice Questions (MCQs). Throughout the block, students are required to complete MCQs. These are drawn from the School of Medicine's extensive bank of questions which are mapped to learning objectives for the block. Students use these MCQs throughout the block as a study aid and method of self-assessment.
6. Cumulative Achievement Tests (CAT). At the end of each block, students complete a secure formative MCQ achievement test, based on content covered in the current teaching block as well as on content from each previous block. These exams are designed utilizing test question resources available through the National Board of Medical Examiners (NBME). Tests will become progressively longer throughout the Foundations of Medicine and Health. The final CAT reflects material across all curriculum blocks. These formative tests enable students to gain perspectives on their overall progress and preparedness for the USMLE Step 1.
7. Student progress in Foundations of Clinical Medicine is measured by small group facilitator assessment in the Seminars of Clinical Practice, direct observation of skills, preceptor evaluation of patient-based activities, and OSCE examinations.
8. Professional Learning Plan. During the Block, students review learning objectives and reflect on their learning, identifying their strengths and areas for further study. A reflective essay is completed that links to pieces of evidence, accumulated throughout the block, to support areas of strength and areas for further growth that have been identified. Students, working with their Society Deans develop a plan for further learning.

The WR2 Curriculum provides students with a focused education that is faculty-directed and student-centered. Classroom hours are limited. The content of WR2, organized across biological systems, provides students with an integrated view of medicine and health and an understanding of how the basic sciences and clinical practice relate to one another. The flexibility of WR2 permits students to explore in depth an area of interest to them alongside a mentor. The curriculum places great emphasis on the social and behavioral context of health and disease as well as on population medicine which will prepare students to face the emerging challenges of today's health care system.

**Assessment for Promotion and Graduation**

The faculty of the School of Medicine is charged with assessing student performance, including knowledge, skills and personal characteristics that are important qualities of a responsible, competent and humane physician. This responsibility is delegated by the faculty to the Committee on Students, a standing committee of the faculty of medicine, with a majority of its members faculty-elected.

The Committee on Students reviews the performance of every medical student in the University Program during each of the four years, determines each student’s continuing status as a student in the school, and recommends candidates for graduation. The committee reviews a medical student’s total performance, which includes the usual indices such as formal grades and assessments, as well as the professional attitudes and behavior manifested by the student. Medical education entails the mastery of didactic, theoretical, and technical matters as well as the demonstration of appropriate professional and interpersonal behavior, sensitivity, sense of responsibility and ethics, and the ability to comport oneself suitably with patients, colleagues and co-workers. To be eligible for promotion and graduation, students must complete the requirements and perform satisfactorily in all components of the curriculum. Medical students in the University Program are graded "meets expectations" or "does not meet expectations" in the first two years and as "honors," "commendable," "satisfactory," "unsatisfactory," or "achieves or exceeds expectations" in the clerkships of the third and fourth years. There is no class ranking.

**Graduation Requirements**

To graduate from CWRU School of Medicine with the MD degree (or the MD degree with Special Qualifications in Biomedical Research for students in the Cleveland Clinic Lerner College of Medicine program), students must:

1. Satisfactorily complete all Program Specific Requirements and Educational Program Objectives of the School of Medicine
2. Pass the USMLE Step 1 and USMLE Step 2 CK and CS
3. Pass or remediate the School of Medicine’s Clinical Skills Exam
4. Satisfactorily complete the MD Thesis
5. Meet financial obligations to the University
6. Be approved to graduate by the Committee on Students

**Overview of the College Program**

The Cleveland Clinic Lerner College of Medicine (CCLCM or College Program) is a distinct 5-year program within the School of Medicine. In 2002, Cleveland Clinic and CWRU formed a historic partnership to
collaborate in education and research through creation of the CCLCM. As stated in the affiliation agreement between the two institutions, “the principal purpose and educational mission of the College shall be to attract and educate, in specially designed programs, a limited number of highly qualified persons who seek to become physician investigators and scientists who will advance biomedical research and practice.” To achieve this mission, the CCLCM selects students with a desire to pursue careers as physicians and researchers, educates them to be excellent doctors, nurtures their curiosity about science and medicine, provides them with substantive research experience and core research skills, and offers financial support to ensure that excess debt does not preclude their ability to follow careers in research and medicine.

The College Program in Detail
Training the Physician Investigators of Tomorrow: A Synopsis of the Program

Recognizing the critical shortage of physicians engaged in research, the College Program offers an educational program that provides medical students with the necessary skills and knowledge to enter academic residencies and pursue successful careers as basic, translational or clinical investigators and expert doctors – without requiring them to complete an advanced degree in addition to the MD. Graduates are expected to be scientifically inquisitive, to be life-long learners, to be independent thinkers with excellent teamwork skills, to have broad-based research knowledge as well as strong clinical acumen, and to be reflective practitioners of medicine and science who take a critical approach to self-assessment and self-improvement. All three components of the curriculum – basic science, clinical and research – in addition to the advising and assessment processes have been created to support the development of these attributes in our medical students.

The basic science curriculum applies adult learning principles, building on problem-based learning (PBL) to create an early link between clinical problems and basic science learning and to help students develop their skills in hypothesis generation, critical thinking, self-identification of learning objectives, oral presentation, and teamwork. Almost all faculty-student contact time involves some form of active learning – graduate school-style seminars and problem sets rather than lectures, case-based anatomy sessions using projections and cross-sectional images rather than full cadaver dissections, interactive lab sessions rather than demonstrations, and journal clubs. To support this educational model, curriculum schedules provide extensive time for independent study. The basic science curriculum is organ-system based, with the disciplines of anatomy/embryology, biostatistics/epidemiology, cell biology, histology, imaging, immunology, pathology, pharmacology, physiology, infectious disease, oncology, genetics, evidence-based medicine, bioinformatics and ethics designated as curricular threads woven through every organ-based basic science course and extending into the year 3-5 clinical curriculum. Learning objectives for the thread disciplines are used to determine the organ system curriculum structure in the first two years, with the goal of providing a logical, coherent two-year curriculum in each of these topics basic to medicine. Courses in Year 1 focus on normal human structure and function; in Year 2, courses focus on pathophysiology of disease. Later, in Years 3 through 5, students revisit advanced basic science concepts in their core clinical rotations, clinical electives, and College Program specific pullout sessions.

The clinical curriculum begins in the fall of the first year contiguous with the first basic science course in Year 1. At its foundation is a continuity teaching and learning experience with a primary care preceptor and his/her patients throughout the first two years. Students spend one half-day every other week in Year 1 and one half-day every week in Year 2 with the same preceptor. During Year 1, students learn core clinical skills in doctor-patient communications and physical diagnosis in sessions linked whenever possible to the basic science courses (e.g., learning the cardiac and lung exams during the Cardiovascular and Respiratory Sciences course and the basic neurological exam during the Neurological and Behavioral Sciences course) and then practice those skills with real patients in their preceptors’ offices on alternate weeks. Once they have mastered the basics of the history and physical, they begin to apply their skills to more complete evaluations of ambulatory patients with direct observation and feedback from their preceptors. By the end of Year 2, students are capable of performing a complete history and physical and confidently evaluating adults with common outpatient problems.

In Year 2, students spend a second half-day each week in sessions focused on building advanced clinical skills or clinical activities designed to complement concomitant basic science systems topics (e.g., a session in the Diabetes Clinic during the week devoted to learning about diabetes). The other key component of the clinical curriculum in Years 1 and 2 is the weekly Art and Practice of Medicine Seminar series. This course focuses on principles of leadership and their application to medical practice, professionalism and ethics, health care systems, population medicine, and provides a setting for students to reflect on their experiences and observations of the health care system. In Years 3 through 5, students in CCLCM participate in the same core clinical experiences as students in CWRU’s University Program. Friday afternoon sessions in Years 3-5 bring CCLCM students together regardless of clinical location and focus on program-specific topics in research and human values.

During all five years, there are close mentoring and advising relationships between students and faculty. To ensure this happens, at the beginning of medical school each student is assigned a physician advisor who serves as the student’s partner and guide in navigating and mastering the curriculum throughout all five years. In addition, during the first summer, each student is assigned to an experienced basic or translational research preceptor who integrates the student into all activities in his/her lab and provides guidance and feedback to the student in such as working effectively with the lab team, research design, data analysis, and oral and written presentations of research. During the second summer, each student develops a similar relationship with an experienced clinical researcher who includes the student as an active participant in one or more ongoing research projects. Students are exposed to a broad range of basic, translational and clinical researchers during the first two years – during the summer research blocks, during weekly research seminars (Advanced Research in Medicine series), and in class during basic science and clinical courses. Students then select a research advisor for the master’s level research project on which they will spend 12 to 15 months during the last three years of medical school.

The College uses a unique approach to student assessment designed to enhance student learning and to promote self-directed learning. There are no grades for any course or rotation and no class ranking. Instead, each student is expected to attain a defined level of achievement in each of the 9 CWRU School of Medicocompetencies. Seven of these defined competencies encompass the 6 core competencies defined for all U.S. graduate medical education programs accredited by the ACGME (Accreditation Council for Graduate Medical Education) as well as research and personal development. Starting on the first day of medical school, students begin collecting evidence from faculty and peers of their progress in achieving the standards in each of the 9 competencies and reflecting on how the evidence demonstrates their development as
doctors and researchers—the two interrelated professional roles for which they are preparing.

One of the principles of the College is that assessment drives learning—that a curriculum designed to foster self-directed learning and achievement of competencies is ineffective if assessment focuses on what the "teacher" said in class and factual recall. Therefore, the College uses a student-centered, student-driven approach to assessment with strong support from the physician advisors who know the students well and guide them as they develop skills and self-confidence as self-directed learners.

Students gather a broad range of types of evidence over their five years of study and work as partners with their physician advisors to review the evidence and their reflections, to create individual learning plans to address areas of relative weakness and to tailor the curriculum to build on their areas of particular strength. Evidence of achievement and reflections on progress in their professional development are collected in electronic Student Portfolios and used to document readiness for promotion and graduation from the program. By training students in accurate self-assessment and developing their reflective ability, we intend to send them out of medical school already skilled in the kind of independent, self-directed learning habits that will be required of them as residents and throughout the rest of their professional lives.

CCLCM’s Foundation: A Comprehensive Research Curriculum

The research curriculum begins on the first day of medical school with the basic and translational research block and is integrated throughout all five years of the College Program. Every student participates actively in a “bench” project in the first summer, prepares an oral presentation describing the project in the format used at most scientific meetings, and develops a mock research proposal that extends the summer research project to the next research question. In addition, students learn the basic principles of research design and data analysis, ethics of the use of animals in research, and critical appraisal and interpretation of the basic science research literature in a journal club. At the end of the summer, students formally present their research project and findings to students and preceptors. Linked with the summer research curriculum is a core curriculum in basic biochemistry, cell biology, molecular biology, genetics, and bioinformatics.

The second summer is devoted to clinical research. Coursework focuses on applied medical biostatistics, clinical epidemiology, including appropriate design and analysis of various kinds of clinical research protocols, and ethical issues such as human subjects protection. Each student participates actively in an ongoing clinical research project and writes an original clinical research protocol to extend the summer research project to the next research question, prepares an oral presentation describing the proposed research protocol, and formally presents this proposal at the end of the summer.

During the remainder of Years 1 and 2, students participate in Advanced Research in Medicine (ARM), a weekly series of highly interactive research seminars linked to the content of the basic molecular science courses. In Year 1, ARM is designed to provide students opportunities for interaction with a wide range of successful investigators to help them understand the sequence of problem identification, exploring prior work in the area, hypothesis development, experimentation, successes and failures that lead to new research findings. ARM 1 also helps students appreciate the interaction between basic and clinical research—how basic science discoveries translate into changes in the clinical care of patients and how clinical observations or research findings result in new directions in basic science research. In ARM 2, the presentations are linked to the basic clinical science content each week but are more focused on current research projects and development of well-constructed research questions and reinforcement of epidemiology and biostatistics principles learned in the Year 2 summer. The sessions take on the format of a formal research presentation at a scientific meeting.

Students must submit a research proposal with the thesis advisor and thesis committee members listed at least 6 months prior to the start date of the research. A Thesis Committee made up of the research advisor and two or more additional faculty supervise and approve the student’s research proposal, progress, and final master’s level thesis that must be completed by February 15 of Year 5.

The last three years of the curriculum are specifically designed to provide flexibility to students in scheduling their research and clinical rotations. Working together, the student, research advisor, and physician advisor tailor the curriculum to the student. Students complete their research projects in one 12- to 15-month block of time, usually during the fourth year. Every student regardless of the overall schedule will continue to engage in clinical experiences at least one half-day per week during blocks devoted primarily to research—to ensure that students maintain clinical skills and contact with patients, develop a deeper appreciation of the connection between advances in biomedical research and patient care, and have the opportunity to reflect on their ongoing development as both physicians and researchers.

Curriculum Timeline: Years 1 and 2

Students begin Year 1 with a one-week-long Orientation in which they are formally welcomed to the profession of medicine by the Deans and their physician advisors. The week includes individual meetings with the student’s summer research preceptor and physician advisor, an introduction to the unique assessment system and the Student Portfolio, and an introduction to the summer curriculum and its expectations. A White Coat Ceremony that commemorates the entry of all students in both the College and University programs into the CWRU School of Medicine highlights the week.

The Basic and Translational Research Block occupies the first 10 weeks of Year 1 and includes a course reviewing core concepts in cell biology, molecular biology and biochemistry. Scheduled classes and meetings occur 5 days a week for 2 hours, with the remainder of each day devoted to independent study and hands-on experience in the lab of the student’s summer research preceptor. This block sets the stage for active learning in the rest of the curriculum. Throughout the core basic science course and all the basic science courses, each week has a conceptual “theme” within which more detailed learning objectives fall. All assignments and scheduled activities are designed to help students master the core concepts for the week. Mastery is defined as being able to explain the concepts and to apply them to new or different problems or situations, rather than simply “listing” all the factual details. Sessions for the core basic science course are held on Monday, Wednesday and Friday mornings and students are expected to study background material before
class and self-assess their understanding of the readings. They then work together in class to solve complex problems related to what they have studied. Tuesday mornings are devoted to focused discussions and presentations related to the science topics discussed that week or introduce students to key concepts in areas such as genetics, oncology, and bioinformatics.

Students meet each Friday for a Journal Club aimed at enhancing skills in critically assessing the basic science research literature. Each week, two students present an article; the other students are expected to read the articles carefully and come prepared with questions. Each presenter works with a faculty facilitator to review the paper and presentation before Journal Club. Using feedback from faculty and other students on their presentations and on the questions they ask of others, students begin to hone their communication skills and develop confidence participating as speakers in this setting.

The primary focus of the Year 1 Basic and Translational Research Block is the summer research project. Students are assigned to a summer research preceptor with attention to individual preferences for specific research areas. They are expected to engage fully in all activities in the preceptor's research group, such as special lab meetings or journal clubs, in addition to working on their defined project. At the end of week 2, they submit a draft plan for their summer research project and review it with their preceptor to set the expectations for the summer. During the summer, students also develop a brief research proposal that extends their research project. At the end of week 5, they submit a draft outline of their brief research proposal. The final document is due in week 9. During week 10, students present their projects orally in the format used at many scientific meetings – a 10-minute presentation with audiovisuals followed by 5 minutes for questions. Thus, in addition to actually working on a bench project, students are guided by their preceptors in developing a number of other key skills. Students receive feedback from their preceptors, other members of the lab team, and peers on their contributions in the lab and their written and oral presentations.

During the summer, students schedule their first formal meeting with their physician advisors to review the evidence in their Student Portfolios, to discuss their reflections on their development in their new professional roles, and to review their learning plans to address any specific weaknesses or gaps they have identified. They review feedback on their activities in small group and journal club, lab work, mock grant proposal, oral presentations and scientific writing. This evidence is provided by their summer preceptors, peers, and self-assessments of their mastery of the core basic science concepts. Just as the interactive learning in class sets the stage for research and the rest of the curriculum, the first summer sets the stage for student success in the unique assessment process used in College Program.

Each week of the Year 1 and 2 basic science courses is organized around a theme that provides a focus of learning for the students and an opportunity to integrate when possible the basic science, clinical, and research curriculum components. For example, the theme of one of the weeks of the Gastrointestinal System 1 course is “Liver, Gallbladder and Pancreas.” The Problem-Based Learning (PBL) case focuses on a patient who takes an overdose of acetaminophen and alcohol and subsequently develops liver failure. Students learn normal liver function as they explore who takes an overdose of acetaminophen and alcohol and subsequently suffers a penetrating injury to the chest may be used to focus students on the anatomical structures that might be injured and their relationship to one another.

Histology is also integrated into the basic science courses, with students using a computer-based virtual microscopy system rather than a mechanical microscope to look at slides. This allows students not only to scan slides but also to see slide annotations and related gross and radiographic images. Specific learning objectives for histology are included in PBL cases in addition to seminars devoted to histology. The goal is for students to understand the gross and histological structures of each organ system in relation to its function, rather than as isolated anatomical facts. For example, during the week in CRS1 devoted to the theme of how the heart functions as a pump, students learn the structure and anatomical relationships of the four chambers of the heart and heart valves and the histological appearance of myocardial cells while they are studying the physiological concepts of preload, afterload, and contractility.

In addition to anatomy/embryology, imaging, and histology, the other “threads” in Year 1 include cell biology, pharmacology, physiology, bioinformatics, evidence-based medicine, genetics, nutrition, health care systems, ethics and humanities, building on the core concepts from the summer in specific relation to each organ system. In CRS1, students learn not only the molecular structures and functions of α- and β-receptors but also the physiology of endogenous and exogenous agonists and antagonists of these receptors as they study myocardial contractility and physiological regulation of blood pressure. They learn the biochemical pathways involved in aerobic and anaerobic production of ATP as they study determinants of oxygen delivery to myocardial cells, concepts they will revisit and build upon during subsequent courses when they study skeletal muscle metabolism during exercise and the role of the liver in maintenance of normal blood glucose levels. They study physiology of the heart, lungs, red blood cells and plasma as an integrated system providing oxygen and removing carbon dioxide, supporting metabolic needs of the entire body. During each course, students return to the core concepts they mastered in previous courses, using those concepts as a framework for building their understanding of the human organism as a whole. The basic science curriculum continues with Gastrointestinal System (4.5 weeks), Endocrinology and Reproductive Biology (4 weeks), Renal Biology (3 weeks), Musculoskeletal Sciences (3 weeks), Neurosciences (5 weeks),
and Hematology, Immunology and Microbiology (7 weeks). Each basic science course focuses on normal structure and function, relating back to previous courses and preparing students for concepts in future courses.

Starting in the fall of Year 1, the Basic and Translational Research Summer Block’s Friday journal clubs are replaced by Advanced Research in Medicine 1, a weekly series of research seminars in which students are exposed to a wide range of basic and clinical research topics in interactive discussions with accomplished investigators. Presentations are linked closely with the basic science curriculum in order to reinforce core basic science concepts, help students feel confident in questioning the investigators based on what they are learning at the time, and illustrate the process whereby new biomedical discoveries change clinical practice.

Foundations of Clinical Medicine begins at the same time as the first basic science course and continues throughout Years 1 and 2. The guiding principle is that early exposure to patients, with direct observation and feedback by experienced faculty physicians, is optimal for real-time assessment and feedback of student clinical skills. Foundations of Clinical Medicine has 3 interrelated components – clinical skills training, patient care experiences, and Art and Practice of Medicine seminar series. The Art and Practice of Medicine seminar series is a two-year continuum addressing professionalism, ethics, leadership and its application to the care of patients and the practice of medicine, evidence-based medicine, health care systems and patient safety introduced to students primarily through the humanities.

Core clinical skills training occurs every other week from September through May and is coordinated with the organ systems under study. On alternate weeks, students practice the basic skills they just learned with standardized patients in the classroom by conducting histories and physical exams with real patients and writing chart notes on the previous week under the supervision of their longitudinal preceptors. Starting in February, students are exposed to special aspects of the history and physical for geriatric and pediatric patients, while continuing to work on basic skills every other week with their preceptors. They also begin to take on more patient care responsibility in preparation for their weekly clinics with the same preceptor in Year 2. An Objective Structured Clinical Examination (OSCE) with feedback from preceptors is used to help students chart their progress in mastering core skills.

Year 2 begins with the 9-week Clinical Research Block. Students work with a preceptor in an active clinical research environment on an ongoing project, continuing to develop their skills in building relationships with members of a research team. They also write a mock clinical research proposal that extends the research question on which the student is working during the summer. Scheduled coursework occupies 2 hours each weekday and includes a rigorous immersion in biostatistics with students using statistical software to analyze real data sets and a clinical epidemiology course focusing on formulation of scientific questions, study design, clinical trials, and legal and ethical issues in research including human subjects’ protection. The coursework requires significant class preparation for students, thus students must balance their time and effort between the coursework and research project in the Year 2 summer. Journal Club sessions on Fridays focus on articles from the clinical research literature, with students using knowledge gained from biostatistics and epidemiology to help them analyze the papers. Feedback from peers and faculty facilitators help students enhance their presentation skills and ability to critically read and present scientific papers. Students complete the second summer with a comprehensive range of clinical research skills and knowledge, complementing their basic research experience in the first summer and preparing them to engage in basic, translational or clinically oriented research for their thesis.

For the remainder of Year 2, students return to the same organ-system based basic science curriculum they studied in Year 1, this time focusing on learning the pathophysiology of common diseases. Immunology, Pathology, Oncology, Infectious Disease/Microbiology, and Biostatistics/Epidemiology are now integrated as threads throughout the Year 2 basic science curriculum. The first basic science course is Musculoskeletal Sciences (2 weeks), followed by Neurosciences (3 weeks) and Behavioral Sciences (3 weeks), Endocrinology and Reproductive Biology (4.5 weeks), Cardiovascular and Respiratory Sciences (7 weeks), Hematology (4 weeks), Gastrointestinal System (4 weeks), and Renal Biology (4 weeks). Anatomy and embryology seminars are conducted less often during Year 2, usually 1-3 sessions per course. The clinical curriculum continues to be closely linked to the basic science courses. Students spend one half-day every week in their primary care longitudinal preceptor’s office. An additional clinical half-day is added and students see patients who demonstrate the pathophysiology being studied that week. Some of the additional half-days are devoted to learning advanced clinical skills (the gynecologic and urologic exams, evaluation of geriatric and pediatric patients with common problems) and an exposure near the end of Year 2 to the acute care setting helps to prepare students for Year 3. The Art and Practice of Medicine seminar series begin in September of Year 1 and ends in April of Year 2. Students also participate in two OSCEs, one at the beginning of Year 2 to help students identify skills to address over the year and the second at the end of Year 2 to help students document their skills for their portfolio. After classes end in mid-May, students have 6 weeks available to study for and take the USMLE Step 1 Examination.

By the end of Year 2, students have engaged actively in both basic and clinical research, learned and practiced a wide range of research skills. They have extensive experience in self-directed learning both independently and in teams and have mastered core basic science concepts related to human health and disease. They are comfortable “doctoring” adult outpatients and competent in the complete history, physical examination, oral and written presentations, and basic clinical skills such as reading EKGs. Perhaps most important, they have learned to accurately assess their own strengths and weaknesses and create learning plans for themselves – preparing them to succeed in the next three years of the curriculum and a lifetime of professional practice.

Curriculum Timeline: Years 3 through 5
After Year 2, the clinical curriculum for the College Program is the same as the University Program. In all Core Clinical Rotations, students experience both breadth and depth in clinical care, and clinical experiences are developmental, with opportunities to reinforce, build upon, and transfer knowledge and skills. Clinical learning is also integrated across disciplines whenever possible, and the roles of basic science, civic professionalism, scholarship, and population health in clinical care are evident throughout the clinical curriculum. Students likewise have patient care responsibilities that are progressive in sophistication and increasing in amount as their level of clinical skill and knowledge increases, and all core clinical competencies are addressed and assessed using common methods applied at the clinical sites at which rotations occur.

Core Rotations: Beginning in July of their third year, students have the opportunity to begin their core clinical rotations. These rotations are organized in blocks that integrate core specialties at one site for 8 or 12 weeks. Core 1 combines Family Medicine, Internal Medicine, and Geriatrics for 12 weeks, Core 2 combines Pediatrics and OB/Gyn for 12 weeks, Core 3 combines Neurology and Psychiatry for 8 weeks, and Core
4 combines Surgery and Undifferentiated Care for 8 weeks. Each of these clinical rotations is offered at all of the School of Medicine’s hospital affiliates (including University Hospitals of Cleveland, the Cleveland Clinic, MetroHealth Medical Center and the Louis Stokes VA Medical Center).

These Core Clinical Rotations, launched in July 2006 and modified in 2009 and 2012, represent an integrated approach to clinical education that is shared by students from both the University and College programs of the School of Medicine. Students engage in clinical learning with basic science correlation through patient-based experiences that are developmental and provide opportunities to acquire, reinforce, build upon, and transfer knowledge and skills.

**Advanced Clinical and Scientific Studies**

Advanced clinical and scientific studies provide students with flexible learning opportunities that support ongoing professional development and residency preparation and planning:

- **Two Acting Internships** are required: one in Internal Medicine, Surgery, Pediatrics, or Inpatient Family Medicine, and one in an area of student choice.
- **One Acting Internship and all electives** can potentially be done outside of the CWRU system.
- **Students are encouraged to augment their interest in scholarship** through rotations and activities that focus on sciences basic to medicine as well as clinical rotations.

The last three years are purposely designed as a flexible continuum of core clinical rotations, clinical and other electives, and research — to allow each student to individualize the curriculum to address his/her own career goals, learning needs and research interests. Each student plans the last three years with the advice of his/her physician and research advisors.

Every CWRU student must pass the CWRU Clinical Skills Examination and USMLE Step 2 CK (Clinical Knowledge) and CS (Clinical Skills) Examinations to graduate from the CWRU School of Medicine. Students take OSCEs similar in format and content to the USMLE Step 2 CS Examination as part of routine assessments of their clinical skills beginning in Year 1 and are well prepared for the CWRU Clinical Skills Examination and USMLE Step 2 CS Examination by the time they have completed the required clinical rotations. Students must take the USMLE Step 2 CK and CS Examinations by October 31 of their 5th year.

Students spend 12 to 15 months during the last three years on their mentored research project, including preparation and defense of a masters’ level thesis. Students are expected to complete their research in one block of time. During time devoted primarily to research, students spend one half-day each week in related clinical activities. Students must complete all required thesis research rotations by December 31 of Year 5 and defend the Research Thesis within 3 months of research completion, but no later than February 15 of Year 5. Within these guidelines, students and their advisors are encouraged to be as creative as possible in designing the final 3-year continuum. Research may be conducted with faculty research advisors at any CWRU campus, or in some instances, with advisors at a limited number of other institutions (e.g., the NIH), with advanced approval from the Research Education Committee. Student research may focus on clinical, translational or basic research. Some students may wish to engage in health services research, research in biomedical ethics, or other areas relevant to the advancement of biomedical science and the care of patients in addition to the more “traditional” research areas.

**The Student Portfolio: Competency-Based Assessment and Reflective Practice**

The College’s approach to student assessment is based on two key educational concepts – “competency-based assessment” and “reflective practice.” Competency-based assessment emphasizes the need for every student to achieve the broad range of required learning outcomes by providing an appropriate curriculum, learning resources, and regular formative assessments. No grades are assigned in the College Program during the 5-year program; when a student achieves the standards for all competencies, they are assigned a “Achieves Expectations” (“AE”) for each course on their transcript. Assessment of student performance is criterion-referenced, not norm-referenced; students are not compared to one another but to faculty-defined standards of achievement. A full range of assessment methods are used to profile learning outcomes. Reflective practice emphasizes that learning is dependent upon the integration of reflection and experience. Professionals learn by reflecting on their experiences both during the experiences (“reflection-in-action”) and after the experiences (“reflection-on-action”) and by using these reflections to develop new knowledge and skills. The assessment process helps our students develop their reflective practice skills – the ability to accurately describe, analyze and evaluate their performance and to identify and follow through on effective learning plans. We are committed to helping every student achieve our competency standards and develop reflective practice skills through frequent formative assessments and close advising.

Evidence of achievement for each of the Case Western Reserve University School of Medicine’s Program’s 9 competencies is collected and documented in an electronic portfolio. Students and their advisors share access to the e-Portfolio database of evidence and thus can track and document student progress in meeting our nine competencies. A broad range of types of evidence is collected from the learning experiences in the research, basic science, and clinical curriculum.

During research blocks, research preceptors, journal club facilitators, problem-solving session facilitators, and student peers provide written assessments of both individual work and teamwork in the lab, written and oral presentations, and critical thinking and reasoning skills. Written research proposals and reports and the final thesis are also included in the e-Portfolio.

During the basic science courses, students complete weekly online quizzes called Self-Assessment Questions (SAQs) that cover the breadth of knowledge for each week’s theme at the level of factual recall and simple application of the facts. Faculty design the SAQs so that students who are actively participating and studying should expect to know at least 80% of the answers; the individual results of the SAQs are available only to the students, but students are encouraged to contact the course director for help with any difficulties they are having. Students have continued access to the SAQs to assess their retention of this basic science knowledge. At the end of each week, students complete 1-2 open book Concept Appraisals (CAPPs) designed to determine if they have mastered the concepts for that week well enough to apply them to new or different problems or situations in brief, well-organized, clearly written essay(s). CAPPs are designed to assess depth of knowledge in key concept areas. Other evidence is provided by PBL facilitators and peers who provide assessments of performance in PBL sessions.

Assessments in the clinical curriculum include written feedback on performance from longitudinal preceptors and other faculty physicians and residents, results of OSCEs, patient logs documenting breadth of clinical exposure, patient journals in which students record their
reflections on specific patients and their problems, self-assessments of videotaped interviews with patients (both standardized and real), and feedback from patients and other health care providers.

Students are expected to meet regularly with their physician advisor to discuss their progress. Several times each year, they are required to review their assessment evidence in relation to expected levels of achievement in the 9 competencies and write Formative Portfolios composed of structured reflective essays on how the evidence demonstrates their development as doctors and researchers. Based on this analysis, they develop learning plans to address areas needing improvement. The essays also include judgments on whether previously established learning goals have been achieved and reflections on the process of achieving these goals. Students discuss these materials with their physician advisors during Formative Assessment meetings. During the last three years, students submit learning plans on a bi-annual basis and meet with their physician advisor to review their progress. Students are expected to assume more and more responsibility and independence in accurate self-assessment, in developing learning plans and following through on addressing their own learning needs, and in recognizing and building on their own strengths.

At the end of Years 1, 2 and 4, students assemble a Summative Portfolio for review by the Medical Student Promotions and Review Committee that determines if the evidence presented by the student indicates a level of achievement sufficient for promotion to the next year of the program (or graduation). Students are expected to choose not only their best examples of their work, but more importantly evidence demonstrating their growth across the year in specific competencies. We want to graduate students who recognize areas needing improvement, identify an approach to addressing them, and can show that they have now achieved that skill as well as those students who excel in specific areas throughout the year. Graduates of CCLCM will have not only achieved a defined level of achievement of each of the 9 competencies, they will also have developed their reflective ability to accurately assess their own strengths and areas needing improvement. The assessment process is designed to enhance student learning and the student portfolio enables students to document their progress in the achievement of defined competencies.

Graduation Requirements

To graduate from CWRU School of Medicine with the MD degree (or the MD degree with Special Qualifications in Biomedical Research for students in the Cleveland Clinic Lerner College of Medicine program), students must:

1. Satisfactorily complete all Program Specific Requirements and Educational Program Objectives of the School of Medicine
2. Pass the USMLE Step 1 and USMLE Step 2 CK and CS
3. Pass or remediate the School of Medicine’s Clinical Skills Exam
4. Satisfactorily complete the MD Thesis
5. Meet financial obligations to the University
6. Be approved to graduate by the Committee on Students

Dual Degree Programs

Dual Degree Programs with the MD

The degree programs listed in this section may require admission to another school at the university in addition to or instead of the School of Medicine. Each school may have different deadlines and requirements for admissions. Please contact the other schools separately using information provided under that school’s listing in this publication. Additional dual degree programs not including the MD are also offered through the medical school’s departments. Several certificate programs (p. 81) are also offered in General Medical Sciences (p. 72).

MD/PhD (MSTP)

The Medical Scientist Training Program (p. 28) leads to the MD/PhD in various biomedical programs. Additional admissions information can be obtained here (https://case.edu/medicine/admissions-programs/md-phd-program/prospective-students/mstp-admissions).

Doctor of Medicine- MD/JD

This program, offered in conjunction with Case Western Reserve University School of Law, may be completed in six years. The JD portion requires the completion of 88 credit hours of study. Admission is through the School of Medicine and the School of Law. For more information about the JD portion of the program, visit the Law School section (http://bulletin.case.edu/schooloflaw/dualdegreeprograms), call the law school admissions office at 216.368.3600 or 800.756.0036, or e-mail lawadmissions@case.edu (//lawadmissions@case.edu).

Master of Arts in Bioethics- MD/MA

The 27-credit-hour Master’s degree program, including a 12-hour foundations course taken during the first year of medical school, provides advanced training in bioethics while emphasizing the interdisciplinary and interprofessional nature of the field. In this program, medical students will participate in and contribute to the critical analysis of moral issues related to health, health care, and health policy at local, national and international levels. Medical school students complete the bioethics program while pursuing their medical degrees; no additional time is required. Admission for the master’s degree portion is through the Case Western Reserve University School of Graduate Studies. For more information about the MA requirements, visit the Bioethics section (p. 59), call 216.368.8718, or e-mail bioethics@case.edu (//bioethics@case.edu).

Master of Public Health- MD/MPH

Graduates of this 5-year, 36-hour master’s degree program are qualified to work in local and state health departments, universities and colleges, hospitals, ambulatory medical centers, non-profit organizations and the insurance and pharmaceutical industries. Areas of concentration include adolescent health, health promotion and disease prevention, epidemiology, public health research, health management and policy, clinical research, international health, human sexuality and reproductive health, and urban health. For more information about the MPH requirements, visit the Master of Public Health website (http://mph.case.edu), call 216.368.3128, or email mph-info@case.edu (mph-info@case.edu).

Master of Science in Applied Anatomy-MD/MS

Students seeking advanced training in the anatomical sciences may begin the 30-hour master’s degree program in the fall or spring semester of the first year of medical school. Required graduate courses include the anatomical sciences core curriculum, completed during the first two years of medical school, and an advanced surgical anatomy course taken in the fourth year. Students earn the remaining credits through elective courses. Completion of a thesis is not required, but students
may undertake independent research experiences as electives; a thesis-based program also is available. Interested medical students must apply to the master’s program through the Department of Anatomy. The program is excellent preparation for those preparing for biomedical careers or those planning to pursue a PhD. Additional details and a sample course of study are described in the Anatomy section (p. 42) of the General Bulletin. For more information about the MS requirements, visit the Master of Science in Applied Anatomy website (https://case.edu/medicine/anatomy/curriculum), call 216.368.2433, or email anatomy@case.edu.

Master of Science in Biomedical Engineering- MD/MS

Medicine is undergoing a transformation based on the rapid advances in science and technology that are combining to produce more accurate diagnoses, more effective treatments with fewer side effects, and improved ability to prevent disease. The goal of the MD/MS in Engineering is to prepare medical graduates to be leaders in the development and clinical deployment of this technology and to partner with others in technology based translational research teams. Current CWRU medical students in either the University Program (UP) or the Cleveland Clinic Lerner College of Medicine (CCLCM) may apply to the MD/MS in Engineering program.

Students must complete the normal requirements in either MD program. Portions of the medical school curriculum earn graded credit toward the MD/MS degree. Six credit hours can be applied to the MS component of the joint degree. The balance of 12 credit hours (4 courses) must be graduate level engineering concentration courses that provide rigor and depth in a field of engineering relevant to the area of research. All students attend monthly seminars focusing on the integration of engineering and medicine, with the opportunity to present their own research and to hear and interact with other presenters. Students must also complete training in the responsible conduct of research. The thesis serves as a key integration role for the joint degree, with both medical and engineering components. The thesis also fulfills the research requirement of the UP or CCLCM programs. Students should apply through the BME department admissions office. For more information about the MS requirements, visit the Biomedical Engineering website (http://engineering.case.edu/ebme), call 216.368.4063, or email bmedept@case.edu.

Master of Science in Biomedical Investigation- MD/MS

This five-year dual degree program is designed for students who wish to prepare for careers in basic or clinical research at academic medical centers. The core components of this degree are three to six graduate courses in a specific track chosen by the student based on his or her interest, six graded credits of medical school coursework, a common seminar series, training in scientific integrity, and a full-year research project culminating in a written report and examination by faculty. Tracks include biochemistry, clinical investigation, epidemiology, health services research, nutrition, pathology, and physiology and biotechnology. Each track has specific course requirements. There is no tuition charge for the research year, and a stipend is provided. For more information contact the College Program Advisor, Dr. Chris Moravec (MORAVEC@ccf.org) or the University Program Advisor, Dr. William Merrick (william.c.merrick@case.edu).

Master of Business Administration- MD/ MBA

There is a growing need for physicians with business skills to manage organizations such as corporate practices, hospitals, etc. Those who complete this 5-year program will be able to apply learned management principles and take leadership roles as they navigate through varying and increasingly complex healthcare environments. For more information about the MBA requirements, visit the Weatherhead School of Management website (https://weatherhead.case.edu/degrees/masters/dual-degree/md-mba), call 216.368.2030, or email casemed-admissions@case.edu.

Master of Anthropology- MD/MA

This 4-year dual degree program is an organized course of study for students with a range of medical anthropological interests, from ethnomedicine to international health, urban health, psychiatric anthropology, psychological anthropology, cross-cultural aging, human adaptation and disease, nutritional anthropology, etc. The program is designed for students who wish to pursue anthropology beyond the baccalaureate level and to become acquainted with professional work in anthropology and to meet the challenges of our increasingly globalized world. For more information about the MA requirements, visit the Department of (http://anthropology.case.edu) Anthropology (http://anthropology.case.edu/graduate-programs/joint-programs/mdma-or-mdphd) website (http://mph.case.edu), call 216.368.2264, or email the Department Administrator, Linda Rinella (linda.rinella@case.edu).

Medical Scientist Training Program (MSTP)

A combined MD/PhD program in biomedical sciences, the Medical Scientist Training Program (MSTP) is available for students desiring research careers in medicine and related biosciences. This program takes seven to eight years to complete, depending on the time needed to complete the PhD dissertation research. Financial support includes a stipend and full tuition support.

Candidates must meet established prerequisites for admission to both the School of Medicine and the School of Graduate Studies. Criteria include demonstrated capabilities in research and superior undergraduate academic credentials. Applicants must have either U.S. citizenship or permanent residency status to be considered for admission to the MSTP. Information can be obtained by contacting the MSTP program (mstp@case.edu) or from the program website (http://mstp.case.edu). Admissions are coordinated via the School of Medicine admissions program and the AMCAS application.

The first two years of the MSTP are centered on the University Program pre-clinical core medical school curriculum, which occupies five mornings each week. Afternoons include time for graduate courses and/or research rotations, as well as clinical training, thus integrating the medical school and graduate school experiences. The next three to four years are devoted to completion of graduate courses and PhD thesis research in one of the multiple MSTP-affiliated graduate programs. During the PhD phase, MSTP students participate in the MSTP Clinical Tutorial, a program designed to enhance clinical skills and allow students to develop connections between their research and clinical interests (this further addresses the goal of integrating medicine and science). After
completion of the PhD program, students return to medical school for two years to complete clinical clerkships and finish the MD curriculum.

The program is administered by the MSTP Steering Committee, which consists of faculty from both basic science and clinical departments. Its functions include selecting candidates for admission, designing and administering the program curriculum, advising students and evaluating student progress.

Please see the Doctor of Medicine (MD) (http://bulletin.case.edu/schoolofmedicine/md) page for information about the MD curriculum.

**MSTP Program by Year**

**Year 1**
- University Program MD curriculum
- Summer Intro to MSTP course
- One graduate course or research rotation each semester (fall and spring)

**Year 2**
- University Program MD curriculum
- Summer research rotations (1 or 2)
- Graduate course or research rotation in the fall semester

**Year 3**
- PhD program

**Year 4**
- PhD program
- MSTP Clinical Tutorial

**Year 5**
- PhD program
- Optional MSTP Clinical Tutorial

**Year 6 (If Needed)**
- PhD program
- Optional MSTP Clinical Tutorial

**Year 7**
- Third year MD curriculum (core clinical clerkships)

**Year 8**
- Fourth year MD curriculum (completion of core clinical clerkships if necessary, clinical and research electives)

The Medical Scientist Training Program in detail

**General Description**

The Case Medical Scientist Training Program (MSTP) provides training for future physician-scientists by integrating well-developed curricula in science and medicine. Unique aspects of the program include the integration of graduate school and medical school in many phases of the program to optimize dual-degree training and a high degree of student involvement in running the program.

The MSTP includes three major phases of training.

**First phase:** During the first two years, each student completes the first two years of the University Program medical school curriculum, including early clinical experiences, completes at least three research rotations, takes graduate courses, and chooses his or her PhD graduate program and thesis lab. During the summer between the first two years of medical school, students complete one or two research rotations. During the fall and spring semesters of year one and the fall semester of year two, students take a graduate course or complete a research rotation.

**Second phase:** During the PhD phase, students complete all requirements of their PhD program. They also participate in the MSTP Clinical Tutorial for at least one year in a patient-based clinical specialty. A second year of MSTP Clinical Tutorial is optional.

**Third phase:** In the final phase, students complete years three and four of the University Program medical school curriculum. The focus is clinical training, but research electives can be taken for part of year four.

Although each of these three phases has a different focus, opportunities exist for students to pursue both research and clinical training in each phase. The philosophy of the Case MSTP is to integrate medicine and science throughout the program as much as possible.

The Case MSTP is run by faculty, students and staff. The MSTP Council is a body of students that plans and runs certain aspects of the program. The administrating director, program coordinator, and program assistant have many important roles and run the day-to-day management of the program. The co-director is involved in decisions at all levels of the program and is the primary advisor for students in the first two years of the program. The director is responsible for all aspects of the program and is available to students for advice at any stage. The MSTP Steering Committee makes decisions on MSTP policy, curriculum planning, student admissions, approval of mentors and evaluation of students.

Incoming MSTP students are expected to enter the program on or about July 1. The MSTP summer retreat, usually held in early July, provides an important orientation to the program and includes sessions and workshops for program and professional development.

**Advising System**

The program director provides advising to students in all phases of the program. The MSTP co-director advises students in the first two years on research rotations and course work. Students may also meet with an MSTP Steering Committee member representing an area of research interest or with the MSTP director. During the PhD training period, mentoring is provided by the thesis advisor and thesis committee, which includes a member of the MSTP Steering Committee and a member with an MD. MSTP students are full members of the medical school class and enter one of the four societies of the University Program when they matriculate in the program. The society dean provides important advice on matters concerning the MD curriculum.
Classes and Research Rotations in Years One and Two

During years one and two of the University Program, MSTP students register for 9 credit hours of graduate course work each semester.

### Plan of Study

#### First Year

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<thead>
<tr>
<th>Course</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<td>Clinical Science I (IBIS 411)</td>
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#### Second Year

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<td>3-4</td>
<td></td>
</tr>
<tr>
<td>Clinical Science III (IBIS 413)</td>
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<tr>
<td>Research Rotation in Medical Scientist Training Program (MSTP 400)*</td>
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<td>0-3</td>
</tr>
<tr>
<td>Graduate School courses</td>
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<td>5-6</td>
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<td>Year Total:</td>
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<td>8-10</td>
</tr>
</tbody>
</table>

Total Units in Sequence: 23-37

* MSTP 400 Research Rotation in Medical Scientist Training Program or an appropriate graduate school course. If a 4-credit graduate course is taken, registration in IBIS 401 Integrated Biological Sciences I, IBIS 402 Integrated Biological Sciences II or IBIS 403 Integrated Biological Sciences III is reduced to 3 units.

IBIS 401 Integrated Biological Sciences I, IBIS 402 Integrated Biological Sciences II and IBIS 403 Integrated Biological Sciences III are 3-4 credits each. IBIS 411 Clinical Science I, IBIS 412 Clinical Science II, and IBIS 413 Clinical Science III are 2 credit hours each. In contrast to their fellow medical students, MSTP students are graded during years one and two of the medical school curriculum for these graduate courses, which provide graduate school credit for the medical school curriculum. These grades are for graduate school purposes and do not affect standing in the medical school.

In addition to the medical curriculum, students take MSTP 400 Research Rotation in Medical Scientist Training Program or one 3-4 credit graduate school course per semester in the first two years. Graduate courses are scheduled in the afternoon in the fall and spring semesters to avoid conflict with the medical school curriculum. MSTP students will be registered for MSTP 400 during the summer terms before each of the first two years of medical school. Students also may complete a research rotation instead of a graduate school course during the fall or spring semester.

### The PhD Phase

After completion of the second year of medical school, each student chooses a PhD thesis mentor, joins a specific PhD program, and completes any remaining graduate school course work and other requirements for the PhD degree. The following training programs are affiliated with the MSTP. (If the training program is not itself an independent PhD program, the program through which it is offered is indicated in parentheses.)

- Biochemistry
- Biomedical Engineering
- Cancer Biology (Pathology)
- Cell Biology
- Clinical Translational Science
- Epidemiology and Biostatistics
- Genetics and Genome Sciences
- Immunology (Pathology)
- Molecular Biology and Microbiology
- Molecular Virology
- Neurosciences
- Nutrition
- Pathology (Molecular and Cellular Basis of Disease)
- Pharmacology
- Physiology and Biophysics
- Structural Biology and Biophysics
- Systems Biology and Bioinformatics

All MSTP students are required to take a one-week responsible conduct of research (RCR) course (IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research) during the spring semester of their second year in the program.

#### Clinical Tutorial, Clinical Refresher Course and Years Three and Four of Medical School

During the PhD thesis phase, MSTP students take the MSTP Clinical Tutorial, which provides a unique longitudinal part-time clinical experience. The MSTP Clinical Tutorial is a year-long course that enhances clinical skills for year three of medical school. It also serves a special career development objective by allowing students to balance medical and scientific interests and explore the connections between these areas. The MSTP Clinical Tutorial, offered during the PhD phase, is an example of the integration of science and medicine in the Case MSTP. An optional MSTP Clinical Refresher course may be taken before the start of year three. After completion of the PhD, MSTP students are enrolled in medical school to complete the requirements for the MD (see description provided for the University Program [http://bulletin.case.edu/ schoolofmedicine/md/#universityprogramtext]).

#### MSTP Activities

The MSTP supports several activities that enhance the scientific and professional development of students. These activities also foster a vibrant and collegial MSTP community with a strong sense of mission in the training of physician scientists.
Summer retreat: The annual MSTP summer retreat is a two-day event focusing on scientific presentations, professional development and program planning for the upcoming academic year.

Winter retreat: This is a one-day retreat on campus, usually in early March. Students in their research years present their thesis work through an oral or poster presentation.

MSTP Council coordinates many activities of the Case MSTP. The Council meets once each month to discuss activities that are run by different student committees. The overall goals of the MSTP Council are to identify objectives for the program, to allow students to initiate programs to enhance the MSTP, to encourage increased student involvement in the operation of the MSTP, and to enhance development of leadership skills of MSTP students. The president, vice president, and secretary are all elected for a one-year period. Committees are led by 1-3 committee chairs who take charge of committee activities and coordinate the involvement of other students in the committee activities. All students are welcome and encouraged to participate in the various committees and to attend the council meetings. Recent Council committees and other program activities have included the following:

1. **Monthly Dinner Meeting Committee**
   This committee is responsible for planning monthly dinner meetings, selecting topics, speakers, and menus. The series is organized by students and is attended by students, Steering Committee members, and research mentors. Invited speakers (students, faculty, alumni and outside speakers) address issues pertinent to research, professional issues, career development or other topics of interest. The informal environment at these gatherings promotes social and professional interactions.

2. **Communications and Webpage Committee**
   This committee organizes communications and the Case MSTP website content.

3. **Summer Retreat Committee**
   This committee plans the summer retreat.

4. **Intro to MSTP**
   This committee organizes events for first year MSTP students, to integrate them into the program and the community.

5. **Community Service Committee**
   Plans events for involvement of MSTP students in community service.

6. **Social Committee**
   This important committee plans fun events throughout the year!

7. **Student Representative to Faculty Council**
   One student is selected to represent the MSTP on Faculty Council.

8. **Student Representative to the Committee on Medical Education**

9. **Representative to the Graduate Student Senate**

10. **MSTP Women’s Committee**
    Women in the MSTP organize luncheons or other meetings to discuss issues that face women pursuing careers in science. Students may invite a successful woman scientist who provides a role model as a physician scientist.

**Scientific meetings:** The program strongly encourages students to present their research at national or international meetings and provides financial support to pay for part of meeting travel expenses (other funding is obtained from the research mentor). In addition to the general meeting support for all students, each year two students are offered the opportunity to attend the annual MD/PhD national student conference in Colorado or the American Physician Scientist Association annual meeting in Chicago, with all expenses paid by the MSTP.

**Research symposia:** MSTP students are encouraged to present their research at Case student symposia, including the annual graduate student symposium and the Irwin H. Lepow Student Research Day. These symposia feature a nationally recognized keynote speaker, and students have the opportunity to interact extensively with the noted scientist. A committee awards prizes for outstanding student presentations.

**Assessment of MSTP Students**
Students in the MSTP are assessed for the medical school component of the program in the same manner as students in the University Program, with the exception that grades are awarded for those courses in the MD curriculum in years one and two that receive graduate school credit and are used to satisfy requirements for the PhD degree. Students must satisfactorily complete all requirements for both the MD and the PhD.

**IBIS Courses**

**IBIS 401. Integrated Biological Sciences I. 1 - 9 Units.**
A four-semester sequence encompassing anatomy, biochemistry, physiology, pharmacology, pathology, and microbiology.

**IBIS 402. Integrated Biological Sciences II. 1 - 9 Units.**
A continuation of IBIS 401.

**IBIS 403. Integrated Biological Sciences III. 1 - 9 Units.**
A continuation of IBIS 402.

**IBIS 411. Clinical Science I. 2 Units.**

**IBIS 412. Clinical Science II. 2 Units.**

**IBIS 413. Clinical Science III. 2 Units.**

**IBIS 434. Integrated Biological Sciences in Medicine. 6 Units.**
This course is open only to candidates enrolled in the M.D./M.S. program (College plan). Registration is for the Spring semester of the second year in medical school. The course content includes the areas of hematology, gastroenterology and renal physiology. Students will also be required to participate in Process of Discovery. Assessment of performance will be through requirements for the medical areas identified above and by the evaluation of a term paper. Recommended preparation: First three semesters of medical school and currently a medical student in good standing.

**IBIS 451. Clinical Science (for M.D./M.A. Bioethics Students). 3 Units.**

**IBIS 600. Exam in Biomedical Investigation. 0 Unit.**
Students are required to pass an examination established for each student, generally reflecting the preparation and oral defense of a written report on the project. Prereq: Must be enrolled in MD/MS Biomedical Investigation program.
Physician Assistant Program

Physician Assistant Program Plan of Study-27 Months

Didactic Curriculum Summer Semester I, Fall Semester I, and Spring Semester I

First Year

<table>
<thead>
<tr>
<th>Course</th>
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<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Foundations of Clinical Medicine-Principles of Interviewing (PAST 401)</td>
<td>3</td>
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</table>
Diagnostic Methods-Clinical Lab (PAST 403)  1  
Clinical Correlations (PAST 404)  1  
Professional Issues for PA's-History & Roles of the PA I (PAST 411)  1  
Cadaver dissection-based human anatomy with histology and physiologic correlations (PAST 410)  6  
Physical Diagnosis (PAST 402)  4  
Medical Microbiology & Infectious Disease (PAST 405)  2  
Pharmacology I (PAST 420)  2  
Principles of Internal Medicine (PAST 430)  7  
Pre-Clinical Clerkships I (PAST 440)  1  
Human Physiology (PAST 477)  4  
Ethics in Healthcare Delivery (PAST 406)  1  
Professional Issues for Physician Assistants II (PAST 412)  2  
Pharmacology II (PAST 421)  3  
Principles of Clinical Medicine-Surgery & Emergency Medicine (PAST 431)  4  
Principles of Clinical Medicine-OB/GYN (PAST 432)  3  
Principles of Clinical Medicine-Pediatrics (PAST 433)  3  
Principles of Clinical Medicine-Behavioral Medicine (PAST 434)  2  
Pre-Clinical Clerkships II (PAST 441)  1  
Year Total:  12  

Total Units in Sequence:  51  

Didactic Curriculum Summer Semester II  

Second Year  

Clinical Procedures (PAST 407)  4  
Professional Issues for Physician Assistants III (PAST 413)  2  
Culture and Health (PAST 450)  2  
Introduction to Public Health (PAST 451)  1  
Introduction to Evidence Based Medicine (PAST 452)  2  
Medical Spanish Elective (PAST 453) or Research Methods Elective (PAST 454)  1  
Year Total:  12  

Total Units in Sequence:  12  

Clinical Curriculum Year  

PAST 500 Clinical Residency: Emergency Medicine Rotation  3  
PAST 501 Clinical Residency: Family Medicine  3  
PAST 502 Clinical Residency: Geriatrics  3  
PAST 503 Clinical Residency: Internal Medicine Rotation  3  
PAST 504 Clinical Residency: Obstetrics & Gynecology  3  
PAST 505 Clinical Residency: Pediatrics  3  
PAST 506 Clinical Residency: Behavioral and Mental Health  3  
PAST 507 Clinical Residency: Surgery  3  
PAST 508 Clinical Residency: Primary Care Elective  3  
PAST 509 Clinical Residency: Inpatient Medicine Elective  3  
PAST 510 Clinical Residency: Elective  3  
PAST 511 Clinical Residency: Elective  3  
PAST 600 Capstone Quality Improvement Project & Comprehensive Examination  3  

Required Clinical Experience Credit hours = 39 hours  
Total Credit Hours to Complete Program: 102  

Courses  

PAST 401. Foundations of Clinical Medicine-Principles of Interviewing. 3 Units.  
The general purpose of this course is to teach the physician assistant student the skills necessary to conduct a clinical/medical interview with a patient and to be able to present the information to other health care professionals in both an oral and written form. This course, which is designed as small, group seminars, will focus on the skills necessary to question patients in a directed fashion and to listen to the patient with concern and empathy. Instruction will emphasize what data is needed in a complete medical history as well as the focused interview, the proper technique for gathering information, and the format for presentation of the data. Instructional techniques will include role-playing, small group discussion, and observation and critique by instructors, other students and simulated patient models. Prereq: Students must be in Physician Assistant Program.  
PAST 402. Physical Diagnosis. 4 Units.  
This lecture/discussion/laboratory course presents and explores the techniques for performing a complete and competent physical examination, understanding the pathophysiology presented by the patient, and organizing and reporting the findings in both written and oral format. Synthesis of historical and physical presentations for an accurate evaluation of the patient will be emphasized. The problem-oriented physical examination and special examination tools and techniques will be presented. Instructional techniques will include small group discussion, practical experience with other students and faculty, and the observation and critique of physical examination skills by faculty. Prereq: Students must be in Physician Assistant Program.
PAST 403. Diagnostic Methods-Clinical Lab. 1 Unit.
This course is designed to introduce the student to clinical laboratory and diagnostic medicine. Lectures are designed to review the various types of laboratory tests, acquisition and handling of specimens, normal values as well as interpretation of results and correlation with clinical conditions. This course also includes an introduction to radiology, microbiology and electrocardiogram interpretation. The skills learned here carry over to the principles of medicine series in subsequent semesters. Prereq: Students must be in Physician Assistant Program.

PAST 404. Clinical Correlations. 1 Unit.
This seminar course places emphasis on internal organs with clinical correlation to anatomic conditions. Content will include basic concepts of genetics, the comparison of normal and abnormal structural relationships and the demonstration of how these things relate to health and disease. Students will review on-line genetics learning modules and meet in small seminar groups to review anatomical clinical correlates. Prereq: Students must be in Physician Assistant Program.

PAST 405. Medical Microbiology & Infectious Disease. 2 Units.
This course is the study of microorganisms and the diseases they cause in man. It includes consideration of infectious disease microorganisms including their biochemical, serological and virulence characteristics, and clinical manifestations. An organ system approach is used to examine the fundamentals of pathogenicity, host response, epidemiological aspects of infectious disease, as well as clinical manifestations, diagnosis and treatment of infections with clinical correlations. Prereq: Students must be in Physician Assistant Program.

PAST 406. Ethics in Healthcare Delivery. 1 Unit.
This course is an overview of the discipline of medical ethics presenting the study and application of relevant principles, insights, and understandings of modern medical practice. The course includes a brief overview of ethical theories which lay the foundation for subsequent investigation into specific ethical problems found in medical science and technology. The purpose of the course is to provide a framework which enables the student to reason clearly and effectively about the ethics involved in medical science and technology. The course assumes no prior knowledge of philosophical ethics or medical science. A framework of ethical decision making is introduced and practiced using realistic medical cases via seminar discussion. Prereq: Students must be in Physician Assistant Program.

PAST 407. Clinical Procedures. 4 Units.
The purpose is to prepare these future clinicians for clinical management of health and disease by preparing them for common clinical procedures. These will include basic and advanced surgical skills, basic laboratory skills, common outpatient procedures, common emergency procedures, and interpretation of common radiologic tests. Prereq: Students must be in Physician Assistant Program.

PAST 410. Cadaver dissection-based human anatomy with histology and physiologic correlations. 6 Units.
This course will provide students with a sound understanding of the normal human body as a foundation for subsequent pursuing biomedical careers. A combination of daily lectures and laboratories integrates cadaver dissection-based gross anatomy with the associated histology, embryology, neuroanatomy and basic physiology. This course is well-suited to all biomedical careers, including pre-clinical and biomedical undergraduates, post-baccalaureate, pre-clinical master of science graduate programs, plus medical and dental students seeking additional training in the anatomical sciences. It will meet any of the anatomy-oriented prerequisites being implemented for medical and dental school applications, including those preferring or requiring a cadaver-based experience. The assessments will include a combination of written and cadaver-based practical questions. Offered as ANAT 410 and PAST 410. Prereq: Students must be in Physician Assistant Program.

PAST 411. Professional Issues for PA's-History & Roles of the PA I. 1 Unit.
In this three course series students explore, through lecture and discussion, the factors affecting the development of the profession and role socialization with emphasis on history and regulations/organizations governing PA practice. An overview of clinical responsibilities, team based practice, the PA role, and licensing/credentialing practices will be presented and discussed. Prereq: Students must be in Physician Assistant Program.

PAST 412. Professional Issues for Physician Assistants II. 2 Units.
In this three course series students will explore factors affecting the development of the profession, the status of the PA in the U.S. healthcare system and current issues in clinical practice including practice-based improvement and systems-based practice. Through lecture and discussion, this series prepares the student for the transition from classroom to clinical training and clinical practice. Emphasis is given to the responsibilities that come with being a professional, professionalism and practicing quality improvement. Prereq: Students must be in Physician Assistant Program.

PAST 413. Professional Issues for Physician Assistants III. 2 Units.
In this three course series students will explore factors affecting the development of the profession, the status of the PA in the U.S. healthcare system and current issues in clinical practice including practice-based improvement and systems-based practice. Through lecture and discussion, this series prepares the student for the transition from classroom to clinical training and clinical practice. Emphasis is given to the responsibilities that come with being a professional, professionalism and practicing quality improvement. Prereq: Students must be in Physician Assistant Program.

PAST 420. Pharmacology I. 2 Units.
In this two course series, (PAST 421 Pharmacology II) students will be provided with a basic introduction to the principles of pharmacology and to drug classes of particular relevance to the physician assistant. Information concerning drug doses and calculations used in determining doses will be included in this course and PAST 421 Pharmacology. Prereq: Students must be in Physician Assistant Program.
PAST 421. Pharmacology II. 3 Units.
In this two course series (PAST 420 Pharmacology), physician assistant students will be provided with foundational knowledge of the therapeutic uses and effects of drugs. The indications, contraindications and adverse effects of prototypical drugs are covered. Drug dependence and addiction are also discussed. This course also includes a problem-based learning component which will enhance students’ teamwork and clinical reasoning skills by examining and analyzing case scenarios in small groups. Prereq: Students must be in Physician Assistant Program.

PAST 430. Principles of Internal Medicine. 7 Units.
This one semester lecture/discussion course provides students with a detailed study of the etiology, pathophysiology, signs, symptoms, diagnosis and treatment of various disorders encountered in internal medicine. A broad array of diseases in cardiology, dermatology, endocrinology, gastroenterology, gerontology, hepatology, hematology, oncology, urology, nephrology, neurology, pulmonology and rheumatology are explored. Prereq: Students must be in Physician Assistant Program.

PAST 431. Principles of Clinical Medicine-Surgery & Emergency Medicine. 4 Units.
This one semester lecture course presents the fundamentals of surgical disease and care of the acutely injured and ill patients. The purpose is to familiarize the student with the etiology, anatomy, pathophysiology, clinical manifestations and appropriate diagnosis and treatment of selected surgical conditions and conditions encountered in the surgical subspecialty and emergency medical settings. Prereq: Students must be in Physician Assistant Program.

PAST 432. Principles of Clinical Medicine-OB/GYN. 3 Units.
This lecture/case presentation course gives the student an overview of commonly encountered obstetric and gynecologic disorders. Anatomy and physiology of the human reproduction system are examined, including the changes in pregnancy, prenatal care, medical and surgical complications of pregnancy, pre- and postpartum care. Common gynecologic conditions, methods and effectiveness of contraception, cancer detection methods and the diagnosis and treatment of sexually transmitted infections in the female are explored. Prereq: Students must be in Physician Assistant Program.

PAST 433. Principles of Clinical Medicine-Pediatrics. 3 Units.
This course introduces the student to a unique, complex and challenging field of pediatrics. It emphasizes aspects of general pediatrics and provides a foundation for those students who elect to further study the health care of infants, children and adolescents. This course addresses issues unique to childhood and adolescence by focusing on human developmental biology, and by emphasizing the impact of family, community, and society on child health and well-being. Additionally, it focuses on the impact of disease and its treatment on the developing human, and emphasizes growth and development, principles of health supervision, and recognition of common health problems. Prereq: Students must be in Physician Assistant Program.

PAST 434. Principles of Clinical Medicine-Behavioral Medicine. 2 Units.
This one semester course gives students an overview of some of the most important areas in behavioral psychiatry. This course is an overview of basic psychiatric concepts and focuses on assessing patients who manifest psychological symptoms. Topics include diagnosis and treatment of anxiety disorders, mood disorders, common child and adolescent disorders, somatoform and factitious disorders, psychotic disorders, sleep disorders, adjustment and personality disorders, and drug and alcohol abuse and addresses forensic issues in behavioral health. Prereq: Students must be in Physician Assistant Program.

PAST 440. Pre-Clinical Clerkships I. 1 Unit.
This course/clerkship provides the student with clinical experience at clinical sites in the didactic year utilizing what was learned in Foundations of Clinical Medicine (Interviewing and Physical Diagnosis class/lab). During the pre-clinical time at program designated sites, students will continue to develop and apply their history and physical exam skills, interpersonal skills, oral presentation and medical documentation skills. For expanding skills and creating relationships within the community, this course also encompasses community service, experiential learning and interprofessional education activities. This course/clerkship will help to better prepare students to gain experience and develop confidence in approaching patients prior to entering the clinical year. Prereq: Students must be in Physician Assistant Program.

PAST 441. Pre-Clinical Clerkships II. 1 Unit.
This course/clerkship provides the student with clinical experience at clinical sites in the didactic year utilizing what was learned in Foundations of Clinical Medicine (Interviewing and Physical Diagnosis class/lab). During the pre-clinical time at program designated sites, students will continue to develop and apply their history and physical exam skills, interpersonal skills, oral presentation and medical documentation skills. For expanding skills and creating relationships within the community, this course also encompasses community service, experiential learning and interprofessional education activities. This course/clerkship will help to better prepare students to gain experience and develop confidence in approaching patients prior to entering the clinical year. Prereq: Students must be in Physician Assistant Program.

PAST 450. Culture and Health. 2 Units.
This lecture/discussion course provides students with a detailed understanding of the societal and individual prejudices, preconceptions, and biases that enter into the clinical interaction and how to develop appropriate responses and coping strategies. This course provides the student with common psychosocial problems encountered by health professionals today. Students explore issues related to sexuality, cultural competency, multicultural health, cross-cultural communication, and healthcare disparities. Prereq: Students must be in Physician Assistant Program.

PAST 451. Introduction to Public Health. 1 Unit.
This course will introduce students to concepts of public health and provide experience in public health by completion of a project. The course will enhance the student’s knowledge of the history and philosophy of public health, the Healthy People 2020 initiatives and the social determinants of health and how they can be impacted. Teaching methodologies will include discussion, lecture and development of a public health project. Prereq: Students must be in Physician Assistant Program.

PAST 452. Introduction to Evidence Based Medicine. 2 Units.
This course is intended to provide learners with a basic understanding of the principles of epidemiology, biostatistics and evidence-based medicine. The course involves analysis of prospective and retrospective studies, cross-sectional studies and experimental epidemiology. It will focus on epidemiological scenarios that relate to both infectious disease and chronic disease. In addition, the course will provide the student with a basic understanding of the application of statistical techniques to the biological and health sciences and to demonstrate their areas of application. Emphasis will be placed on probability laws, sampling and parameter estimation, test of hypothesis, correlation, regression and analysis of variance. Finally, students will be introduced to the basic concepts of evidence-based medicine, information mastery, and critical appraisal of the medical literature. Prereq: Students must be in Physician Assistant Program.
PAST 453. Medical Spanish Elective. 1 Unit.
This course will teach students the basics of Spanish as it applies to the medical field such as physical examinations, emergencies, common diseases within the Latino population, and specializations. By familiarizing students with conversational Spanish and medical Spanish, this course will enable students to apply their learning to real-world situations, to assist in communications, and ultimately to break down the barrier between doctors and patients. Prereq: Students must be in Physician Assistant Program.

PAST 454. Research Methods Elective. 1 Unit.
This lecture course introduces students to research design and scientific inquiry and provides them with the skills necessary for interpretation and critical evaluation of the medical literature. It includes a brief review of important statistical principles and methods and their application to problems in medicine and health. Prereq: Students must be in Physician Assistant Program.

PAST 477. Human Physiology. 4 Units.
This lecture/seminar experience is meant to enhance the student’s fundamental knowledge in human physiology with an emphasis on physiologic concepts in relationship to health, disease and illnesses. The course will provide students with an understanding of the function, regulation and integration of the major organ systems. Offered as PAST 477 and PHOL 477. Prereq: Students must be in Physician Assistant Program.

PAST 500. Clinical Residency: Emergency Medicine Rotation. 3 Units.
This clinical rotation is designed to expose the student to the wide variety of problems encountered in the hospital-based emergency room setting in both the fast track and acute care sides of the emergency department. The rotation experience includes the medical/surgical management of patients of all ages (infant to geriatric) with presenting problems that may be of a life threatening nature. The formulation and understanding of the many and varied medical problems is accomplished via the accurate collection of data through a history and physical exam, interpretation of diagnostic testing, and the development of a plan. The student will also be exposed to and perform diagnostic and therapeutic procedures. These experiences will be under appropriate supervision. Prereq: Students must be in Physician Assistant Program.

PAST 501. Clinical Residency: Family Medicine. 3 Units.
This clinical rotation is designed to give the student an understanding of family medicine/primary care medicine as practiced in office and/or clinic in an outpatient setting. The student will work with patients from a variety of social, economic and cultural backgrounds across the lifespan. They will experience continuity of care while assessing, diagnosing, monitoring, managing, referring and educating patients. The student will be exposed to both acute and chronic problems as well as the psychosocial problems that are encountered in this setting. Students may encounter and participate in the care of patients of all ages: pediatric, adolescent, adult and geriatric populations. The formulation and understanding of the many and varied medical problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem. Prereq: Students must be in Physician Assistant Program.

PAST 502. Clinical Residency: Geriatrics. 3 Units.
This clinical rotation is designed to give the student an understanding of geriatric medicine. The understanding of the many and varied medical and psycho-social problems in geriatric patients is accomplished via the accurate collection of data through a complete history and physical examination, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem. Teaching rounds and lectures may be used to introduce concepts of geriatric medicine. Prereq: Students must be in Physician Assistant Program.

PAST 503. Clinical Residency: Internal Medicine Rotation. 3 Units.
This clinical rotation is designed to provide the student with an understanding of the wide variety of problems encountered in hospital-based internal medicine. The formulation and understanding of the many and varied medical problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem. Students are assigned to medical teams during their rotation. Teaching rounds and lectures are used to introduce concepts of internal medicine. Prereq: Students must be in Physician Assistant Program.

PAST 504. Clinical Residency: Obstetrics & Gynecology. 3 Units.
This clinical rotation is designed to expose the student to the variety of problems encountered in women’s health care. The focus of the learning experience is on recognition and management of common gynecological illnesses, sexually transmitted infections, family planning, birth control, and cancer of the female reproductive system and breast. Obstetrical focus is on pregnancy, labor and delivery, and postpartum care. The student will also have an exposure to the surgical management of gynecological and obstetric problems. Teaching rounds and lectures may be used to introduce concepts of obstetrics and gynecology. Prereq: Students must be in Physician Assistant Program.

PAST 505. Clinical Residency: Pediatrics. 3 Units.
This clinical rotation is designed to emphasize care of the child from birth to adolescence. The focus of the learning experience is on recognition and management of common childhood illnesses, assessment of variations of normal growth and development, and the counseling of parents regarding immunizations, preventative health care visits, growth and development, nutrition, injury prevention and common psycho-social problems. The formulation and understanding of the many and varied medical problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem. Teaching rounds and lectures may be used to introduce concepts of pediatrics. Prereq: Students must be in Physician Assistant Program.

PAST 506. Clinical Residency: Behavioral and Mental Health. 3 Units.
This clinical rotation is designed to give the student an understanding of the psycho-social and behavioral components of health, disease, and disability. The student will be exposed to a variety of mental illnesses and disabilities and will also be able to recognize and categorize psychiatric disorders along with the therapeutic modalities used in their treatment. The formulation and understanding of the varied psychiatric problems is accomplished via the accurate collection of data through a complete history and mental status exam, interpretation of diagnostic testing when appropriate, formulation of a problem list, and the development of a plan for each presenting problem. Emphasis is placed on early recognition, intervention, and psychiatric referral and/or consultation. Teaching rounds and lectures are used to introduce concepts of psychiatric medicine. Prereq: Students must be in Physician Assistant Program.
PAST 507. Clinical Residency: Surgery. 3 Units.
This clinical rotation is designed to expose the student to the varied population with surgically manageable disease from adolescence to geriatrics. The formulation and understanding of the varied medical problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan. The focus of the learning experience is on the pre-operative evaluation and preparation of the patients for surgery, procedures and assisting during the intra-operative period, and the care of patients post-operatively. The student will be exposed to both emergent and non-emergent surgical management of patients. The student may be assigned to surgical teams during his/her rotation. Teaching rounds and lectures are used to introduce concepts of surgical care. Prereq: Students must be in Physician Assistant Program.

PAST 508. Clinical Residency: Primary Care Elective. 3 Units.
This clinical rotation is designed to give the student an understanding of family medicine/primary care medicine as practiced in office and/or clinic in an outpatient setting. The student will work with patients from a variety of social, economic and cultural backgrounds across the lifespan. They will experience continuity of care while assessing, diagnosing, monitoring, managing, referring and educating patients. The student will be exposed to both acute and chronic problems as well as the psychosocial problems that are encountered in this setting. Students may encounter and participate in the care of patients of all ages: pediatric, adolescent, adult and geriatric populations. The formulation and understanding of the many and varied medical problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem. Prereq: Students must be in Physician Assistant Program.

PAST 509. Clinical Residency: Inpatient Medicine Elective. 3 Units.
This clinical rotation is designed to provide the student with an understanding of the wide variety of problems encountered in hospital-based internal/surgical medicine. The formulation and understanding of the many and varied medical and or surgical problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem. Students are assigned to medical teams during their rotation. Teaching rounds and lectures are used to introduce concepts of hospital based medicine. Prereq: Students must be in Physician Assistant Program.

PAST 510. Clinical Residency: Elective. 3 Units.
This elective clinical rotation is designed to provide the student with the knowledge and skills in an area of interest. Students will gain an understanding of the variety of problems encountered in a medical or surgical sub-specialty discipline. The formulation and understanding of the many and varied medical and/or surgical sub-specialty problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem including pharmacologic and non-pharmacologic management. Acquisition of these skills helps facilitate the PA student to progress through the clinical rotation with increasing complexity of clinical experiences, building confidence, competence and compassion. In addition to gaining clinical skills specific to the specialty of the rotation, the student will also continue to develop skills in systematic medical problem solving and patient management abilities, establish or reinforce patterns of independent learning, self-evaluation, interprofessional relationships and communication skills. Elective rotation sites are chosen based on practice characteristics that are important for the PA student within this rotation. These may include practice location, patient populations, and availability of specific experiences and procedures. Prereq: Students must be in Physician Assistant Program.

PAST 511. Clinical Residency: Elective. 3 Units.
This elective clinical rotation is designed to provide the student with the knowledge and skills in an area of interest. Students will gain an understanding of the variety of problems encountered in a medical or surgical sub-specialty discipline. The formulation and understanding of the many and varied medical and/or surgical sub-specialty problems is accomplished via the accurate collection of data through a complete history and physical exam, interpretation of diagnostic testing, formulation of a problem list, and the development of a plan for each presenting problem including pharmacologic and non-pharmacologic management. Acquisition of these skills helps facilitate the PA student to progress through the clinical rotation with increasing complexity of clinical experiences, building confidence, competence and compassion. In addition to gaining clinical skills specific to the specialty of the rotation, the student will also continue to develop skills in systematic medical problem solving and patient management abilities, establish or reinforce patterns of independent learning, self-evaluation, interprofessional relationships and communication skills. Elective rotation sites are chosen based on practice characteristics that are important for the PA student within this rotation. These may include practice location, patient populations, and availability of specific experiences and procedures. Prereq: Students must be in Physician Assistant Program.
Graduate Programs in the Biomedical Sciences

The School of Medicine is proud to administer doctoral, master’s, professional and certificate graduate programs in the biomedical sciences, described fully in this bulletin under their departmental or center affiliations. The Graduate Education Office provides support and information on the graduate and postdoctoral training programs in the School of Medicine, as well as professional skill development and training grant proposal support. Resources for proposal development as well as current training information are available at the SOM Graduate Education (http://casemed.case.edu/gradprog) website.

Case Western Reserve University School of Medicine has a strong commitment to the importance of diversity in its research and educational programs. The CWRU community celebrates how our individual diversity in race, ethnicity, gender, country of origin, sexual orientation or gender identity enhances our work together. CWRU programs welcome diverse individuals, including those individuals of racial and ethnic groups underrepresented in biomedical science, those with physical disabilities, and those with disadvantaged backgrounds.

Common Academic Requirements

Each graduate program follows the overall regulations established and described in Graduate Studies Academic Requirements pages (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements) and documented to the Regents of the State of Ohio. In particular, students and faculty are directed to sections regarding Academic Requirements for Master’s and Doctoral Degrees regarding total and graded course requirements, dissertation advisory committees, maintenance of quality-point average, and other general aspects of graduate study at CWRU.

Within those overall expectations, a specific course of study for each graduate program is required and described in each degree plan of study.

Guiding Principles for Graduate Education in the School of Medicine

Training and educating graduate students in the biomedical sciences is a complex process that continually evolves based on the rapid progression of scientific discovery and ever expanding technological landscape. Graduate programs must continually modify their approaches to meet these modern-day needs. Students are expected to master their overall discipline, become experts in their field of research, as well as gain expertise in a diverse, but interrelated professional skill set. That skill set should be clearly defined, widely communicated and integrated across all PhD disciplines at CWRU SOM. Moreover, a set of common principles or goals for educating all graduate students in the SOM helps to guide our programs in course or curriculum development. The School of Medicine Graduate Education Office, in collaboration with the graduate program directors, developed a formal set of Guiding Principles (https://case.edu/medicine/sites/case.edu.medicine/files/2019-06/Guiding%20Principles_rev%202018_0.pdf) for the education and training of all PhD students in order to help accomplish these important goals.

Graduate Admissions to School of Medicine Programs

Graduate students are admitted to our programs through several streams, including the Biomedical Sciences Training Program (http://www.case.edu/med/BSTP), the Medical Scientist Training Program (http://mstp.cwru.edu), dual-degree initiatives, and direct admission to specific programs (please see individual program entries under their affiliated department pages). Postdoctoral Fellows and Postdoctoral Scholars are appointed through the Office of Postdoctoral Affairs (http://postdoc.case.edu).

Student Affinity Groups

Graduate students interact in vibrant groups in the School of Medicine including:

The Biomedical Graduate Student Organization (BGSO) (http://gsc.case.edu/org/bgso/home) seeks to unite biomedical graduate students pursuing master’s and doctoral degrees in various biomedical graduate programs in the Case Western Reserve University School of Medicine, with the ultimate goal of enriching the student experience and promoting career and professional development.

What We Do:
Promote greater career and professional development
Promote more interaction between graduates and professionals of the School of Medicine
Ease the transition into graduate school by creating a “survival guide”

Get Involved!
It’s your graduate career - why not make sure you get what you want out of it? As a graduate student, you can get involved by becoming a representative for your department or coming to monthly meetings. Please email us for more information or attend our next meeting.

Highlights include:
Hosted the following professional development seminars - “Funding 101: Funding Opportunities for Graduate Students”, “Scientific Journalism”, “Life as a Forensic Scientist”, “Planning Your Graduate
and mentors who recognize the skills of such students. A mentor and degree and simultaneously develops partnerships with organizations and support to PhD and Master's students pursuing biomedical science. The CWRU School of Medicine EnRICH Program provides career guidance and a more informal setting.

In addition, doctoral students in the School of Medicine organize the annual Biomedical Graduate Student Symposium.

The Graduate Student Council (GSC) is the governing body for all graduate students at CWRU. The aim is to enrich your experience at CWRU in every way possible. We connect students through social and professional events, provide funding and assistance for their initiatives, and work to insure that they are treated as valued members of the campus community.

The Minority Graduate Student Organization promotes, engages and advances underrepresented minority graduate and postdoctoral trainees in the various fields of biomedical research within the Case Western Reserve University community, in the greater Cleveland area, and in the nation.

Professional Development

The Graduate Education Office provides professional development opportunities for trainees including:

The Professional Enrichment for Trainees Series (PETS)

CWRU SOM Graduate Education Office hosts the PETS seminar series which focuses on developing core competencies of leadership, entrepreneurship, communication skills, appreciative inquiry, emotional intelligence, teamwork and other key areas. This noon luncheon series is held monthly, together with the COTS (described below), for all graduate students and postdoctoral trainees in the SOM, though it often attracts participants from across the entire campus. The format is generally a presentation by faculty experts or a panel discussion among several faculty. A large emphasis is placed on audience discussion and participation throughout the session.

The Career Opportunities for Trainees Series (COTS)

This professional development series is designed to introduce trainees to the array of career paths that are available to PhD biomedical researchers. Local, regional, and national leaders as speakers or panel discussants are invited to present each semester. Presentations include information on the speaker's career trajectory, their daily activities, and a description of additional training necessary for entering each career path. Major advantages and disadvantages of the career choice are also discussed. These sessions are often followed by an informal networking event allowing trainees to interact with the speaker and each other in a more informal setting.

The Enhancing Research and Industry Career Horizons (EnRICH) Program

The CWRU School of Medicine EnRICH Program provides career guidance and support to PhD and Master’s students pursuing biomedical science degrees and simultaneously develops partnerships with organizations and mentors who recognize the skills of such students. A mentor and student spend time together for a paid or non-paid work or exposure experience that is beneficial to both the employer and student. The timeframe and duration of the experience are flexible where the mentor and student agree on the duration of the work experience and to an hourly and weekly work schedule. During the experience, students will clarify career goals as s/he; realizes the results of applied skills in a non-academic career, identifies ways to adapt skills for a variety of occupations and work environments, gains broader perspectives of careers that require his or her skills and talents, identifies ways to adapt skills for a variety of occupations and work environments, learns the business side of science and technology, and develops personal and interpersonal skills for relationship building to broaden professional networks. For more information, contact enrich@case.edu (entich@case.edu).

The Expanding Teaching Experiences for Doctoral Students (ExTenD) Program

This program, open to all doctoral students at the CWRU School of Medicine, provides a way for graduate students to get formal experience in teaching at the university or college level by providing training and experiences in post-secondary education.

Students in this program complete program requirements by:

- Attending a one-semester seminar-style class taught by Educational Student Services to learn the basics of curricular design, development, and delivery

AND

- Completing two “significant” teaching experiences, such as:
  - Guest lecturing at least 5 class hours
  - Co-teaching a course at CWRU or another accredited university
  - Facilitating small group sessions for certain approved courses
  - Other teaching experiences as approved

Students completing program requirements will get a formal letter from the program director stating their completion of the program, as well as experiences, gained and feedback received as part of the program. For more information, email extend@case.edu (EXTEND@CASE.EDU).

Biomedical Sciences Training Program (BSTP)

Phone: 216.368.3347
http://www.case.edu/med/BSTP/

George Dubyak, PhD (gxd3@case.edu), Director
Debbie Noureddine (dm2@case.edu), Coordinator

The Biomedical Sciences Training Program (BSTP) offers a common admission portal to most biomedical PhD degree programs at CWRU School of Medicine. The BSTP includes eleven doctoral programs in the School of Medicine with more than 200 faculty based in both basic science and clinical departments, giving BSTP students a tremendous range of research opportunities in many disciplines. It also provides a
distinct advantage over traditional programs, which restrict choices of research area and faculty advisors.

Admissions
Students usually apply in the fall or winter and begin their studies the following summer. The application deadline is January 15th. Priority will be given to applications received by December 1. Applications will be considered by the Admissions Committee as soon as they are complete. In general a year of biology, organic chemistry and mathematics through calculus are required, and biochemistry and molecular biology are strongly recommended. We also seek students with strong backgrounds in physics or math who may be interested in our Structural Biology track (http://sbb-tp.case.edu) or Systems Biology and Bioinformatics (http://bioinformatics.case.edu) programs. Depending on preparation, we may suggest additional biology coursework once graduate training begins. This background prepares most students for success in our programs.

Research Experience and Recommendations
Experience performing original research is essential. This might include an undergraduate honors thesis, summer research internships, or a technical position after graduation. Letters of recommendation from research mentors that describe creativity, hardwork, and promise in science are very important.

Exams
The GRE general test is no longer required for admission through the BSTP. The Test of English as a Foreign Language (TOEFL) is required for international students unless they are from an English-speaking country or have a degree from a university where the instruction is primarily in English. Students may be eligible to apply for the transfer of some graduate credit from their previous institution. Please go here (http://gradstudies.case.edu) for more information. Transfer credit must be requested prior to beginning coursework at CWRU.

The First Year
Coursework
Students take integrated courses in Cell and Molecular Biology (IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I). They also complete a course in biostatistics (IBMS 450 Fundamental Biostatistics to Enhance Research Rigor & Reproducibility) and a literature based reading course (IBMS 456A Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A ). These four courses, offered in the fall semester, emphasize the molecular approaches that form the basis of modern biology. We also seek students with strong quantitative training who may have majored in physics or math, and offer alternative courses for these students to acquire foundations in biology. Qualified students also may take more specialized elective courses. All students take IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research.

Research Rotations
The research rotations allow students to explore research areas and become familiar with faculty members and their laboratories. The main purpose of these rotations is to aid students in selecting a laboratory for their thesis work. Students are encouraged to begin their rotations in July. Doing so gives them the opportunity to complete rotations during the summer before classes begin at the end of August. Students must complete at least three rotations.

Choosing a Thesis Advisor
During the first year, students select an advisor for their dissertation research. Each student also joins the PhD program with which their advisor is affiliated. Once students choose a PhD program, the requirements of that program are followed to obtain the PhD. The emphasis of the PhD work is on research, culminating in the completion of an original, independent research thesis and publishing the results in the scientific literature. PhD programs also focus on educating students to work as professional scientists.

Participating Training Programs
- Biochemistry (p. 54)
- Cell Biology (p. 98)
- Genetics and Genome Sciences (p. 95)
- Molecular Biology and Microbiology (p. 98)
- Molecular Virology (p. 98)
- Neurosciences (p. 105)
- Nutrition (p. 118)
- Pathology (p. 125)
- Pharmacology (p. 136)
- Physiology and Biophysics (p. 143)
- Systems Biology and Bioinformatics (p. 85)

These programs have tracks that allow specialization in the following areas: Cancer Biology; Cancer Therapeutics; Cell and Molecular Physiology; Developmental Biology; Experimental Pathology; Immunology; Membrane Structural Biology; Molecular and Cellular Biophysics; Molecular Pharmacology and Cell Regulation; Molecular Pharmacology and Cell Regulation; Organ Systems Physiology; RNA Biology; Structural Biology & Biophysics; Translational Therapeutics.

Training faculty, course offerings, and individual degree requirements are described in detail in the separate listings for each of these programs. All PhD programs have similar requirements, including an original thesis, coursework, examinations, publications in scientific journals with lead authorship, seminars, journal clubs, and other activities.

BSTP Course
BSTP 400. Research Rotation in Biomedical Sciences Training Program. 0 - 9 Units.

CBIO Courses

IBMS Courses
IBMS 450. Fundamental Biostatistics to Enhance Research Rigor & Reproducibility. 1 Unit.
This is a required graduate level course for all first year PhD students in the School of Medicine biomedical PhD programs excluding Biomedical Engineering, Population and Quantitative Health Sciences, Molecular Medicine and Clinical Translation Science. This course focuses on providing students with a basic working knowledge and understanding of best practices in biostatistics that can be applied to common biomedical research activities in numerous fields. Weekly sessions involve a combination of basic programming activities, lectures, exercises, hands-on data manipulation and presentation. Topics include experimental design and power analysis, hypothesis testing, descriptive statistics, linear regression, and others with an emphasis on when and in which experimental design a particular test is properly used. The overall goal of the course is to empower students to use these biostatistics to enhance the rigor of their experimental design and reproducibility of their primary data. The major focus is not on theory, but on a practical acquisition of a working knowledge of basic data processing analysis, interpretation, and presentation skills.
IBMS 453. Cell Biology I. 3 Units.
Part of the first semester curriculum for first year graduate students along with IBMS 455. This course is designed to give students an intensive introduction to prokaryotic and eukaryotic cell structure and function. Topics include membrane structure and function, mechanisms of protein localization in cells, secretion and endocytosis, the cytoskeleton, cell adhesion, cell signaling and the regulation of cell growth. Important methods in cell biology are also presented. This course is suitable for graduate students entering most areas of basic biomedical research. Undergraduate courses in biochemistry, cell and molecular biology are excellent preparation for this course. Recommended preparation: Undergraduate biochemistry or molecular biology.

IBMS 455. Molecular Biology I. 3 Units.
Part of the first semester curriculum for first year graduate students along with IBMS 453. This course is designed to give students an intensive introduction to prokaryotic and eukaryotic molecular biology. Topics include protein structure and function, DNA and chromosome structure, DNA replication, RNA transcription and its regulation, RNA processing, and protein synthesis. Important methods in molecular biology are also presented. This course is suitable for graduate students entering most areas of basic biomedical research. Undergraduate courses in biochemistry, cell and molecular biology are excellent preparation for this course. Recommended preparation: Undergraduate biochemistry or molecular biology.

IBMS 456A. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A. 1 Unit.
This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel Prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456A section will cover Nobel Prizes related to the areas of Genetics & Genome Science, Systems Biology & Bioinformatics, and RNA Biology. These include: 1) 2012 Prize, J. Gurdon and S. Yamanaka: Mechanisms of pluripotency & stem cell development and reprograming; 2) 2010 Prize, R. Edwards: Development of in vitro fertilization; 3) 2009 Prize, E. Blackburn, C. Greider, and J. Szostak: Mechanisms of chromosome protection by telomeres and telomerase; 4) 2009 Prize, Y. Ramakrishnan, T. Steitz, and A. Yonath: Structure/function analysis of ribosomes; 5) 2007 Prize, M. Capicchi, M. Evans, and O. Smithies: Discovery/development of transgenic and gene-deletion methods in mice; 6) 2006 Prize, A. Fire and C. Mello: Discovery/development of RNA interference-gene silencing methods; 7) 2006 Prize, R. Kornberg: Mechanisms of eukaryotic transcription; 8) 1995 Prize, E. Lewis, C. Nusslein-Volhard, and W. Wieschaus: Mechanisms of genetic control in early embryonic development.

IBMS 456B. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section B. 1 Unit.
This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel Prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456B section will cover Nobel Prizes related to the areas of Molecular Biology & Microbiology, Molecular Virology, Pathology-Immunology, and Cell Biology. These include: 1) 2016 Prize, Y. Ohsumi: Mechanisms of Autophagy; 2) 2015 Prize, W. Campbell, S. Omura, and Y. Tu: Therapies against roundworms & malaria; 3) 2011 Prize, B. Beutler, J. Hoffman, and R. Steinman: Mechanisms underlying innate immunity and adaptive immunity; 4) 2008 Prize, H. zur Hausen, F. Barre-Sinoussi, and L. Montagnier: Discovery of human immunodeficiency virus and oncogenic papilloma viruses; 5) 2008 Prize, O. Shimomura, M. Chalfie, and R. Tsien: Discovery/development of green fluorescent protein for biological applications; 6) 2005 Prize, B. Marshall and J. Warren: Discovery of Helicobacter pylorisis as pathogenic mechanism in peptic ulcers/gastritis; 7) 1999 Prize, G. Blobel: Mechanisms of protein sorting and subcellular trafficking; 8) 1996 Prize, P. Doherty and R. Zinkernagel: Mechanisms of cell-mediated immune defense.

IBMS 456C. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section C. 1 Unit.
This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel Prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456B section will cover Nobel Prizes related to the areas of Biochemistry, Nutrition, Pharmacology, and Pathology-Cancer. These include: 1) 2015 Prize, T. Lindahl, P. Modrich, and A. Sancar: Mechanisms of DNA Repair; 2) 2014 Prize, E. Betzig, S. Hell, W. Moerner: Development of super-resolution fluorescence microscopy; 3) 2012 Prize, R. Lefkowitz and B. Kobilka: Structure/function analysis of G protein-coupled receptors; 4) 2004 Prize, A. Ciechanover, A. Hershko, and I. Rose: Mechanisms of ubiquitin-mediated protein degradation; 5) 2003 Prize, P. Lauterbur and P. Mansfield: Development of magnetic resonance imaging (MRI) methods; 6) 2002 Prize, S. Brenner, H. R. Horvitz, and J. Sulston: Mechanisms for genetic regulation of organ development and programmed cell death; 7) 2002 Prize, J. Fenn, K. Tanaka, and K. Wuthrich: Development of mass spec and NMR methods for biological macromolecules; 8) 2001 Prize, L. Hartwell, T. Hunt, and P. Nurse: Mechanisms of cell cycle regulation.
IBMS 456D. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years - Section D. 1 Unit.

This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456D section will cover Nobel Prizes related to the areas of Neuroscience, Physiology & Biophysics, and Pathology-Molecular Basis of Disease. These include: 1) 2014 Prize, J. O’Keefe, M-B. Moser, and E. Moser: Mechanisms of nerve cell spatial positioning in the brain; 2) 2013 Prize, J. Rothman, R. Scheckman, and T. Sudhof: Mechanisms of intracellular vesicle trafficking and biomolecule secretion; 3) 2004 Prize, R. Axel and L. Buck: Structure/function of odorant receptors and organization of olfactory system; 4) 2003 Prize: P. Agre and R. MacKinnon: Structure/function analysis of channel proteins in cell membranes; 5) 2000 Prize, A. Carlsson, P. Greengard, and E. Kandel: Mechanisms of signal transduction in the nervous system; 6) 1998 Prize, R. Furchgott, L. Ignarro, and F. Murad: Discovery/mechanisms of nitric oxide as signaling molecule in cardiovascular system; 7) 1997 Prize, S. Prusiner: Discovery/prions as new biological principle of infection in neurological disease; 8) 1997 Prize, P. Boyer, J. Walker, and J. Skou: Mechanisms of mitochondrial ATP synthesis and Na, KATPase pump function.

IBMS 500. On Being a Professional Scientist: The Responsible Conduct of Research. 1 Unit.

The goal of this course is to provide graduate students with an opportunity to think through their professional ethical commitments before they are tested, on the basis of the scientific community’s accumulated experience with the issues. Students will be brought up to date on the current state of professional policy and federal regulation in this area, and, through case studies, will discuss practical strategies for preventing and resolving ethical problems in their own work. The course is designed to meet the requirements for “instruction about responsible conduct in research” for BSTP and MSTP students supported through NIH/ADAMHA institutional training grant programs at Case. Attendance is required.

Department of Anatomy

Room WG-46, School of Medicine  
http://www.case.edu/med/anatomy/  
Phone: 216.368.2433  
Clifford V. Harding, MD, PhD, Interim Chair  
clifford.harding@case.edu

Christine Marshall (christine.marshall@case.edu), Department Administrator

The Department of Anatomy provides cutting-edge instruction in human anatomy to medical students, graduate students, and undergraduate students and is home to international research programs in paleontology and paleobiology. Our program leading to the Master of Science degree in Applied Anatomy provides rigorous training for students who aspire to careers requiring a solid foundation in human anatomy. This curriculum is ideal for students with a range of career goals, including those who will be future teachers of anatomy or who will pursue careers in medicine or other health professions or scientific fields that involve anatomy. The MS in Applied Anatomy can be combined with the MD curriculum in a four-year joint MD-MS curriculum. This provides an enhanced background for medical students who plan to enter a surgical specialty, radiology, or another field that relies on detailed understanding of human anatomy.

MS Applied Anatomy

The Applied Anatomy program is designed for students who seek a comprehensive education in the anatomical sciences, particularly those individuals pursuing careers as medical health professionals and teachers who desire an advanced degree to enhance their skills and credentials. The Anatomical Sciences Core Curriculum (ASCC) courses emphasize the traditional aspects of anatomical structure, function, and nomenclature with critical aspects of cell and developmental biology, biochemistry, and physiology of cells, tissues, and organs integrated into their content. The elective courses allow curriculum flexibility for students to emphasize their diverse individual interests. The Master of Science in Applied Anatomy serves as an excellent preparation for subsequent studies in schools of medicine, dentistry, and nursing. The knowledge of the human body and its physiological processes gained in this program also forms a significant foundation for physician assistants, physical therapists, dental technicians, and K-12 life sciences teachers.

Students in this post-baccalaureate program earning the Master of Science in Applied Anatomy use their training in the anatomical sciences to establish an academic basis for their application to professional schools. Case Western Reserve University medical students earning the joint MD/MS degree program seek advanced training in the anatomical sciences. The joint MD/MS program is undertaken and completed concurrently with the medical curriculum, particularly if the student enters the graduate program during the first year of medical school.

Admission

Acceptance into the Master of Science in Applied Anatomy program requires a baccalaureate degree from an accredited institution and is based on undergraduate and/or graduate GPAs, results of admission examinations (GRE, MCAT, DAT), plus letters of recommendation; an Educational Credential Evaluation and Authentication Report is required for foreign transcripts plus documentation (TOEFL) of English language skills for foreign applicants. Acceptance into the joint MD/MS program requires that the medical student be in good academic standing in the CWRU medical curriculum at the time of matriculation into the program, and a letter of approval from their respective Associate (Society) Dean of Student Affairs. Each student in the Applied Anatomy program has a faculty advisor from the Department of Anatomy Graduate Executive Committee which coordinates the program and reviews the graduate Program of Study for individual students. Contact the Department of Anatomy for additional program and application information.

Degree Requirements

The Master of Science in Applied Anatomy degree requires a minimum of 30 graduate course credits. Required courses include 17 credits of the Anatomical Sciences Core Curriculum; the remaining credits are elective courses selected to fulfill individual student interests and goals. Medical students are required to take at least one of the Surgical Anatomy courses. A research thesis is not required for the non-thesis Type-B Master of Science in Applied Anatomy, although research experience may be obtained by enrolling in ANAT 499: Independent Study with individual faculty members.

Comprehensive written and oral exams covering the basic scientific principles presented in the core curriculum must be passed after successful completion of the formal coursework comprising the Anatomical Sciences Core Curriculum. All degree requirements must be
completed within five years; most students complete the program in 2 years. Tuition or stipends will not be provided for the master of science program (no additional tuition is required for enrolled medical students).

These specific sequences of classes, while common, are not exclusive and are meant only to exemplify the typical program of study leading to the Master of Science in Applied Anatomy degree. The required courses (19 credits) comprising the Anatomical Sciences Core Curriculum are specifically delineated, whereas the elective courses (13 credits minimum) are not identified since they vary significantly between individual students. Students become eligible to take the MS Comprehensive Examination upon successful completion of the ASCC courses.

MD/MS students are required to take one of two surgical anatomy courses during their fourth year (ANAT 515 - Orthopaedics or ANAT 516 - Head & Neck).

MS & MD/MS Applied Anatomy, Plan of Study (4 semesters)

First Year

**Fall**

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ANAT 412</td>
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<td></td>
<td>(Elective)</td>
<td></td>
</tr>
<tr>
<td>ANAT 491</td>
<td>Embryology</td>
<td>3</td>
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**Spring**

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<td>(Medical students apply to MD/MS program)</td>
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**Summer**

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<td>1-6</td>
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Second Year

**Fall**

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<tr>
<td>ANAT 414</td>
<td>Neurological Anatomy</td>
<td>4</td>
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<tr>
<td>Elective</td>
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**Spring**

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<td>Elective</td>
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Master of Science ASCC Comprehensive Examination

**Courses**

**ANAT 312. Basic Histology. 3 Units.**

Fundamental histology course covering microscopic structure, nomenclature, and function of normal cells, tissues, and organs (human emphasis) to provide a sound foundation for bioengineering, pre-medical and pre-dental students.

**ANAT 375. Human Evolution: The Fossil Evidence. 3 Units.**

This course will survey the biological and behavioral changes that occurred in the hominid lineage during the past five million years. In addition to a thorough review of the fossil evidence for human evolution, students will develop the theoretical framework in evolutionary biology. Recommended preparation: ANTH 377, BIOL 225. Offered as ANAT 375, ANTH 375, ANAT 475 and ANTH 475. Prereq: ANTH 103.

**ANAT 377. Human Osteology. 4 Units.**

This course for upper division undergraduates and graduate students will review the following topics: human skeletal development and identification; and forensic identification (skeletal aging, sex identification and population affiliation). Offered as ANAT 377, ANTH 377, ANAT 477 and ANTH 477.

**ANAT 391. Embryology. 3 Units.**

A detailed description of development will be presented, focusing mainly on the developing human. Discussions and presentations will also include several developing systems that have served as useful models in experimental embryology for deciphering mechanisms responsible for producing adult metazoan organisms. Offered as ANAT 391 and ANAT 491.

**ANAT 399. Independent Study. 1 - 4 Units.**

Laboratory research project. Student must obtain approval of a supervising Anatomy department professor before registration and list the professor’s name on the schedule card.

**ANAT 401. HoloAnatomy of the Human Body. 2 Units.**

This course introduces students to the gross anatomical structure of the human body using innovative Microsoft HoloLens technology. It differs from most traditional anatomy courses not only in its use of three-dimensional imaging technologies but also in its systemic rather than regional approach; the structure of the human body is learned by studying organ systems (e.g., the nervous system, the musculoskeletal system) rather than focusing on one region at a time (e.g., the thorax or the lower limb). This approach gives students the ‘big picture’ of how the human body is organized, thereby providing a solid foundation for other courses that deal with the anatomy of the human body in greater detail.

**ANAT 410. Cadaver dissection-based human anatomy with histology and physiologic correlations. 6 Units.**

This course will provide students with a sound understanding of the normal human body as a foundation for subsequent pursuing biomedical careers. A combination of daily lectures and laboratories integrates cadaver dissection-based gross anatomy with the associated histology, embryology, neuroanatomy and basic physiology. This course is well-suited to all biomedical careers, including pre-clinical and biomedical undergraduates, post-baccalaureate, pre-clinical master of science graduate programs, plus medical and dental students seeking additional training in the anatomical sciences. It will meet any of the anatomy-oriented prerequisites being implemented for medical and dental school applications, including those preferring or requiring a cadaver-based experience. The assessments will include a combination of written and cadaver-based practical questions. Offered as ANAT 410 and PAST 410.

**ANAT 411. Gross Anatomy. 6 Units.**

This in-depth, cadaver dissection-based, course covers all aspects of human gross anatomy. The course is modeled after a traditional medical school gross anatomy curriculum and taught by the CWRU School of Medicine, Department of Anatomy faculty. It is divided into three sections: thorax and abdomen; pelvis/perineum and limbs/back; and head and neck. One hour of lecture will precede 3 hours of dissection laboratory Monday, Wednesday, and Friday. Lectures and dissection labs will cover all human anatomy, and students should be prepared to devote more time that the scheduled hours of 1:00 to 5:00pm. Dissection labs are open 24 hours 7 days a week. Recommended preparation: B.A./B.S., or fourth year undergraduate science major.
ANAT 412. Histology and Ultrastructure. 4 Units.
Comprehensive functional histology course integrating microscopic identification ("structure plus nomenclature") of normal cells, tissues, and organs with aspects of their cell biology, biochemistry, and physiology ("function"). Topical coverage includes complete (head-to-toe) tissue and organ survey with human emphasis.

ANAT 414. Neurological Anatomy. 4 Units.
This course employs a variety of teaching-learning methods--among them lectures, small-group discussions, hands-on "construction" of pathways, and brain dissection. Regional morphology will be studied via examination of the preserved brain and of sections through the CNS; functional systems will be "followed" through the spinal cord, brain stem and/or forebrain.

ANAT 431. Statistical Methods I. 3 Units.
Application of statistical techniques with particular emphasis on problems in the biomedical sciences. Basic probability theory, random variables, and distribution functions. Point and interval estimation, regression, and correlation. Problems whose solution involves using packaged statistical programs. First part of year-long sequence. Offered as ANAT 431, BIOL 431, CRSP 431, PQHS 431 and MHPH 431.

ANAT 445. Mammal Diversity and Evolution. 4 Units.
This course focuses on the anatomical and taxonomic diversity of mammals in an evolutionary context. The emphasis is on living (extant) mammals, but extinct mammals are also discussed. By the end of the course, students will be able to: (1) describe the key anatomical and physiological features of mammals; (2) name all orders and most families of living mammals; (3) identify a mammal skull to order and family; (4) understand how to create and interpret a phylogenetic tree; (5) appreciate major historical patterns in mammal diversity and biogeography as revealed by the fossil record; (6) read and critique a scientific article dealing with mammal evolution. One weekend field trip to Cleveland Metroparks Zoo; additional individual and group visits to the Cleveland Museum of Natural History. This course satisfies a laboratory requirement for the biology major. Recommended preparation: BIOL 223 Vertebrate Biology, BIOL 225 Evolution, or BIOL 346 Human Anatomy. Offered as ANAT 445 and BIOL 345. Prereq: BIOL 214.

ANAT 462. Principles of Developmental Biology. 3 Units.
The descriptive and experimental aspects of animal development. Gametogenesis, fertilization, cleavage, morphogenesis, induction, differentiation, organogenesis, growth, and regeneration. Students taking the graduate-level course will prepare an NIH-format research proposal as required term paper. Offered as BIOL 362, BIOL 462 and ANAT 462.

ANAT 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic in interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHIL/PHOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467.

ANAT 475. Human Evolution: The Fossil Evidence. 3 Units.
This course will survey the biological and behavioral changes that occurred in the hominin lineage during the past five million years. In addition to a thorough review of the fossil evidence for human evolution, students will develop the theoretical framework in evolutionary biology. Recommended preparation: ANTH 377, BIOL 225. Offered as ANAT 375, ANTH 375, ANAT 475 and ANTH 475. Prereq: ANTH 103.

ANAT 491. Embryology. 3 Units.
A detailed description of development will be presented, focusing mainly on the developing human. Discussions and presentations will also include several developing systems that have served as useful models in experimental embryology for deciphering mechanisms responsible for producing adult metazoan organisms. Offered as ANAT 391 and ANAT 491.

ANAT 499. Independent Study. 1 - 4 Units.
Laboratory research project. Student must obtain approval of a supervising Anatomy department professor before registration and list the professor’s name on the schedule card.

ANAT 503. Readings and Discussions. 1 - 3 Units.
In-depth consideration of special selected topics through critical evaluation of the literature. Student must obtain approval of supervising Anatomy department professor before registration.

ANAT 515. Surgical Anatomy: Orthopaedic Musculoskeletal. 4 Units.
This orthopaedic musculoskeletal anatomy course is offered to M.S. in Applied Anatomy students and fourth year medical students. The course will familiarize participants with surgical approaches used to treat musculoskeletal disease. Students will learn to correlate normal and abnormal anatomical findings with radiographical studies. Recommended preparation: ANAT 411.

ANAT 516. Surgical Anatomy: Head and Neck. 4 Units.
This cadaver-based advanced anatomy course is offered to M.S. in Applied Anatomy students and fourth year medical students. Students will build on their understanding of basic gross, histological, pathologic, and embryonic anatomy of the head and neck. The course will familiarize participants with surgical approaches used to treat pathological conditions of the head and neck including cranial cavity, cranial base, orbit, maxillofacial, oral, otic, pharyngeal, and airway. Students are required to attend and participate in lectures, surgical labs, and discussions in order to successfully complete the course. Instructor consent is required. Recommended preparation: ANAT 411.

ANAT 520. Imaging Anatomy. 3 Units.
Online course offering during the summer semester. The 8 week course is constructed to reinforce normal anatomy by imaging modalities of plain film, CT, and MRI images. Imaging anatomy will reinforce the student's knowledge of anatomy and introduce the field of radiology. Students would be motivated to broaden their understanding of anatomy by being exposed to the application of that knowledge. The curriculum would introduce radiologic concepts, while stressing the normal anatomy of organ systems by imaging modalities. Anatomical structures will be recognized by projectional and cross-sectional modalities. The student will be expected to demonstrate the anatomical characteristics of that structure, for example course, area of supply, relations, morphology, etc. Primarily for medical and graduate students who have a comprehensive knowledge of human anatomy. We would encourage having taken ANAT 411, Gross Anatomy or Structure.
ANAT 523. Histopathology of Organ Systems. 3 Units.
Comprehensive course covering the underlying basic mechanisms of injury and cell death, inflammation, immunity, infection, and neoplasia followed by pathology of specific organ systems. Material will include histological (‘structure’) and physiological (‘function’) aspects related to pathology (human emphasis). Recommended preparation: ANAT 412 or permission of instructor. Offered as ANAT 523 and PATH 523.

ANAT 560. Applied Neuroanatomy. 3 Units.
This course is constructed to reinforce the student’s understanding of neuroanatomy. Through problem-based learning the student will set their own learning objectives based on a neurosurgical case. Presentations will use imaging, anatomic diagrams, and cadaveric dissection to demonstrate applications. Learning in this clinical context will increase motivation and understanding of this important subject. Primarily for medical students and graduate students, enrollment is by permission of instructor and completing ANAT 414, Neurological Anatomy. Prereq: ANAT 414.

ANAT 610. Oxygen and Physiological Function. 1 Unit.
Lecture/discussion course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include oxygen transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as ANAT 610, NTRN 610, and PHOL 610.

ANAT 611. Practicum in Human Gross Anatomy. 3 Units.
A course of study designed especially for the preparation of teachers that involves the supervised practical application of previously studied theory. The teaching experience obtained will be obtained in ANAT 411 - Human Gross Anatomy. Teaching will be guided, supervised, and evaluated by the appropriate faculty from the department of anatomy. The three sections of ANAT 611 and the subjects covered are: Trunk Gross Anatomy (6 weeks), Musculoskeletal Gross Anatomy (3 weeks), Head & Neck Gross Anatomy (4 weeks). Required preparation: ANAT 411 and permission of instructor.

ANAT 612. Practicum in Histology and Ultrastructure. 2 Units.
A course of study designed especially for the preparation of teachers that involves the supervised practical application of previously studied theory. The prerequisite knowledge required for ANAT 612 must have been obtained previously in ANAT 412: Histology and Ultrastructure and the associated laboratory ANAT 413: Histology Laboratory. Required participation in ANAT 612 is defined as: 1. Meet weekly with course instructor to (pre)review course material; 2. Attend all ANAT 412 lectures; 3. Participate/assist in all ANAT 413 laboratory sessions. Teaching will be guided, supervised, and evaluated by the course instructor with reference to the graduate student’s overall progress and performance as a teacher. Required prerequisites: ‘A’ grades on ANAT 412 and ANAT 413; permission of instructor required.

ANAT 651. Thesis M.S.. 1 - 9 Units.
Master’s Thesis Plan A.

Master of Science in Anesthesia Program
Program Overview
Joseph M. Rifici, CAA, MEd

Executive Program Director
Jennifer Puin, PhD
Network Admissions Director
msaprogram@case.edu or 216.844.8077
https://case.edu/medicine/msa-program/

The Master of Science in Anesthesia Program at Case Western Reserve University began in 1970, the second anesthesia program of its kind in the nation. The program originally awarded a baccalaureate degree, then evolved into a professional postgraduate program in 1987 and began granting the master’s degree. Today, students earn a Master of Science in Anesthesia degree that is designed to prepare them to enter the certified anesthesiologist assistant profession.

Admission to the MSA Program requires a bachelor’s degree with prescribed prerequisites typical of premedical coursework and successful completion of the MCAT or GRE. The early decision deadline for admission into the program is in October and the regular decision deadline is in February each year. Coursework begins at the end of May, and consists of 24 consecutive months of didactic and clinical study. The MSA Program is accredited by the Commission on Accreditation of Allied Health Education Programs (http://www.caauh.org) and is based on the Standards for Anesthesiologist Assistant Programs. Graduates must complete a curriculum that includes 70 credit hours (six semesters) of classroom and clinical instruction. The first three semesters integrate basic science and clinical instruction.

In addition to the main campus program, CWRU also oversees the Master of Science in Anesthesia Program’s Houston, Texas branch (https://case.edu/medicine/msa-program/houston) and Washington, DC branch. (https://case.edu/medicine/msa-program/washington)

The network is led by Joseph M. Rifici, CAA, MEd, and Matthew P. Norcia, MD, and the program is housed within the School of Medicine of Case Western Reserve University. Additionally, the MSA Program maintains partnerships with more than 80 affiliate clinical sites across the country. More information can be obtained from Jennifer Puin, (msaprogram@case.edu) Network Admissions Director.

Academic Requirements for Admission

The mission of the Master of Science in Anesthesia Program is to graduate skilled and compassionate anesthesiologist assistants. The admission policy reflects this goal. Applicants are considered on a variety of parameters that measure academic ability, communication skills, clinical aptitude, and personality traits.

Admission to the MSA Program requires that the following criteria are met:

1. Bachelor’s degree from an accredited college or university

Applicants for admission must complete a course of study leading to a baccalaureate degree at an accredited U.S. or Canadian college or university, or its equivalent, prior to matriculation.

2. Prerequisite courses

Documentation of each of the prerequisites having been completed with a grade of B- or higher at an accredited U.S. or Canadian institution of higher learning is required. Prerequisites must be taken within five years
of the application deadline. For those courses that have been repeated, the highest grade will be used in the calculation. Prerequisites include:

- one semester of biochemistry
- one year of biology with laboratory*
- one semester of human anatomy with laboratory
- one semester of human physiology
- one year of chemistry with laboratory*
- one year of organic chemistry with laboratory*
- one year of physics with laboratory*
- one semester of calculus*
- one semester of advanced statistics (preferably for the life sciences)*
- one semester of English with expository writing*

All academic requirements must be completed satisfactorily before matriculation.

* Courses marked with an asterisk that were completed with a grade of B- or higher in excess of five years prior to the application deadline will meet the prerequisite criteria only if the MCAT composite score is 500 or higher. A high MCAT score indicates your knowledge of the coursework is still current, and we do not ask that you retake your older coursework.

### 3. Admissions Tests

If the applicant has taken the Medical College Admissions Test (MCAT), then they must earn a minimum composite score of 493 on the MCAT. The test must be taken within three years of the application deadline.

If the applicant has taken the Graduate Record Examination (GRE), then they must earn a minimum score of 153 in Verbal Reasoning, 156 in Quantitative Reasoning, and 4.0 in Analytical Writing. The test must be taken within five years of the application deadline.

When an applicant has taken the MCAT or GRE more than once, component scores will not be combined. If an applicant has taken both admissions tests, they should submit both official scores for review.

### 4. CASPer Test

Applicants must complete the Computer-Based Assessment for Sampling Personal Characteristics, or CASPer test, in order for their application to be considered complete. CASPer is an online assessment that can only be taken once per cycle. The scores are valid for one year. There is no minimum score required, but successful completion of CASPer is required in order to maintain admission eligibility. The program recommends taking CASPer before or concurrently with the submission of your application materials so that the scores will be received in a timely manner.

### International Admissions

Applicants with international undergraduate, graduate or advanced degrees must meet the standard admission requirements listed above. International application requirements also include the Test of English as a Foreign Language (TOEFL), the International English Language Testing System (IELTS), or the Pearson Test of English (PTE-Academic). An Education Credential Evaluation and Authentication Report for foreign transcripts is required.

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**The Application Process**

All materials must be received by the deadline. Candidates participate in interviews with members of the Admissions Committee, which is comprised of faculty and staff members of the MSA Program. Prospective candidates are permitted and encouraged to shadow an anesthetist in the operating room. Prior approval for this visitation is required, and dates are approved and determined by the individual location of study. An overview of the admissions timeline can be viewed here. (https://case.edu/medicine/msa-program/admissions)

**Curriculum Overview**

The 24-month program includes 70 credit hours (six consecutive semesters) of classroom and clinical instruction. The first three semesters integrate basic science and clinical instruction. During the remaining three semesters, students complete month-long rotations in all subspecialties of anesthesiology: ambulatory surgery, burns and trauma, cardiothoracic surgery, general surgery, neurosurgery, obstetrics, pediatrics, surgical intensive care unit. Clinical training focuses on all types of anesthesia including general, epidural, spinal and peripheral nerve blockade.

Instruction is also provided in advanced patient care monitoring techniques and pre-testing, calibration and operation of anesthesia delivery systems and monitors. At CWRU, our personal approach and rigorous educational standards produce compassionate and highly skilled anesthesiologist assistants.

The MSA Program is accredited by the Commission on Accreditation of Allied Health Education Programs (CAAHEP) and is based on the Standards for Anesthesiologist Assistant Programs. Graduates sit for the Certification Examination administered by the National Commission for Certification of Anesthesiologist Assistants (NCCAA) and co-sponsored by the National Board of Medical Examiners (NBME).

Additional information may be found on the Master of Science in Anesthesia Program website (http://case.edu/medicine/msa-program).

**Plan of Study**

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<thead>
<tr>
<th>Basic Science Year</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<td>Ethics, Law and Diversity for Anesthesiologist Assistants (ANES 490)</td>
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Minimum Clinical Experience Required = 413 hours
Year Total: 11 11 6

Total Units in Sequence: 70
Total Clinical Hours Required (Basic Science Year) = 560
Total Clinical Hours Required (Clinical Year)= 1440

Courses

**ANES 403. Cardiac Electrophysiology. 2 Units.**
In this course students will learn basic and advanced Electrocardiogram interpretation using simulators and electrocardiograms to understand an overview of heart anatomy, function, and neurophysiology.

**ANES 440. Patient Monitoring and Instrumentation I. 2 Units.**
Students are taught the proper balance between circuits and engineering concepts and the clinical application of anesthesia instrumentation. Monitors and devices used in the operating room are studied with respect to principles of operation, calibration, and interpretation of data. A hands-on laboratory is utilized to maximize direct contact to the instrumentation of the profession.

**ANES 441. Patient Monitoring and Instrumentation II. 2 Units.**
Continuation of ANES 440. Recommended preparation: ANES 440.

**ANES 456. Applied Physiology for Anesthesiologist Assistants I. 3 Units.**
Basic and applied human systems physiology with emphasis on topics and areas of special concern to the anesthetist.

**ANES 458. Applied Physiology for Anesthesiologist Assistants II. 3 Units.**
Continuation of ANES 456. Recommended preparation: ANES 403 and ANES 456.

**ANES 460. Introduction to Anesthesia. 2 Units.**
Introduction to basic concepts dealing with clinical anesthesia. Medical terminology, human anatomy, medical chart interpretation and drug dosage calculations.

**ANES 461. Orientation to Clinical Experience. 3 Units.**
Introduction to experience in the operating room with emphasis on the fundamental procedures and techniques used in administering an anesthetic. Preoperative assessment, IV placement techniques, airway management, intraoperative patient care and postoperative management are all emphasized in this course. BLS (basic life support) certification is required for course completion. Recommended preparation: Acceptance in the M.S.A. program.

**ANES 462. Anesthesia Clinical Correlation I. 1 Unit.**
A series of conferences presented by students that applies to anesthetic theory as it relates to the clinical experience. Specific anesthetic situations are emphasized. Recommended preparation: ANES 460.

**ANES 463. Anesthesia Clinical Experience I. 3 Units.**
A continuation of the preparation, observation, and hands-on learning format initiated in ANES 461. Patient management and technical skills are refined with close attention to the didactic course work. A comprehensive clinical examination is administered at the end of the semester. ACLS (Advanced Cardiac Life Support) certification is required for course completion. Recommended preparation: ANES 461.
ANES 464. Anesthesia Clinical Correlation II. 1 Unit.
A spectrum of case presentation conferences presented by the students dealing with basic and major problems in anesthesia management. Medical and surgical history of individual patients and the outcomes of anesthesia and surgery are emphasized. Journal Club and Morbidity and Mortality conferences are included. Recommended preparation: ANES 462.

ANES 465. Anesthesia Clinical Experience II. 4 Units.
A continuation of ANES 463. A comprehensive clinical examination is administered at the end of the semester. PALS (Pediatric Advanced Life Support) and ACLS (Advanced Cardiac Life Support) certification is required for course completion. Recommended preparation: ANES 463, BLS Certification, ACLS Certification.

ANES 467. Anesthesia Clinical Experience III. 4 Units.
Extended exposure to all of the clinical subspecialties of anesthesiology (obstetrics, pediatrics, neurosurgery, cardiovascular, etc.). Students alternate through rotations at several area hospitals. Recommended preparation: ANES 465, ACLS certification and PALS.

ANES 468. Anesthesia Clinical Correlation III. 1 Unit.

ANES 469. Anesthesia Clinical Experience IV. 8 Units.
A continuation of ANES 467. A comprehensive clinical examination is administered at the end of the semester. Recommended preparation: ANES 467.

ANES 470. Anesthesia Clinical Correlation IV. 1 Unit.

ANES 471. Anesthesia Clinical Experience V. 8 Units.
A continuation of ANES 469. A comprehensive clinical examination is administered at the end of the semester. Recommended preparation: ANES 469.

ANES 475. Pharmacology for Anesthesiologist Assistants I. 3 Units.
Pharmacodynamics, pharmacokinetics, uptake, distribution and action of the volatile and intravenous anesthetics, muscle relaxants, narcotics, hypnotics and other pharmaceuticals used in the administration of an anesthetic. Prereq: Consent of Department.

ANES 476. Pharmacology for Anesthesiologist Assistants II. 3 Units.
Continuation of ANES 475. Prereq: ANES 475.

ANES 477. Clinical Decision Making in Anesthesia. 2 Units.
An introduction to thinking about clinical situations and problems and coming to safe and effective solutions to these problems. This course focuses on common clinical situations where appropriate decision making is important to the outcome of the case. Numerous areas of medicine and anesthesiology will be covered to provide the student with a wide sampling of decisions made each day with patient care. This course supplements the other courses offered during the spring semester by integrating and applying basic science knowledge to the care of patients. Prereq: Consent of department.

ANES 478. Clinical Decision Making in Anesthesia II. 2 Units.
Guided and targeted discussion on common anesthetic considerations relegated by co-existing disease, comorbidity, anatomy, surgical procedures and common practice. Prereq: ANES 477.

ANES 480. Fundamentals of Anesthetic Sciences I. 1 Unit.
A continuum of courses over the fall and spring semesters that covers a series of topics in basic medical science with special emphasis on the effect of anesthetics on normal physiology. An examination is administered at the end of each semester.

ANES 481. Fundamentals of Anesthetic Sciences II. 1 Unit.
A series of topics in basic medical science with special emphasis on the effect of anesthetics on normal physiology. An examination is administered at the end of the semester. Prereq: ANES 480.

ANES 485. Introduction to Physiological Model-Based Simulation. 1 Unit.
Introduction to physiological model-based simulation using on-screen computer simulation and mannequins. Emphasis is placed on improving appropriate anesthesia-related basic science knowledge, manual skills in anesthesia machine checkout, drug and equipment setup, safety inspections, and performing anesthesia for uncomplicated surgical cases.

ANES 486. Physiological Model-Based Simulation I. 1 Unit.
An extension of ANES 485 with emphasis on improving or exercising knowledge of anesthesia-appropriate basic science, the use of more advanced equipment and techniques for uncomplicated surgical cases with an introduction to crisis management. Recommended preparation: ANES 485.

ANES 487. Physiological Model-Based Simulation II. 1 Unit.
An extension of ANES 486 emphasizing the physical techniques aspects of crisis management, team work and rescue in anesthesia, including support for and review of training in Basic Life Support and Advanced Cardiac Life Support. Recommended preparation: ANES 486.

ANES 488. Anesthesia Non-Technical Skills Lab. 1 Unit.
In this course the student will learn anesthesia non-technical skills, which are used integrally with medical knowledge and clinical techniques. They encompass both interpersonal skills (e.g. communication, team working, leadership) and cognitive skills (e.g. situation awareness, decision making). This course uses modified Crew Resource Management techniques taught in the aviation industry and considers the limitations of human performance and the nature of human error. The goals are to train individuals to avoid, capture and mitigate against the consequences of error. During the course, behaviors shown to minimize errors and maximize patient safety are highlighted and then practiced, with feedback being given to students on their performance.

ANES 490. Ethics, Law and Diversity for Anesthesiologist Assistants. 2 Units.
This course will focus on three topics. First, a discussion of legal practice as it applies to health care including basics of medical jurisprudence, negligence, and how to avoid a lawsuit. Second, a discussion of ethical theory including the principles of medical ethics, do not resuscitate, truth telling, and assessment of competence. Last, a discussion on diversity that will focus on the differences and similarities among people and how these factors influence patient care. The final grade will be based on an essay and a multiple choice exam.

ANES 499. Clinical Remediation. 1 - 10 Units.
(Credit as arranged.) Course offered to the student one time during the program of study which remediates "C" or below work in a clinical course.

ANES 580. Fundamentals of Anesthetic Sciences III. 1 Unit.
The second-year equivalent of ANES 480 and ANES 481. An examination is administered at the end of the semester. Recommended preparation: ANES 480 and ANES 481.
ANES 581. Fundamentals of Anesthetic Sciences IV. 1 Unit.
The second year equivalent of ANES 481. An examination is administered at the end of the semester. Prereq: ANES 580.

ANES 584. Physiological Model-Based Simulation III. 1 Unit.
An extension of ANES 487 emphasizing the physical techniques and aspects of crisis management, team work, and rescue in anesthesia. Prereq: ANES 487.

ANES 585. Physiological Model-Based Simulation IV. 1 Unit.
Extension of ANES 584 emphasizing the physical techniques and aspects of crisis management, team work, and rescue in anesthesia. Prereq: ANES 584.

ANES 599. Clinical Remediation. 1 - 10 Units.
(Credit as arranged.) Course offered to the student one time during the program of study which remediates "C" or below work in a clinical course.

Department of Biochemistry
Room W-427, School of Medicine
http://www.case.edu/med/biochemistry/
Phone: 216.368.3334; Fax: 216.368.3419
Vivien C. Lee, PhD, Interim Chair
vivien.yee@case.edu

Department Coordinator (biochemistry@case.edu)

Biochemistry is the study of the molecular basis of cellular and organismal function, making it a central discipline in the biological sciences. Biochemists ask the question, “How do life processes work at the molecular level?” The Department of Biochemistry offers undergraduate programs leading to the BA and BS degrees in biochemistry and graduate programs leading to the MS and PhD degrees. There are also dual-degree programs, leading to the MD/PhD, MD/MS in Biomedical Investigation, JD/MS, MS/MBA, and MS/MA in Patent Practice degrees. The department also participates in several interdisciplinary and interdepartmental programs in the School of Medicine and at Case Western Reserve University that provide additional avenues of study.

Research by Biochemistry faculty members covers a range of topics aimed at understanding life processes at the molecular level. Our efforts are broadened by collaborations with faculty in other university departments and with scientists at other academic and biotech research institutions. Research in the department is aimed at understanding the structures of biological macromolecules, the functions of proteins and enzymes, and the growth and differentiation of cells. There is also a focus on antibiotics and drug development.

Major
The two undergraduate major programs in Biochemistry, BA and BS, are based on the Arts and Sciences General Education Requirements, but differ in amount and intensity of the mathematics and physical sciences required. Either degree is excellent for students planning to undertake graduate work in biochemistry or in related areas of the biomedical sciences. Both the BA and the BS programs permit students to follow many options after graduation. Graduates are well prepared to pursue further studies in the biological sciences, for a career in medicine, for Doctor of Pharmacy programs, for employment in the chemical, pharmaceutical, and biotechnology industries, or as research assistants in research laboratories. The BA has a reduced emphasis on the quantitative aspects of science and makes available a considerable amount of elective time that permits a student to either concentrate on biochemistry even more intensively than the curriculum requires, or pursue other subjects in science or liberal arts. The BS degree is for the student who has a particularly strong interest in the quantitative physical sciences.

In both programs, undergraduate research is required. As many as nine hours of Research in Biochemistry (BIOC 391 Research Project) may be credited toward the requirements for graduation. At least six credits are highly recommended. The capstone in Biochemistry (BIOC 393 Senior Capstone Experience) is a thesis and presentation of a student’s undergraduate research studies.

Bachelor of Arts in Biochemistry

Required Courses:

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<td>BIOC 308</td>
<td>Molecular Biology</td>
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Biochemistry elective:

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<td>BIOC 312 or BIOC 334</td>
<td>Proteins and Enzymes Structural Biology</td>
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Two approved technical electives in biochemistry | 6

BIOC 393 | Senior Capstone Experience | 3

Additional Required Courses:

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<td>BIOL 215 &amp; 215L</td>
<td>Cells and Proteins and Cells and Proteins Laboratory</td>
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<td>CHEM 106 or ENGR 145</td>
<td>Principles of Chemistry II Chemistry of Materials</td>
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<td>CHEM 113</td>
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2019-2020 Case Western Reserve University  49
### BA Biochemistry, Sample Plan of Study

#### Freshman

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<tr>
<td>Elective</td>
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<td><strong>Year Total:</strong></td>
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#### Junior

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Introductory Physical Chemistry I (CHEM 301) or Physical Chemistry I (CHEM 335)</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 307)</td>
<td>4</td>
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<tr>
<td>GER Course</td>
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<tr>
<td>Electives</td>
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<tr>
<td>Molecular Biology (BIOC 308)</td>
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<tr>
<td>Approved Technical Elective</td>
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<tr>
<td>Research Project (BIOC 391)</td>
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<tr>
<td>Electives or GER Courses</td>
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#### Senior

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<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Biochemistry SAGES Seminar (BIOC 373)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Research Project (BIOC 391)</td>
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<tr>
<td>Electives</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Proteins and Enzymes (BIOC 312) or (Approved Technical Electives)</td>
<td>3</td>
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<tr>
<td>Senior Capstone Experience (BIOC 393)</td>
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<td>3</td>
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<tr>
<td>Structural Biology (BIOC 334) or Approved Biochem or Technical Elective</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Electives</td>
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<td><strong>Year Total:</strong></td>
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**Total Units in Sequence:** 120-123

Note: At least the 3 credits of undergraduate research, BIOC 391 Research Project, is minimally recommended for the Capstone. An additional 3 credits of BIOC 391 is highly recommended. Students should consult their academic advisers about the elective parts of the curriculum.

- a Selected students may be invited to take CHEM 323 Organic Chemistry I or CHEM 324 Organic Chemistry II
- b Selected students may be invited to take PHYS 123 Physics and Frontiers I - Mechanics and PHYS 124 Physics and Frontiers II - Electricity and Magnetism in place of PHYS 121 General Physics I - Mechanics and PHYS 122 General Physics II - Electricity and Magnetism
- c BA students must take either BIOC 312 Proteins and Enzymes or BIOC 334 Structural Biology. For BA students who take both courses, one course will serve as a technical elective.

### Bachelor of Science in Biochemistry

**Required Courses:**

- BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science 4
- BIOC 308 Molecular Biology 4
- BIOC 312 Proteins and Enzymes 3
- BIOC 334 Structural Biology 3
- BIOC 373 Biochemistry SAGES Seminar 3
- Approved Technical Elective in Biochemistry 3
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
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<tbody>
<tr>
<td>BIOC 393</td>
<td>Senior Capstone Experience</td>
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<td>BIOL 214 &amp; 214L</td>
<td>Genes, Evolution and Ecology and Genes, Evolution and Ecology Lab</td>
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<tr>
<td>BIOL 215 &amp; 215L</td>
<td>Cells and Proteins and Cells and Proteins Laboratory</td>
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<td>CHEM 105 or CHEM 111</td>
<td>Principles of Chemistry I or Principles of Chemistry for Engineers</td>
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<tr>
<td>CHEM 106 or ENGR 145</td>
<td>Principles of Chemistry II or Chemistry of Materials</td>
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<tr>
<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
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<tr>
<td>CHEM 223 or CHEM 323</td>
<td>Introductory Organic Chemistry I or Organic Chemistry I</td>
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<tr>
<td>CHEM 224 or CHEM 324</td>
<td>Introductory Organic Chemistry II or Organic Chemistry II</td>
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<tr>
<td>CHEM 301 or CHEM 335</td>
<td>Introductory Physical Chemistry I or Physical Chemistry I</td>
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<td>CHEM 302 or CHEM 336</td>
<td>Introductory Physical Chemistry II or Physical Chemistry II</td>
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<tr>
<td>CHEM 233</td>
<td>Introductory Organic Chemistry Laboratory I</td>
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<tr>
<td>CHEM 234</td>
<td>Introductory Organic Chemistry Laboratory II</td>
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<tr>
<td>MATH 121</td>
<td>Calculus for Science and Engineering I</td>
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<td>MATH 122</td>
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<tr>
<td>or MATH 124</td>
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<td>MATH 223 or MATH 227</td>
<td>Calculus for Science and Engineering III or Calculus III</td>
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<tr>
<td>MATH 224 or MATH 228</td>
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<tr>
<td>PHYS 121 or PHYS 123</td>
<td>General Physics I - Mechanics or Physics and Frontiers I - Mechanics</td>
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<td>PHYS 122 or PHYS 124</td>
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<tr>
<td>PHYS 221</td>
<td>Introduction to Modern Physics</td>
<td>3</td>
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<tr>
<td>STAT 312R or STAT 313</td>
<td>Basic Statistics for Engineering and Science Using R Programming or Statistics for Experimenters</td>
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**BS Biochemistry, Sample Plan of Study**

**Freshman**

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<tr>
<th>Course Code</th>
<th>Course Name</th>
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<tbody>
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<td>MATH 121</td>
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<tr>
<td>MATH 122</td>
<td>Calculus for Science and Engineering II</td>
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<tr>
<td>or MATH 124</td>
<td>Calculus II</td>
<td></td>
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<tr>
<td>MATH 223 or MATH 227</td>
<td>Calculus for Science and Engineering III or Calculus III</td>
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<tr>
<td>MATH 224 or MATH 228</td>
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<td>3</td>
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<tr>
<td>PHYS 121 or PHYS 123</td>
<td>General Physics I - Mechanics or Physics and Frontiers I - Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 122 or PHYS 124</td>
<td>General Physics II - Electricity and Magnetism or Physics and Frontiers II - Electricity and Magnetism</td>
<td>4</td>
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<tr>
<td>STAT 312R or STAT 313</td>
<td>Basic Statistics for Engineering and Science Using R Programming or Statistics for Experimenters</td>
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**Sophomore**

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<tr>
<td>or CHEM 324</td>
<td>Introductory Organic Chemistry II or Organic Chemistry II</td>
<td>3</td>
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<tr>
<td>or CHEM 335</td>
<td>Introductory Physical Chemistry I or Physical Chemistry I</td>
<td>3</td>
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<tr>
<td>or CHEM 336</td>
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<tr>
<td>MATH 223 or MATH 227</td>
<td>Calculus for Science and Engineering III or Calculus III</td>
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<tr>
<td>or MATH 228</td>
<td>Elementary Differential Equations or Differential Equations</td>
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<td>PHYS 121 or PHYS 123</td>
<td>General Physics I - Mechanics or Physics and Frontiers I - Mechanics</td>
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<td>PHYS 122 or PHYS 124</td>
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<tr>
<td>PHYS 221</td>
<td>Introduction to Modern Physics</td>
<td>3</td>
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<tr>
<td>STAT 312R or STAT 313</td>
<td>Basic Statistics for Engineering and Science Using R Programming or Statistics for Experimenters</td>
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**Junior**

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<td>MATH 122</td>
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<tr>
<td>or MATH 124</td>
<td>Calculus II</td>
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<td>MATH 223 or MATH 227</td>
<td>Calculus for Science and Engineering III or Calculus III</td>
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<tr>
<td>or MATH 228</td>
<td>Elementary Differential Equations or Differential Equations</td>
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<td>PHYS 121 or PHYS 123</td>
<td>General Physics I - Mechanics or Physics and Frontiers I - Mechanics</td>
<td>4</td>
</tr>
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<td>PHYS 122 or PHYS 124</td>
<td>General Physics II - Electricity and Magnetism or Physics and Frontiers II - Electricity and Magnetism</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 221</td>
<td>Introduction to Modern Physics</td>
<td>3</td>
</tr>
<tr>
<td>STAT 312R or STAT 313</td>
<td>Basic Statistics for Engineering and Science Using R Programming or Statistics for Experimenters</td>
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**Senior**

<table>
<thead>
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<tbody>
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<td>MATH 121</td>
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<td>MATH 122</td>
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<td>or MATH 124</td>
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<tr>
<td>MATH 223 or MATH 227</td>
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<td>or MATH 228</td>
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<tr>
<td>STAT 312R or STAT 313</td>
<td>Basic Statistics for Engineering and Science Using R Programming or Statistics for Experimenters</td>
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satisfy the following requirements:

To graduate with departmental honors in biochemistry, a student must be admitted to the department’s Undergraduate Honors Program. To Biochemistry majors who have excellent academic records may be invited to take PHYS 123 Physics and Frontiers I - Mechanics and PHYS 124 Physics and Frontiers II - Electricity and Magnetism in place of PHYS 121 General Physics I - Mechanics and PHYS 122 General Physics II - Electricity and Magnetism.

**Honors Program**
Biochemistry majors who have excellent academic records may be admitted to the department’s Undergraduate Honors Program. To graduate with departmental honors in biochemistry, a student must satisfy the following requirements:

1. A combined grade point average of at least 3.600
2. A minimum of 6 credit hours of undergraduate research (BIOC 391) in one laboratory
3. A BIOC 393 capstone report approved by the Undergraduate Education Committee of the department on the basis of the quality of the research, the written report, and an oral presentation. An acceptable report:
   a. Should follow a standard journal format
   b. Should demonstrate the student’s understanding of the research area, experimental techniques, goals and implications of the project
   c. Should show that the student has advanced his/her knowledge of the applicable techniques and the underlying scientific concepts.
4. Using all or part of the capstone report, the student must be a co-author on a manuscript either submitted, in press or published in a peer reviewed journal.

<table>
<thead>
<tr>
<th>Senior</th>
<th>Units</th>
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<tr>
<td>Proteins and Enzymes (BIOC 312)</td>
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<td>Biochemistry SAGES Seminar (BIOC 373)</td>
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<td>Research Project (BIOC 391)</td>
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<tr>
<td>Structural Biology (BIOC 334)</td>
<td>3</td>
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<td>Senior Capstone Experience (BIOC 393)</td>
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<td>Electives</td>
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<td>Year Total:</td>
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Total Units in Sequence: 123

Note: At least the 3 credits of undergraduate research, BIOC 391 Research Project, is a prerequisite to the Capstone. An additional 3 credits of BIOC 391 is highly recommended. Students should consult their academic advisers about the elective parts of the curriculum.

a. Selected students may be invited to take CHEM 323 Organic Chemistry I or CHEM 324 Organic Chemistry II
b. Selected students may be invited to take PHYS 123 Physics and Frontiers I - Mechanics and PHYS 124 Physics and Frontiers II - Electricity and Magnetism in place of PHYS 121 General Physics I - Mechanics and PHYS 122 General Physics II - Electricity and Magnetism.

**MS in Biochemistry**
The program leading to the MS degree in biochemistry prepares students for employment in academia and biotechnology and for advancement to other degree programs. Classroom work provides the latest advancements in biochemistry and related fields. In addition, laboratory courses allow students to acquire technical laboratory skills in biotechnology and a solid understanding of the practice of research in this area. Students typically enroll in three courses for each of four semesters.

The duration of the program is 21 months; it follows Plan B for the Master’s degree. The advisor for this program is usually the Graduate Advisor, but another advisor may be selected. The student’s progress is monitored by the Graduate Advisor and by the Graduate Education Committee. The program requires 36 hours of academic credit of which 18 hours must be graded coursework. BIOC 407 and 408 are the only required courses, providing students with flexibility in constructing a program that meets their interests. Students often take 6-12 hours of BIOC 601 Biochemical Research working in the laboratory of a faculty mentor, allowing them to get hands-on research experience. Other students opt for the Experimental Biology Track, which provides research experience and builds lab skills. All courses must be at the 400 level or higher; they must be on the list of approved electives or be approved by the advisor.

**MS in Biochemistry Plan of Study**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Spring</strong></td>
</tr>
<tr>
<td>BIOC 307</td>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)</td>
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<tr>
<td>BIOC 312</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>or BIOC 334</td>
<td>Proteins and Enzymes</td>
</tr>
<tr>
<td>Approved technical elective in biochemistry</td>
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</tr>
<tr>
<td>Total Units</td>
<td>14</td>
</tr>
</tbody>
</table>

Students may obtain credit for a minor in biochemistry by completing one year of freshman chemistry (including laboratory), one year of organic chemistry (including laboratory), two semesters of approved biology courses, and three semesters of didactic courses in biochemistry.

**Masters Degrees**
The Biochemistry Department offers a two-year Masters of Science in Biochemistry provides students with advanced study in biochemistry and related fields. This degree may be combined with other degrees in four dual-degree programs: MD/MS, JD/MS, MS/MBA, and MS/MA in Patent Practice.

Prerequisites for admission into any of the Biochemistry MS Programs are one year each of chemistry, organic chemistry, calculus, biology and physics. Applicants must also have a BA, BS or equivalent undergraduate degree. As part of the application process, students are required to take the Graduate Record Examination. Students with excellent qualifications who lack some of the prerequisites may be conditionally admitted and allowed to make up the deficiencies. Students with advanced training (coursework, laboratory research, MS degree, etc.) may be given advanced standing. Please visit the department’s web page (http://www.cwru.edu/med/biochemistry) for details about the application process.

**MS in Biochemistry**

The program leading to the MS degree in biochemistry prepares students for employment in academia and biotechnology and for advancement to other degree programs. Classroom work provides the latest advancements in biochemistry and related fields. In addition, laboratory courses allow students to acquire technical laboratory skills in biotechnology and a solid understanding of the practice of research in this area. Students typically enroll in three courses for each of four semesters.

The duration of the program is 21 months; it follows Plan B for the Master’s degree. The advisor for this program is usually the Graduate Advisor, but another advisor may be selected. The student’s progress is monitored by the Graduate Advisor and by the Graduate Education Committee. The program requires 36 hours of academic credit of which 18 hours must be graded coursework. BIOC 407 and 408 are the only required courses, providing students with flexibility in constructing a program that meets their interests. Students often take 6-12 hours of BIOC 601 Biochemical Research working in the laboratory of a faculty mentor, allowing them to get hands-on research experience. Other students opt for the Experimental Biology Track, which provides research experience and builds lab skills. All courses must be at the 400 level or higher; they must be on the list of approved electives or be approved by the advisor.

**MS in Biochemistry Plan of Study**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Spring</strong></td>
</tr>
<tr>
<td>BIOC 307</td>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)</td>
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### Second Year

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<th>Spring</th>
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<tbody>
<tr>
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<td>BIOC electives</td>
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<tr>
<td>Structural Biology (BIOC 434)</td>
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<td>BIOC electives</td>
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<tr>
<td>Master's Comprehensive Exam (EXAM 600)</td>
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<td><strong>Year Total:</strong></td>
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<td>9</td>
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</table>

**Total Units in Sequence:** 36

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### MS in Biochemistry: Experimental Biotechnology Track

Many graduates of the Biochemistry MS program work as researchers in academia, government laboratories, and the biotechnology sector. To prepare students for employment opportunities in biotech, the Experiment Biotechnology Track in the MS program prepares students for lab careers. Students take a laboratory-directed sequence in the first year: BIOC 500, BIOC 501, BIOC 502A, BIOC 502B, BIOC 502C, and BIOC 511. BIOC 500-502 introduce students to common techniques used in biochemistry labs and provide hands-on experience and training. BIOC 511 presents information about the organization of biotechnology research in academic and industrial settings. It also covers product development, and the biotech and pharmaceutical industries.

In the first year, students take BIOC 500, 501, 502, and 511, which provide a solid foundation in lab skills and techniques. In the second year, students perform research in an academic or biotech laboratory as BIOC 601, providing hands-on experience to improve the skills they acquired in the first-year courses. Students in this track also take didactic Biochemistry courses to provide a strong base of knowledge to complement the laboratory experiences.

### Experimental Biotechnology Track Plan of Study

#### First Year

<table>
<thead>
<tr>
<th>Courses</th>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)</td>
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<td></td>
</tr>
<tr>
<td>Biotechnology Laboratory: Molecular Biology Basics (BIOC 500)</td>
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<tr>
<td>Biochemical and Cellular Techniques for Biotechnology (BIOC 501)</td>
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<tr>
<td>Practice and Professionalism in Biotechnology (BIOC 511)</td>
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</tr>
<tr>
<td>Molecular Biology (BIOC 408)</td>
<td>4</td>
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<tr>
<td>Biotechnology Laboratory: Molecular Biology and Biochemical Techniques (BIOC 502A)</td>
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<tr>
<td>Biotechnology Laboratory: Eukaryotic Molecular and Cellular Biology (BIOC 502B)</td>
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<tr>
<td>Biotechnology Laboratory: Mass Spectrometry Techniques (BIOC 502C)</td>
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</tr>
<tr>
<td><strong>Year Total:</strong></td>
<td>9</td>
<td>9</td>
<td></td>
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</tbody>
</table>

---

Students may take the 502 courses in the first and/or second year.
MD/MS Biomedical Investigation-Biochemistry Track

The joint MD/MS program combine type B MS programs (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements) at the School of Medicine with the MD, using a common template. The core activities for this degree include limited credit from the medical core curriculum, 3-6 graduate courses in specific tracks, participation in a common seminar series, scientific integrity training, and a requirement for a special problems project that reflects a full year of research (18 hours of BIOC 601 Biochemical Research) culminating in a written report and examination. Both degrees can be completed within 5 years. Students who wish to join the MD/MS program may apply to the program after arriving at the University any time prior to fall of their second year of medical school. For more information, please see MD Dual Degrees.

The Biochemistry track is designed to provide students with knowledge of the latest advances in biochemistry and related fields. Courses offered by other departments may be included with the approval of the Graduate Advisor. Depending on the research project, students may substitute one of the courses below in lieu of one of the biochemistry electives with permission from the Graduate Advisor.

Students in the Biochemistry track must complete:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBIS 401</td>
<td>Integrated Biological Sciences I</td>
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</tr>
<tr>
<td>IBIS 402</td>
<td>Integrated Biological Sciences II</td>
<td>3</td>
</tr>
<tr>
<td>BIOC 412</td>
<td>Proteins and Enzymes</td>
<td>3</td>
</tr>
<tr>
<td>or BIOC 434</td>
<td>Structural Biology</td>
<td></td>
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<tr>
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Note: Students may finish in 18 months if they devote a summer to research (6 credits of BIOC 601 Biochemical Research).

JD/MS in Biochemistry

This program allows students in the School of Law to earn an MS degree in Biochemistry with an additional year of study. This program is useful for students planning careers in patent law or in areas related to biotechnology or pharmaceutical research.

Students in the School of Law can apply to the Biochemistry program for admission to the JD/MS program. In the dual degree program, students complete 12 fewer hours of law school coursework than they would if they were in the JD program alone. The Department of Biochemistry accepts 9 hours of law school coursework in courses dealing with science issues, in place of 9 credits of other elective work. Thus, the student will take a total of 27 hours of Biochemistry coursework of which at least 12 hours must be letter graded.

Dual degree students are advised about matters related to the JD degree by the Associate Dean for Academic Affairs at the School of Law. In addition, dual degree students are granted priority registration for upper-level courses, ensuring that they will be able to adjust their schedules to take all the required classes. Dual degree students are advised concerning matters related to the MS in Biochemistry by the program’s Graduate Advisor.

JD/MS in Biochemistry Plan of Study (plan B) (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

Because most students will apply for the JD/MS in Biochemistry Program after beginning Law School, the sample schedule below begins with Biochemistry coursework in the third year. However, Biochemistry coursework is also available to Law School students during the summer session in years two and three.

PhD Biochemistry

The PhD in Biochemistry program prepares students for careers in biochemistry. The emphasis of the doctoral program is on research, culminating in the completion of an original independent research project under the guidance of a faculty member in the biochemistry program. In addition to the research activities, graduate students participate in formal courses both within and outside the department, formal and informal seminars, discussions of current literature, and career development activities. Although students choose from the various tracks within the department, all are broadly trained in modern aspects of biochemistry and become familiar with techniques and literature in a variety of areas. Many collaborative projects with other departments also are available to broaden the spectrum of training offered. Most students begin with an integrated curriculum in cellular and molecular biology in addition to specialized courses in biochemistry. Students are admitted to the Biochemistry PhD program through the Biomedical Sciences Training Program (BSTP) (http://casemed.case.edu/bstp) or via the Medical Scientist Training Program (MSTP) (https://case.edu/medicine/admissions-programs/md-phd-program). The BSTP offers a common entry point to most of our biomedical PhD programs. The MSTP is available for students desiring the dual MD/PhD degrees and research careers in medicine and related biosciences.

Prerequisites for admission into the Biochemistry PhD Program include one year each of chemistry, organic chemistry, calculus, biology and physics. Applicants must also have a BA, BS or equivalent undergraduate degree. Students must submit scores from the Graduate Record Examination and may submit scores from an advanced area test, usually in biology, biochemistry or chemistry. Some students with otherwise excellent qualifications, but lacking some of the prerequisites may be conditionally admitted allowed to make up the deficiencies. Please visit the Department’s web page (http://www.cwr.edu/med/biochemistry) for details about the application process.

To earn a PhD in Biochemistry, a student must complete rotations in at least three laboratories, followed by selection of a research advisor, and complete core and elective coursework, including Responsible Conduct of Research, as described in the Course of Study below. Students who have completed relevant coursework elsewhere, (for example, with an MS) may petition to complete alternative courses.

In addition, each PhD student must complete a qualifying examination on their research topic in the form of a short grant proposal with oral defense for advancement to candidacy. The qualifying examination is usually completed during the second year. During the dissertation period, students are expected to meet yearly with their thesis committees, present seminars in the department, and fulfill journal publication requirements. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program. Completion of the PhD degree requires 36 hours of coursework (24 hours of which are graded) and 18 hours of BIOC 701 Dissertation Ph.D.

PhD Biochemistry Plan of Study

§ Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)
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**Total Units in Sequence:** 54

### Courses

#### BIOC 307. Introduction to Biochemistry: From Molecules To Medical Science. 4 Units.
Overview of the macromolecules and small molecules key to all living systems. Topics include: protein structure and function; enzyme mechanisms, kinetics and regulation; membrane structure and function; bioenergetics; hormone action; intermediary metabolism, including pathways and regulation of carbohydrate, lipid, amino acid, and nucleotide biosynthesis and breakdown. The material is presented to build links to human biology and human disease. One semester of biology is recommended. Offered as BIOC 307 and BIOC 407. Prereq: CHEM 223 and CHEM 224.

#### BIOC 308. Molecular Biology. 4 Units.
An examination of the flow of genetic information from DNA to RNA to protein. Topics include: nucleic acid structure; mechanisms and control of DNA, RNA, and protein biosynthesis; recombinant DNA; and mRNA processing and modification. Where possible, eukaryotic and prokaryotic systems are compared. Special topics include yeast as a model organism, molecular biology of cancer, and molecular biology of the cell cycle. Current literature is discussed briefly as an introduction to techniques of genetic engineering. Recommended preparation: BIOC 307. Offered as BIOC 308 and BIOC 408. Prereq: CHEM 223, BIOL 214, and BIOL 215.

#### BIOC 312. Proteins and Enzymes. 3 Units.
Aspects of protein and nucleic acid function and interactions are discussed, including binding properties, protein-nucleic acid interactions, kinetics and mechanism of proteins and enzymes, and macromolecular machines. Recommended Preparation: CHEM 301. Offered as BIOC 312 and BIOC 412. Prereq: BIOC 307.

#### BIOC 315. Nuclear Receptors in Health and Disease. 3 Units.
This course focuses on hormone-gene interactions mediated by the ligand-inducible transcription factors termed nuclear hormone receptors. The class will address the mechanisms of action, regulatory features, and biological activities of several nuclear receptors. The usage of nuclear receptors as therapeutic targets in disease states such as cancer, inflammation, and diabetes will also be discussed. The course aims to teach students to critically evaluate primary literature relevant to nuclear hormone receptors biology, and to reinforce presentation/discussion skills. Grades for undergraduates will be based on midterm, final exam; grades for graduates will be based on midterm, final exam, and presentation of a recently published research article related to the role of nuclear receptors in health and disease. Offered as PHRM 315, BIOC 315, PHRM 415 and BIOC 415.

#### BIOC 334. Structural Biology. 3 Units.
Introduces basic chemical properties of proteins and discusses the physical forces that determine protein structure. Topics include: the elucidation of protein structure by NMR and by X-ray crystallographic methods; the acquisition of protein structures from data bases; and simple modeling experiments based on protein structures. Offered as BIOC 334 and BIOC 434. Prereq: BIOC 307.
BIOC 354. Biochemistry and Biology of RNA. 3 Units.
Systematic overview of RNA biochemistry and biology. Course provides solid foundation for understanding processes of post-transcriptional regulation of gene expression. Topics include: RNA structure, RNA types, RNA-protein interactions, eukaryotic RNA metabolism including mRNA processing, ribosome biogenesis, tRNA metabolism, miRNA processing and function, bacterial RNA metabolism, transcriptomics. BIOC 454 requires an additional research proposal. Recommended preparation for BIOC 354: Undergraduate Biology (1 semester minimum), equivalents of CHEM 301, BIOC 307 or BIOC 308. Offered as BIOC 354 and BIOC 454. Prereq: CHEM 223 and CHEM 224.

BIOC 373. Biochemistry SAGES Seminar. 3 Units.
Discussion of current topics in biochemical research using readings from the scientific literature. The goals are for the student: 1) to discuss and critically analyze selections from the biochemical literature; 2) to gain a broader understanding of important topics not formally covered in the didactic courses; and 3) to learn to write in the style of journals in the field of biochemistry. Counts as SAGES Departmental Seminar. Prereq: BIOC 307 and BIOC 308. Restricted to majors in Biochemistry.

BIOC 391. Research Project. 1 - 9 Units.
(Credit as arranged.) Offered on a pass/fail basis only. Maximum 9 hours total credit.

BIOC 393. Senior Capstone Experience. 3 Units.
Students will complete their Capstone Projects, begun in BIOC 391. Pertinent research activities will depend on the nature of the student's project. The student will meet regularly with their Capstone advisor, at least twice monthly, to provide progress reports, discuss the project, and for critique and guidance. By the end of this course, the student will have completed their SAGES Senior Capstone research project, written a project report in the form of a manuscript, and presented their project orally in the department and at the Senior Capstone Fair, or its equivalent. Counts as SAGES Senior Capstone. Prereq: BIOC 307 and BIOC 308.

BIOC 395. Principles of Biochemistry: An Introduction to the Molecules of Life. 3 Units.
This summer course provides an introduction to the macromolecules and small molecules that are the foundation of living systems. The focus is on mammalian biochemistry, with links to human biology and human disease. Topics include: protein structure and function; enzyme mechanisms, kinetics and regulation; membranes; hormone action; bioenergetics; intermediary metabolism, including pathways and regulation of carbohydrate, lipid, amino acid, and nucleotide biosynthesis and breakdown. One semester of biology is recommended. Suitable for students interested in careers in the health professions. This course is not open to undergraduate Biochemistry majors or Biochemistry graduate students. Prereq: CHEM 223 and CHEM 224.

BIOC 407. Introduction to Biochemistry: From Molecules To Medical Science. 4 Units.
Overview of the macromolecules and small molecules key to all living systems. Topics include: protein structure and function; enzyme mechanisms, kinetics and regulation; membrane structure and function; bioenergetics; hormone action; intermediary metabolism, including pathways and regulation of carbohydrate, lipid, amino acid, and nucleotide biosynthesis and breakdown. The material is presented to build links to human biology and human disease. One semester of biology is recommended. Offered as BIOC 307 and BIOC 407. Prereq: CHEM 223 and CHEM 224.

BIOC 408. Molecular Biology. 4 Units.
An examination of the flow of genetic information from DNA to RNA to protein. Topics include: nucleic acid structure; mechanisms and control of DNA, RNA, and protein biosynthesis; recombinant DNA; and mRNA processing and modification. Where possible, eukaryotic and prokaryotic systems are compared. Special topics include yeast as a model organism, molecular biology of cancer, and molecular biology of the cell cycle. Current literature is discussed briefly as an introduction to techniques of genetic engineering. Recommended preparation: BIOC 307. Offered as BIOC 308 and BIOC 408.

BIOC 412. Proteins and Enzymes. 3 Units.
Aspects of protein and nucleic acid function and interactions are discussed, including binding properties, protein-nucleic acid interactions, kinetics and mechanism of proteins and enzymes, and macromolecular machines. Recommended Preparation: CHEM 301. Offered as BIOC 312 and BIOC 412.

BIOC 415. Nuclear Receptors in Health and Disease. 3 Units.
This course focuses on hormone-gene interactions mediated by the ligand-inducible transcription factors termed nuclear hormone receptors. The class will address the mechanisms of action, regulatory features, and biological activities of several nuclear receptors. The usage of nuclear receptors as therapeutic targets in disease states such as cancer, inflammation, and diabetes will also be discussed. The course aims to teach students to critically evaluate primary literature relevant to nuclear hormone receptors biology, and to reinforce presentation/discussion skills. Grades for undergraduates will be based on midterm, final exam; grades for graduates will be based on midterm, final exam, and presentation of a recently published research article related to the role of nuclear receptors in health and disease. Offered as PHRM 315, BIOC 415 and BIOC 415.

BIOC 420. Current Topics in Cancer. 3 Units.
The concept of cancer hallmarks has provided a useful guiding principle in our understanding of the complexity of cancer. The hallmarks include sustaining proliferative signaling, evading growth suppressors, enabling replicative immortality, activating invasion and metastasis, inducing angiogenesis, resisting cell death, deregulating cellular energetics, avoiding immune destruction, tumor-promoting inflammation, and genome instability and mutation. The objectives of this course are to (1) examine the principles of some of these hallmarks, and (2) explore potential therapies developed based on these hallmarks of cancer. This is a student-driven and discussion-based graduate course. Students should have had some background on the related subjects and have read scientific papers in their prior coursework. Students will be called on to present and discuss experimental design, data and conclusions from assigned publications. There will be no exams or comprehensive papers but students will submit a one-page critique (strengths and weaknesses) of one of the assigned papers prior to each class meeting. The course will end with a full-day student-run symposium on topics to be decided jointly by students and the course director. Grades will be based on class participation, written critiques, and symposium presentations. Offered as BIOC 420, Mbio 420, PATH 422, and PHRM 420. Prereq: CBio 453 and CBio 455.
BIOC 432. Current Topics in Vision Research. 3 Units.
Vision research is an exciting and multidisciplinary area that draws on the disciplines of biochemistry, genetics, molecular biology, structural biology, neuroscience, and pathology. This graduate level course will provide the student with broad exposure to the most recent and relevant research currently being conducted in the field. Topics will cover a variety of diseases and fundamental biological processes occurring in the eye. Regions of the eye that will be discussed include the cornea, lens, and retina. Vision disorders discussed include age-related macular degeneration, retinal ciliopathies, and diabetic retinopathy. Instructors in the course are experts in their field and are members of the multidisciplinary visual sciences research community here at Case Western Reserve University. Students will be exposed to the experimental approaches and instrumentation currently being used in the laboratory and in clinical settings. Topics will be covered by traditional lectures, demonstrations in the laboratory and the clinic, and journal club presentations. Students will be graded on their performance in journal club presentations (40%), research proposal (40%), and class participation (20%). Offered as NEUR 432, PATH 432, PHRM 432 and BIOC 432.

BIOC 434. Structural Biology. 3 Units.
Introduces basic chemical properties of proteins and discusses the physical forces that determine protein structure. Topics include: the elucidation of protein structure by NMR and by X-ray crystallographic methods; the acquisition of protein structures from data bases; and simple modeling experiments based on protein structures. Offered as BIOC 334 and BIOC 434.

BIOC 452. Nutritional Biochemistry and Metabolism. 3 Units.
Mechanisms of regulation of pathways of intermediary metabolism; amplification of biochemical signals; substrate cycling and use of radioactive and stable isotopes to measure metabolic rates. Recommended preparation: BIOC 307 or equivalent. Offered as BIOC 452 and NTRN 452.

BIOC 454. Biochemistry and Biology of RNA. 3 Units.
Systematic overview of RNA biochemistry and biology. Course provides solid foundation for understanding processes of post-transcriptional regulation of gene expression. Topics include: RNA structure, RNA types, RNA-protein interactions, eukaryotic RNA metabolism including mRNA processing, ribosome biogenesis, tRNA metabolism, miRNA processing and function, bacterial RNA metabolism, transcriptomics. BIOC 454 requires an additional research proposal. Recommended preparation for BIOC 354: Undergraduate Biology (1 semester minimum), equivalents of CHEM 301, BIOC 307 or BIOC 308. Offered as BIOC 354 and BIOC 454.

BIOC 475. Protein Biophysics. 3 Units.
This course focuses on in-depth understanding of the molecular biophysics of proteins. Structural, thermodynamic and kinetic aspects of protein function and structure-function relationships will be considered at the advanced conceptual level. The application of these theoretical frameworks will be illustrated with examples from the literature and integration of biophysical knowledge with description at the cellular and systems level. The format consists of lectures, problem sets, and student presentations. A special emphasis will be placed on discussion of original publications. Offered as BIOC 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.

BIOC 500. Biotechnology Laboratory. Molecular Biology Basics. 1 Unit.
This course provides basic hands-on laboratory experience in molecular biology with a focus on handling and manipulating DNA in bacterial systems. Specific topics include: General laboratory safety, buffers, media, and other reagent preparation, sterile technique, transformation and culture of bacterial cells, DNA molecular biology techniques including DNA isolation and purification, polymerase chain reaction (PCR), restriction digests, ligation, agarose gel electrophoresis, and sequence analysis. Prereq: Biochemistry Graduate student or Requisites Not Met permission.

BIOC 501. Biochemical and Cellular Techniques for Biotechnology. 3 Units.
This lecture course covers the basics of common, essential laboratory and analytical techniques used in biomedical research and the biotechnology industry. The course will cover recombinant protein production and characterization, mammalian cell culture, molecular and cell biology, and mass spectrometry. Specific topics include: general laboratory safety, record keeping, preparation of research reports, manipulation of bacteria, protein overexpression and purification, enzyme assays, high-throughput techniques, high performance liquid chromatography (HPLC) and mass spectrometry, mammalian cell culture, Western blotting, protein-protein interactions, reverse transcription-quantitative polymerase chain reaction (RT-qPCR), immunofluorescence microscopy and assays for gene expression. This course is suitable for Biochemistry MS students interested in pursuing careers in academia or biotechnology. It is also recommended for undergraduate students to enhance their technical skills and position them for productive research experiences. Graduate students in other programs within or outside the School of Medicine are permitted to enroll. Prereq: (BIOL 215L and CHEM 113) or Graduate standing. Coreq: CHEM 233 or Graduate standing.

BIOC 502A. Biotechnology Laboratory: Molecular Biology and Biochemical Techniques. 2 Units.
This spring course provides hands-on laboratory experience in bacterial recombinant protein biochemistry and molecular and cell biology. Specific topics include: General laboratory safety, good laboratory practices (GLP), standard operating procedures (SOPs), buffers, media, and other reagent preparation, sterile technique, manipulation of bacterial cells, work with DNA including polymerase chain reaction (PCR), molecular cloning, and site-directed mutagenesis, protein overexpression and purification, enzyme activity and biophysical assays, DNA and protein gel electrophoresis, and high performance liquid chromatography (HPLC). This course, together with BIOC 502B and 502C, comprise a one-semester lab course that provides students with a comprehensive introduction to skills used in modern biotechnology laboratories. Students may take one, two, or three of these courses in a single semester. Suitable for biochemistry MS students interested in biotechnological and/or industry careers. All other graduate students and/or undergraduate students must contact the instructor for permission to enroll. Prereq: BIOC 500 and BIOC 501 or Requisites Not Met permission.
**BIOC 502B. Biotechnology Laboratory: Eukaryotic Molecular and Cellular Biology. 2 Units.**

This spring course provides hands-on laboratory experience in mammalian cell culture and molecular and cell biology. Specific topics include: General laboratory safety, good laboratory practices (GLP), standard operating procedures (SOPs), buffers, media, and other reagent preparation, sterile technique, manipulation of mammalian cells, mammalian cell culture, work with DNA and RNA, polymerase chain reaction (PCR) techniques including quantitative reverse transcription (RT-qPCR) and molecular cloning, reporter assays, transfection, immunoprecipitation, immunofluorescence, and protein gel electrophoresis and blotting. This course, together with BIOC 502A and 502C, comprise a one-semester lab course that provides students with a comprehensive introduction to skills used in modern biotechnology laboratories. Students may take one, two, or three of these courses in a single semester. Suitable for biochemistry MS students interested in biotechnological and/or industry careers. All other graduate students and/or undergraduate students must contact the instructor for permission to enroll. Prereq: BIOC 500 and BIOC 501 or Requisites Not Met permission.

**BIOC 502C. Biotechnology Laboratory: Mass Spectrometry Techniques. 1 Unit.**

This spring course provides hands-on laboratory experience in mass spectrometry with an emphasis on biomolecules. Specific topics include analysis of small molecules and biomolecules using high performance liquid chromatography (HPLC) and mass spectrometry. This course, together with BIOC 502A and 502B, comprise a one-semester lab course that provides students with a comprehensive introduction to skills used in modern biotechnology laboratories. Students may take one, two, or three of these courses in a single semester. Suitable for biochemistry MS students interested in biotechnological and/or industry careers. All other graduate students and/or undergraduate students must contact the instructor for permission to enroll. Prereq: BIOC 500 and BIOC 501 or Requisites Not Met permission.

**BIOC 511. Practice and Professionalism in Biotechnology. 1 Unit.**

This course provides an overview of a variety of topics that are relevant to biotechnology research and development in academic and industrial settings. It also provides an opportunity for students to develop professional written and oral communication skills. Specific topics include: Professional communications by email, letters, reports, and oral presentations; data documentation, security, and confidentiality; laboratory safety, certification, and regulation; intellectual property protection and patents; the drug discovery pipeline and approval process; financial aspects of research and development. Prereq: Graduate Student in Biochemistry.

**BIOC 528. Contemporary Approaches to Drug Discovery. 3 Units.**

This course is designed to teach the students how lead compounds are discovered, optimized, and processed through clinical trials for FDA approval. Topics will include: medicinal chemistry, parallel synthesis, drug delivery and devices, drug administration and pharmacokinetics, and clinical trials. A special emphasis will be placed on describing how structural biology is used for in silico screening and lead optimization. This component will include hands-on experience in using sophisticated drug discovery software to conduct in silico screening and the development of drug libraries. Each student will conduct a course project involving in silico screening and lead optimization against known drug targets, followed by the drafting of an inventory disclosure. Another important aspect of this course will be inclusion of guest lectures by industrial leaders who describe examples of success stories of drug development. Offered as BIOC 528, PHOL 528, PHRM 528, and SYBB 528.

**BIOC 601. Biochemical Research. 1 - 18 Units.**

Credit as arranged.

**BIOC 611. Biochemistry Seminar I. 1 Unit.**

Student presentations of topics from the current scientific literature unrelated to the student’s research project. Participants are required to present a seminar.

**BIOC 612. Biochemistry Seminar II. 1 Unit.**

Discussion of current research.

**BIOC 641. Proposition I. 2 Units.**

Design of research proposal.

**BIOC 651. Thesis M.S.. 1 - 6 Units.**

(Credit as arranged.)

**BIOC 701. Dissertation Ph.D.. 1 - 9 Units.**

(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

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**Department of Bioethics**

Room TA-200, School of Medicine
http://www.case.edu/med/bioethics/bioethics.html
Phone: 216.368.8718
Mark P. Aulisio, PhD, Susan E. Watson Professor and Chair
mark.aulisio@case.edu
Marie Norris (marie.norris@case.edu), Program Assistant

The mission of the Department of Bioethics is to improve public and professional understanding of the ethical and contextual issues involved in health sciences research, health care delivery, and health policy development through teaching, research and community dialogue.

The department has offices at the Case’s School of Medicine and MetroHealth Medical Center and has faculty from multiple disciplines, including philosophy, religion, law, political science, anthropology, history, sociology, psychology, nursing and medicine.

Department faculty teach in both core and elective components of the medical school curriculum, undergraduate courses in ethics and medical humanities, and an intensive course in responsible conduct of research for PhD students in the School of Medicine. The department also has a highly successful master’s degree program in bioethics and medical humanities and an undergraduate minor.

Department faculty have gained international prominence for research in many areas of biomedical ethics and medical humanities that collectively address the concerns of the School of Medicine’s spectrum of biomedical disciplines and questions of health more broadly.

Please visit the department website (http://www.case.edu/med/bioethics) to obtain information about the Master’s degree program and learn about department and faculty activities.

**Minor in Bioethics and Medical Humanities**

Bioethics and Medical Humanities together comprise a vibrant area of scholarship concerning the most important and cutting-edge ethical issues surrounding biomedical research and the delivery of health care today. The study of such ethical issues calls into action our most central human values and related behaviors, the exploration of which is of crucial importance for all students whether one plans to enter a career in the healthcare professions, biomedical research, law, nonprofit administration, or some other career path. The topics covered...
in Bioethics and Medical Humanities will help prepare students to become responsible world citizens in an increasingly complex biomedical environment.

The CWRU Minor in Bioethics and Medical Humanities formally recognizes a student’s coordinated course of study comprised of courses currently offered by the Department of Bioethics and other departments in the College of Arts and Sciences. The Bioethics and Medical Humanities Minor is designed to give students ethical and social training centered specifically around the delivery of healthcare and biomedical research and to do so in a highly interdisciplinary manner.

**Plan of Study**

I. Students should select three of the following four course offerings. (9 credit hours)

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<tr>
<td>BETH 271</td>
<td>Bioethics: Dilemmas</td>
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<td>BETH 360</td>
<td>Science and Society</td>
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<td>BETH 371</td>
<td>Advanced Bioethics</td>
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II. ELECTIVE COURSES (6 Credit Hours)

Additional Courses may be added in the future to this list of electives. Each new elective course must be approved by Bioethics Department faculty director of the Minor and must have substantial bioethics or medical humanities content (greater than 75%).

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<td>BETH 371C</td>
<td>Advanced Bioethics: Clinical Observation</td>
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<td>BETH 406</td>
<td>Society, Religion, and Bioethics</td>
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<td>ENGL 217B</td>
<td>Writing for the Health Professions</td>
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<td>ENGL 330</td>
<td>Victorian Literature</td>
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<td>ENGL 341</td>
<td>Rhetoric of Science and Medicine</td>
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<td>ENGL 379</td>
<td>Topics in Language Studies</td>
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<td>ENGL 386</td>
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<td>HSTY 151</td>
<td>Technology in European Civilization</td>
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<td>HSTY 152</td>
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<td>HSTY 202</td>
<td>Science in Western Thought II</td>
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<td>HSTY 243</td>
<td>The Age of Prozac: Social and Cultural Aspects of Depression</td>
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<td>HSTY 346</td>
<td>Guns, Germs, and Steel</td>
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<tr>
<td>HSTY 373</td>
<td>Women and Medicine in the United States</td>
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<td>HSTY 395</td>
<td>History of Medicine</td>
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<tr>
<td>PHIL 101</td>
<td>Introduction to Philosophy</td>
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<tr>
<td>PHIL 203</td>
<td>Revolutions in Science</td>
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<td>PHIL 204</td>
<td>Philosophy of Science</td>
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<tr>
<td>PHIL 305</td>
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**MA in Bioethics and Medical Humanities Plan of Study**

**First Year**

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<tr>
<th>Course Code</th>
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<tr>
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<tr>
<td>BETH 402</td>
<td>Clinical Ethics Rotation (BETH 405)</td>
<td>1.5 - 3</td>
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<td>BETH 403</td>
<td>Elective I</td>
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<tr>
<td>BETH 404</td>
<td>Elective II</td>
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<tr>
<td>BETH 405</td>
<td>Foundations in Bioethics II (BETH 402)</td>
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<tr>
<td>BETH 406</td>
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| Total Units in Sequence: | 30-33 |

**Dual Degree Programs**

**JD/MA**

This program combines the Master of Arts in Bioethics and Medical Humanities with the Doctor of Jurisprudence and is offered in cooperation with the School of Law. Advances in health sciences have created new and difficult moral choices for individuals, their families, and the health professionals who work with them.

The Department of Bioethics is dedicated to responding to the challenge of health care choices faced in today’s society. It focuses on the ethical,
cultural, and policy dimensions of healthcare, technology, and the life sciences. Professionals from many arenas, including public health, prevention sciences, health sciences, the life sciences, and the social sciences have contributed to and drawn from the field of Bioethics.

The JD Degree is a terminal degree; persons with the degree may pursue a variety of career paths. The MA in Bioethics and Medical Humanities is considered a supplemental degree— it enhances careers in other fields. The combined JD/MA program provides excellent preparation for students who desire to practice health law by giving law students firsthand experience in multiple healthcare settings. It is designed to help students identify and assess challenges facing the medical and health law professions in the coming decades, and explore a broad range of health law and policy issues. The program emphasizes the interdisciplinary and inter-professional nature of the field and includes a significant clinical component.

Students must apply and be accepted to each degree program to qualify. New students can apply to both programs simultaneously; current law students may apply before the end of their first year. Students are expected to complete course requirements for the two degrees in either three-and-one-half years, or three years combined with some summer school work. The curriculum for this dual degree program begins with one year of full-time study in law school.

The Department of Bioethics accepts 6 credits of elective law courses toward MA elective requirements. The law school accepts 12 credits of the required Foundations in Bioethics I and II courses as law elective credits toward the JD degree.

**MA/MSN**

This program combines the Master of Arts in Bioethics and Medical Humanities with the Master of Science in Nursing, in cooperation with the School of Nursing. The program provides excellent preparation for advanced practice nurses to gain knowledge about the principles and problem resolution techniques that are foundational to bioethics.

The combined MA/MSN program will enable students to obtain graduate preparation in both fields, contributing to the integration of ethics in advanced practice nursing and thereby increasing the availability of ethics expertise to the nursing community.

Students must apply and be accepted to each program to qualify. Students may take courses required for each program concurrently or may complete the requirements for one program prior to beginning the requirements for another. The Department of Bioethics accepts 6 credits of required elective nursing school courses toward the MA elective requirement. The nursing school accepts 5 credits of the required Foundations in Bioethics I course towards the MSN degree requirement.

**MA/MPH**

This program combines the Master of Arts in Bioethics and Medical Humanities with the Master of Public Health degree. The Master of Public Health Program prepares students to address the broad mission of public health, defined as "enhancing health in human populations, through organized community effort," utilizing education, research, and community service. Public health practitioners must be prepared to identify and assess health needs of different populations, and able to plan, implement and evaluate programs to respond to those needs.

It is the task of the public health practitioner to prevent illness, and to protect and promote the wellness of human-kind. A Master of Public Health degree provides education in public health basics, including biostatistics, epidemiology, environmental health sciences, health policy, and social and behavioral sciences.

The Department of Bioethics offers a graduate program leading to the degree of Master of Arts in Bioethics and Medical Humanities. Advances in health sciences have created new and difficult moral choices for individuals, their families, and the health professionals who work with them. The Department of Bioethics is dedicated to responding to the challenge of health care choices faced in today's society. Professionals from many arenas, including public health, prevention sciences, health sciences, the life sciences, and the social sciences have contributed to and drawn from the field of bioethics.

Because of the breadth and scope of the field of public health and the discipline of bioethics, the CWRU MPH and Bioethics Programs are ideally suited to combine in a joint effort. The MPH/Bioethics and Medical Humanities shared degree will enable students to obtain graduate preparation in both fields, contributing to the application of ethics in public health practice and thereby increasing the availability of leadership and scholarship relating to Bioethics in the public health community.

It is anticipated that this collaboration will improve the ethics component of the public health educational experience for all students through closer collaboration between departments, and through peer interactions of dual degree students and their colleagues.

The MPH Degree is a "terminal" degree and persons with the degree may pursue a variety of career paths. The MA in Bioethics and Medical Humanities is considered a supplementary degree in that it enhances careers in other fields, e.g. law, medicine, nursing, or in this case, public health.

The joint bioethics-public health degree would fuel careers in every aspect of public health, including international and global health, public health preparedness and function, environmental health sciences, behavioral sciences, health education, health communications, and health policy and management.

Bioethics Masters students receive their degree after 30 hours of study over one year. The School of Graduate Studies awards the MPH degree for 36 credit hours over two years. The joint MA/MPH program can be completed in three years of full-time study to complete a minimum of 57 credit hours. It should be noted that in 2007, changes in national education criteria for the Master of Public Health degree will require increasing credit hour requirements to 42 credits.

Options will be available for part-time pursuit of the degree within five years, or for an accelerated plan competed in five semesters. Students will develop individual education plans (IEP) with their advisors and may customize their approach and pace through the program. Each program has a set of core courses that must be completed; 15 core credits in Public Health and 15 core credits in Bioethics for a combined total of 30 required credit hours. The 9-credit Capstone experience is also required of all public health students.

The stand-alone Bioethics program also requires 12 credits taken from a list of approved elective courses plus a 1.5 hour capstone and 1.5 hour mini-elective. In addition to its 24 required credits, the stand-alone MPH program requires 9 concentration credits and 3 elective credits. Joint MA/MPH candidates will combine their Bioethics electives and Public
Health concentration and elective courses to complete a total of 18 credit hours of advanced electives.

MA/MSSA

This program joins two well-known academic programs to offer students an interdisciplinary experience blending the similar values of social work and medicine. This is a "side-by-side" program composed of existing elements of ongoing programs provided by the faculty usually engaged in these efforts. These new elements will be supplemented by an integrative experience designed to make the interdisciplinary character of the program concrete.

Dual-degree students must receive the MSSA and MA degrees simultaneously to be granted credit for specific courses taken in the other program. The dual degree program offered by Case Western Reserve’s Jack, Joseph and Morton Mandel School of Applied Social Sciences and the Department of Bioethics is unlike other programs in the United States. As the number and complexity of ethical dilemmas in health care, aging, and mental health and social work continue to increase, there is a growing need for advanced practice social workers who are knowledgeable about the principles and problem resolution techniques that are fundamental to Bioethics.

In healthcare settings, ethical consultations are often requested on decisions having to do with end-of-life, organ donation, or initiation or withdrawal of medical treatments. In addition, graduates of this program will be able to help counsel health care providers, organizations, and clients, participate in setting policy and teach others about these issues.

Students must apply separately to the Mandel School and the Department of Bioethics for admission into each program. Admission to one program is not a guarantee that the student will gain admission to the other, and application to both programs should be made simultaneously. A joint committee of the two programs will meet and review the joint degree applications.

MA/MD

This program combines the Master of Arts in Bioethics and Medical Humanities with the MD degree, in cooperation with either the School of Medicine or the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University. This program provides physicians with advanced knowledge and experience in Bioethics integrated into the medical curricula in each program.

MS/MA in Genetic Counseling and Bioethics and Medical Humanities

The Departments of Genetics & Genome Sciences and Bioethics and Medical Humanities offer a dual degree program between the Masters in Genetic Counseling and the Masters in Bioethics and Medical Humanities Programs. The dual degree program provides a comprehensive curriculum integrating foundational principles of genetics and ethics. The goal of the program is to train Genetic Counselors who wish to apply additional Bioethics expertise into their clinical practice and/or research.

The dual degree program allows graduates to engage in both contemplative analysis and application of knowledge in the counseling of patients and should allow graduates to be more prepared to participate in the ongoing national dialogue about the ethical, legal, and social implications of advances in genomic technology as well as research within their home institutions and with other counselors nationwide regarding issues of new genomic testing technology, concerns about genetic services, and issues related to genetic discrimination, privacy, and the return of genetic and genomic results.

The curriculum for the Dual Genetic Counseling/Bioethics Degree consists of 62 credit hours to be completed in 2.5 years. Students enrolled in the dual degree program will spend their first year taking courses entirely within the Genetic Counseling Program and then will spread out their Bioethics coursework over the next 1.5 years while continuing with required coursework and clinical rotations in the genetic counseling program.

In addition to both a written and oral comprehensive examination as part of the Genetic Counseling Training Program, the dual degree requires a research project be carried out for the completion of both degrees.

For the dual degree, students will be required to choose a research project that includes ethical, legal, or social issues of genetic counseling practice, clinical genetics or genomics, or genetic research. Students will also be required to include at least one Bioethics Faculty member on their Research Project Committee.

Students who would like to enroll in the dual degree program will apply and be admitted into each program separately. While admissions committees for each program will communicate with each other regarding applicants, each admissions committee will decide independently about the suitability of the applicant to their program.

Once students have been admitted, the Director of the Genetic Counseling Training Program and the Director of the MA Program in Bioethics and Medical Humanities will act as student advisors for each of the two programs individually but will meet monthly to assess student progress, address any student or faculty concerns, and assure that student progress in each of the programs, and their overlapping components, are being achieved.

MS/MA in Genetic Counseling and Bioethics and Medical Humanities

Plan of Study

<table>
<thead>
<tr>
<th>First Year</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<tr>
<td>Advanced Medical Genetics: Molecular &amp; Cytogenetics (GENE 524)</td>
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<td>Advanced Medical Genetics: Quantitative Genetics &amp; Genomics (GENE 526)</td>
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<td>Principles and Practices of Genetic Counseling (GENE 528)</td>
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<td>Direct Practice Generalist Methods &amp; Skills (SASS 477)</td>
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<td>Psychosocial Issues in Genetic Counseling (GENE 529)</td>
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<td>Advanced Medical Genetics: Clinical Genetics (GENE 525)</td>
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<td>Cancer Genetics (GENE 531)</td>
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Department of Bioethics

Second Year

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<tr>
<td>Advanced Medical Genetics: Biochemical Genetics (GENE 527)</td>
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<td>Foundations in Bioethics I (BETH 401)</td>
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<td>Ethical Issues in Genetics/Genomics (BETH 412)</td>
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<td>Research in Genetics (GENE 601)</td>
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Third Year

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Total Units in Sequence: 62

Doctoral Program in Bioethics

The goal of the PhD program is to train scholars in the conceptualization, design, and conduct of interdisciplinary research on issues in bioethics, medical humanities, and related areas. Candidates may enter the program from any discipline. All doctoral students will become fluent in the ways in which bioethics and medical humanities scholarship employs concepts and methods from the humanities, social sciences, clinical research, jurisprudence, and health policy. The Department of Bioethics is a multi-disciplinary learning environment, with faculty representing the fields of philosophy, anthropology, psychology, public health, law, medicine, and nursing. The doctoral program’s curriculum is organized around core areas which include: normative and social science theory and methods; research ethics; clinical ethics; public health ethics; and medical humanities. Concentrations are available to students interested in 1) problems in genetics and genomics; 2) stem cell research and regenerative medicine; 3) research ethics and public health ethics; 4) clinical ethics; and 5) medical humanities and social medicine.

Requirements: Candidates should have a strong background in the social/behavioral sciences, public health/health services research, legal/health policy research, or philosophy and related humanities disciplines. An overall grade point average of 3.3 out of 4.0 (at the undergraduate level) is preferred. Applicants must demonstrate competency in the English language.

Courses

BETH 210. Perspectives on Health: Introduction to Medical Humanities and Social Medicine. 3 Units.
This survey course is designed to give students a broad overview of medical humanities and medical social sciences. Students will engage materials from a wide range of disciplines and learn how to analyze which perspectives afford and obscure which types of knowledge relevant to health, illness and clinical practice. Students will learn how to identify epistemology, methodology, theory and data from various disciplinary perspectives. This course is relevant for students engaged in pre-clinical education as well as those interested in medical humanities and medical social sciences.

BETH 271. Bioethics: Dilemmas. 3 Units.
We have the genetic technology to change nature and human nature, but should we? We have the medical technology to extend almost any human life, but is this always good? Should we clone humans? Should we allow doctor-assisted suicide for the terminally ill? This course invites students from all academic disciplines and fields to examine current and future issues in bioethics—e.g., theory and methods in bioethics; death and dying; organ transplantation; genetics; aging and dementia; fertility and reproduction; distributive justice in health care access. The course will include guest lecturers from nationally-known Bioethics faculty. Offered as BETH 271 and PHIL 271.

BETH 302. Independent Studies in Bioethics. 1 - 3 Units.
This course is for students with Bioethics-related special interests not adequately addressed in regular courses, and who wish to work independently in consultation with faculty.

BETH 314. Global Health: India. 3 Units.
Bioethics is the study of ethical controversies arising at the intersection of biology, medicine, technology, politics, law, philosophy, religion and culture. This course will discuss and analyze the issue of health in India; recognizing that health is more than the diagnosis and treatment of a disease. Using three diseases (HIV/AIDS, leprosy and tuberculosis) students will explore the relationship between culture and health care outcomes. Relevant issues addressed in the course include the history of British rule in India, Hinduism, the Caste system, poverty, access to education and public policy. Faculty will introduce readings on the history of India, medical anthropology, religion and the law. Students will then be given the opportunity to focus on a particular topic, research the existing literature, present their findings to the class and create a plan to observe the chosen topic while in India during the Summer semester. Course instructors include Nicole Deming, JD, MA Assistant Professor of Bioethics; Deepak Sarma, PhD, Associate Professor of South Asian Religions; and Gopal Yadavalli, MD Assistant Professor of Medicine and Chief of the Infectious Diseases Clinic at the Cleveland VA Medical Center. The course will also invite guest lectures from many different departments and schools to share their expertise and experience in the areas of Global Justice, Anthropology, and Human Rights.
BETH 315. International Bioethics: Policy and Practice. 3 Units.
Taught by Case and international faculty, this course will include 7-10 days of intensive didactic and experiential learning in one of several "host" countries. Examples of sites include: Free University of Amsterdam and University of Utrecht in the Netherlands; University of Paris in France; and Ben Gurion University in Israel. It will afford a unique opportunity to gain perspective on important bioethics issues in different societies, i.e., euthanasia, public health policies, access to healthcare, and stem cell research. At the international site, students will spend 6 hours per day (5 days) in seminar (involving didactics, discussion, and guided-observation clinical experience). There will be two 3-hour preparatory sessions, required reading, and two 3-hour post trip sessions. Requirements: preparation, attendance, and class participation, a 12-15 page paper (undergraduate credit) and a 15-20 page paper (graduate credit). Graduate credit will also require students to prepare a presentation for a post-intensive session. Enrollment will be capped at 25. This course has an additional fee to cover costs of travel and lodging. Limited scholarships are available. Offered as BETH 315 and BETH 415.

BETH 315A. International Bioethics Policy and Practice: Women's Health in the Netherlands. 3 Units.
This 3-credit course allows students to familiarize themselves with social policies and practices related to women's health in the United States and the Netherlands. Issues covered in the course include birth control and family planning, abortion, prenatal testing, childbirth, health care disparities, cosmetic surgery, prostitution and trafficking in women. This course also addresses the US and Dutch national policies regarding the public provision of health care for women. The course places an emphasis on the ways in which social norms shape policies over time, which political actors are involved in shaping women's health policy, and the balance between women's health as a matter of the public good or individual responsibility. This course substantively explores gender-specific cultural values and practices in relation to women's health in the United States and the Netherlands and will help students develop the analytical skills necessary for evaluating social policy and ethical issues related to women's health. Offered as BETH 315A, BETH 415A and WGST 315A. Counts for CAS Global & Cultural Diversity Requirement.

BETH 315B. International Bioethics Policy and Practice: Public Health in the Netherlands. 3 Units.
This one week 3-credit intensive course will be held in Amsterdam, The Netherlands. Taught by faculty from Case and Utrecht University, this course offers students a cross-cultural perspective on ethical dilemmas raised by the practice of public health in the United States and Northern Europe. Additionally, this course examines policies related to prostitution, drug use, sex education, infectious disease prevention, and access to health care and how they differ in the cultural and political settings of U.S. and the Netherlands. We will examine both the rationales and outcomes of Dutch and American policies, stimulating course participants to consider their own views on these often controversial issues. Prior to the trip, students will attend lectures at Case, which will acquaint them with the theoretical approaches to public health ethics and major issues raised in the practice of public health. In these pre-trip sessions, students will also analyze and report on a case study designed to stimulate critical thinking on comparative public health ethics. In Amsterdam, students will attend lectures that will be supplemented by site visits and discussion sessions aimed at exploring the ethics of public health policy and practice in the Netherlands. Following the intensive week in Amsterdam, students will meet with instructors at Case for two hours to discuss their experiences and compare policies and practices in the U.S. and the Netherlands. Offered as BETH 315B and BETH 415B. Counts for CAS Global & Cultural Diversity Requirement.

BETH 315C. International Bioethics Policy and Practice: Health Care Costa Rica. 3 Units.
This 3-credit course gives students the unique opportunity to observe patients and practitioners encounter in a radically different health care system. Costa Rica has one of the most comprehensive health care systems in the Western hemisphere, featuring the innovative use of mid-level health care workers organized in basic comprehensive health care teams. This has resulted in a longer life expectancy than the United States, despite a per capita GDP of only $10,000 per person. Students will gain first-hand experience of Costa Rican health care through field experiences at sites including a national hospital in the capital city, San Jose; a peripheral treatment clinic in a smaller town; and observation of the work of an integrated basic health care team in an indigenous reserve. Following each visit, students will discuss the practical and ethical dilemmas that practitioners face in the context of the Costa Rican health care system. Specific topics include: health inequalities within and between nations; the ethics of transplantation, medical research, and end-of-life care; and health care in rural environments and with indigenous populations. Offered as BETH 315C and BETH 415C. Counts for CAS Global & Cultural Diversity Requirement.

BETH 315D. French Connections, A Cross-Cultural Comparison of Medical Ethics. 3 Units.
This 3-credit course is collaboration between Case Western Reserve University and the University of Paris. The course includes a ten-day trip to Paris, France over Spring Break. This course offers a cross-cultural comparison of the French and American medical systems. Students will have the unique opportunity to learn first-hand how the French medical education system is structured and how the social, cultural and political contexts in France shape medical and ethical issues. The trip includes guided field experiences in French clinical settings as well as opportunities to engage with French faculty members and physicians about contemporary issues in bioethics. Ethical issues that may be considered may include reproductive rights, decision-making involving severely impaired newborns, withholding/withdrawing life-sustaining treatment and issues in organ donation and transplant. The course also will also emphasize the role of French culture and history while in Paris with museum and site visits designed to complement seminar content and offer real-life illustrations of course content. Prior to the trip, students attend six hours of lectures, either at Case Western Reserve University or via a web-based tutorial. They are expected to become familiar with the representative articles assigned for the course, and be prepared to integrate those readings into pre-trip class participation and active participation while in France. Following the trip, students meet with the instructor for an additional four hours to discuss and synthesize their experiences. Offered as BETH 315D and BETH 415D. Counts for CAS Global & Cultural Diversity Requirement.
BETH 315F. Bioethics Themes as Expressed in Spanish and American Culture: Film, Television, and Literature. 3 Units.

This 3-credit intensive course will be held in San Sebastian, Spain. Taught by faculty from CWRU and University of the Basque Country, this course offers students a cross-cultural perspective on bioethics in the United States and Spain. This course uses the medium of film, complemented by readings in bioethics, film criticism, and medical research, to introduce students to a number of compelling bioethics problems facing physician-scientists today, including: when life begins, the nature and limits of informed consent, use of randomization without equipoise, medical imperialism (or the appearance thereof), the treatment of so-called "orphan" diseases, use of deception in research, and financial conflicts of interests caused by among other things, the involvement of the pharmaceutical industry in the drug invention process. Offered as BETH 315F and BETH 415F. Counts for CAS Global & Cultural Diversity Requirement.

BETH 315G. Death, Dying & Euthanasia: Netherlands & the USA. 3 Units.

Is it ever permissible for physicians to kill their patients? In the Netherlands, the answer is yes. In the United States, it is no. Are the Dutch sliding down a moral slippery slope? Are the Americans compromising the rights and dignity of dying patients? This 3-credit course is a unique opportunity to examine a range of Dutch and American end-of-life policies and practices with special focus on the unique ethical, cultural, religious, and legal contexts in which they developed. This course will compare how two liberal democracies, the United States and the Netherlands, have handled difficult end-of-life issues, including: The Dutch regulation of euthanasia; Regulation of physician-assisted suicide in the state of Oregon; Terminal sedation; End-of-life decisions in newborns; Withholding and withdrawing of artificially-provided fluids and nutrition; The legal basis for end-of-life decision making in the USA; Palliative care and hospice; Public trust in medicine and physicians.

In the United States, teaching methods will include lectures, case discussion, and exposure to how some of the course's themes are reflected in popular culture such as movies. Offered as BETH 315G and BETH 415G. Counts for CAS Global & Cultural Diversity Requirement.

BETH 315H. Water Security and Social Justice in Brazil. 3 Units.

CWRU, through the Center for Global Health and Diseases, has had projects, student exchanges and courses with institutions in Brazil and especially with the state of Bahia for over 30 years. In that time, personal and professional relationships have been developed with branches of the Ministry of Health (Oswaldo Cruz Foundation, the Municipal and State Health Departments), the Federal University of Bahia, and the Bahiana School of Medicine and Public Health. Brazil is the second largest country in the Western Hemisphere and the 7th or 8th largest economy in the world. There are more people who speak Portuguese in South America than Spanish. Despite newly discovered oil, enormous natural and human resources, development in Brazil has been uneven with the Northeast remaining the least developed. The Northeastern state of Bahia ranked 22nd out of 27 states on the UN's Index of Human Development (http://www.pnud.org.br/IDH/DH.aspx# and http://www.atlasbrasil.org.br/2013/pt/home/). The State capital, Salvador, ranks 14th out of 20 major metropolitan regions and is one site for this study abroad program. The second site, the rural town of Ubaíra, is ranked 4590 out of 5565 municipalities. Even with large social inequities and health care disparities, the Brazilian government and society have produced remarkable social policies, have shown a willingness to implement these policies and have the resources to significantly improve the lives of its most impoverished citizens. Critical basic infrastructure for health and development is water. Its consumption is essential; it is a mechanism for waste disposal, industry and agriculture are dependent on its supply. The problem of water quantity and quality are common all human societies (witness the drought in California and the burning Cuyahoga). Individuals from all walks of life will need to assess issues of water at some time, from doctors, engineers, urban planners, lawyers and politicians. In Brazil the issues of water are more exposed and easier to examine on different scales than in the U.S. The problem also resides within a social, health care, and political context that compares well and at the same time contrasts sharply with that of the USA. As a student in this course, you will gain first-hand knowledge of the social and public health challenges regarding water security in Brazil. Through field experiences in the capital city of Salvador and the rural town of Ubaíra, you will immerse yourself in interdisciplinary perspectives on the public health, scientific, political, and bioethical dimensions of water security in Brazil. This immersive experience will be facilitated by faculty from the CWRU Dept. of Bioethics and the Center for Global Health and Diseases, the Brazilian Ministry of Health, the Federal University of Bahia, the Bahiana School of Medicine and Public Health, and Brazilian graduate student participants. Offered as: INTH 315, INTH 415, BETH 315H, and BETH 415H. Counts for CAS Global & Cultural Diversity Requirement.
BETH 315J. Dutch Perspectives: Drugs, Decriminalization and Detention. 3 Units.
This course will offer students the opportunity to compare and contrast the ways in which the Netherlands and the United States approach drug use. In particular, students will be asked to carefully examine the ethical dimensions of harm reduction programs, policies regarding the availability and the decriminalization of drugs, and the critical role of detention and correctional medical care in addressing drug use. The course will include an introduction to the Dutch and U.S. health care and health insurance systems and will consider how the construction of the patient-physician relationship impacts the prevalence and treatment of drug use in each country. In addition, students will explore the ethics of public health initiatives and social programs aimed at drug users in both settings, including those designed for particular populations such as immigrants and older users. The course will pay special attention to the unique challenges and ethics of the opioid crisis in the U.S. Offered as BETH 315J and BETH 415J. Counts for CAS Global & Cultural Diversity Requirement.

BETH 315Y. Conservation, Compassion and Awe in Yellowstone National Park: Environmental Ethics and Human Health. 3 Units.
This course brings together the study of conservation, ethics and human well-being in a hands-on investigation at Yellowstone National Park. The course returns to the original meaning of the term bioethics as including the biore. It covers conservation ethics and human relationships with the environment and other species as they impact human health across multiple levels. The course draws on theories, models, and methods from psychological anthropology and political ecology to frame the complex dynamics of interaction. The evolution and psychology of compassion and awe are engaged in processual models of human interaction with the natural world and other species. Both have important implications for human health in everyday behavioral practice and in clinical settings. The course involves pre-departure study and then will integrate the materials in the field in Yellowstone National Park looking at contemporary and historical issues in partnership with Yellowstone Forever Institute instructors. In particular, the case of the conservation of the American bison will be used to understand multi-level issues over time in culture, politics, environment, human behavior, and health. The course requires papers, participation, attendance and a field journal. Offered as: BETH 315Y and BETH 415Y.

BETH 319. Medical Science and Technology in Society. 3 Units.
Science, Technology, and Society (STS) is an interdisciplinary field of scholarship that examines how social, cultural, historical, ethical, and political forces impact scientific research and technological development: and, in turn, how our beliefs, values, and perspectives change in response to scientific and technological innovation. This course will take an STS approach to the study of human health and medicine. We will explore how advances in contemporary biomedicine have affected society and culture, and in turn, how society and culture influence medical science, technology, and clinical practice. Topics we will explore include reproductive technologies, genetics, disability, cyborgs and human enhancement, pharmaceuticals, medical practice, and end-of-life care. The course will prepare students to think critically about scientific and medical knowledge, to thoughtfully examine the relationships between science, technology and culture at large, and to consider the ways that new medical technologies shape and re-shape our understandings of illness, health, and the human body. Weekly course meetings will implement a blend of lectures, discussions, and in-class exercises. Offered as BETH 319 and BETH 419.

BETH 353. Hindu and Jain Bioethics. 3 Units.
This course will provide both an introduction to basic Hinduism and Jainism and an introduction to Hindu and Jain bioethics. We will ask: How would a Hindu or a Jain respond to issues concerning euthanasia, abortion, and other topics of controversy. Are these answers altered in the North American context or in the light of recent technological changes? Offered as RLGN 353, RLGN 453, BETH 353, and BETH 453. Counts for CAS Global & Cultural Diversity Requirement.

BETH 360. Science and Society. 3 Units.
This course examines the complex ethical and other value relationships that exist between science and society. Students will be encouraged to question the simplistic view that science proceeds independently of societal values and contentious ethical commitments. A range of other social factors, such as ethical belief systems, political forces, and large-scale financial interests all influence new scientific and technological developments. In order to illuminate each of these larger themes, this course focuses on three exciting areas of scientific inquiry: stem cell research; synthetic biology; and nanotechnology. Each of these contentious scientific fields provides an excellent view into the challenging ethical, cultural, social, political, and economic issues that will face students, both as scholars and as citizens. No prior technical knowledge is necessary for any of these scientific areas. All relevant scientific information will be provided during the course by the professor. Offered as BETH 360, BETH 460 and PHIL 360.

BETH 371. Advanced Bioethics. 3 Units.
This course offers upper-level instruction on many key bioethical issues introduced in BETH/PHIL 271. The class follows a discussion-intensive seminar format. Students begin with an in-depth analysis of ethical issues surrounding the conduct of clinical trials, both within the U.S. and through U.S.-sponsored research abroad. Next students examine the philosophical and practical challenges involved in medical decision making for adults and pediatric patients. This course concludes by addressing the broader ethical problem of what duties we owe to future generations in terms of our reproductive choices and the allocation of health-related public expenditures. Each of these general topic areas - clinical trials, medical decision making, and future generations - is of crucial importance for all students whether one plans to enter a career in biomedical research, the healthcare professions, or some other career path. Everyone is a potential patient or the family member of a potential patient. The topics covered in Advanced Bioethics will help prepare students to become responsible participants in an increasingly complex biomedical world. Offered as BETH 371 and PHIL 371. Prereq: BETH 271 or PHIL 271.
BETH 371C. Advanced Bioethics: Clinical Observation. 1 Unit.
This course is a one credit class intended to supplement BETH 371: Advanced Bioethics. In this course students will become familiar with the clinical, psychological, social, professional, and institutional context in which bioethical problems arise. Students are exposed to clinical cases as they arise, to hospital ethics committees and ethics consultation programs, to institutional review boards (IRB), and to hospital policies covering “do not resuscitate” orders (DNR), advance directives, withdrawal of artificial feeding, and medical futility. The clinical rotation will consist of 20 hours of supervised observation where students attend structured clinical activities such as ICU rounds, case conferences as well as shadow clinicians that work with the Department of Bioethics and are used to having students at various levels of observers. The purpose of the clinical rotation will be to give students first hand observational experience in the health care system and how the key bioethical issues discussed in BETH 371 manifest in the clinical setting. The primary locations for this course are MetroHealth Medical Center and Louis Stokes Cleveland VA Medical Center. Prereq: BETH 271 or PHIL 271. Coreq: BETH 371 or PHIL 371.

BETH 401. Foundations in Bioethics I. 6 Units.
The first of the two required seminar courses, this course covers five basic topic areas in bioethics: death and dying; health professional-patient relationship; method and theory in bioethics; organ transplantation; and ethics and children. The course meets twice weekly and is taught in seminar format by Center faculty members who are experts on specific topics. Recommended preparation: BETH 401.

BETH 402. Foundations in Bioethics II. 6 Units.
This course completes the required seminar core and covers the basic bioethics topic areas: health care justice; defining ‘health care needs;’ reproduction and fertility ethics; research ethics; and ethics in genetics. The course meets twice weekly and is taught in seminar format by Center faculty members who are experts on specific topics. Recommended preparation: BETH 401.

BETH 403. Mental Illness and Bioethics in Film and Literature. 1.5 Unit.
This course examines bioethical issues that arise in the representation of mental illness and its treatment in film and literature. Course requirements include viewing 3 films and reading 3 or more books during the course of the semester, in-class discussion, and assigned writing. The films and works of literature will be rotated each year, with some possible repetitions. Prereq: Graduate Bioethics student or Requisites Not Met permission.

BETH 405. Clinical Ethics Rotation. 1.5 - 3 Units.
In this course students will become familiar with the clinical, psychological, social, professional, and institutional context in which ethical problems arise. This course exposes students to clinical cases, to hospital ethics committees and ethics consultation programs, to institutional review boards (IRB), and to hospital policies covering the “do not resuscitate” orders (DNR), advance directives, withdrawal of artificial feeding, organ procurement and transplantation, and medical futility. Requires minimum of 8 total hours of rotation experience per week during two semester 10-week rotations. Locations for this course include: MetroHealth Medical Center, University Hospitals of Cleveland, and the Hospice of the Western Reserve. Recommended preparation: BETH 401 or concurrent enrollment.

BETH 406. Society, Religion, and Bioethics. 3 Units.
Focus and Scope of Course: The course examines the interplay of politics, governmental structures, culture and religion and their impact on ethics questions that arise in the health arena. The course provides a broad overview of the basic tenets of several major faith traditions and examines how and why the interpretation of such tenets and their impact on bioethics issues varies across different societies. The specific domains in which we explore such issues, e.g., reproductive health, regenerative medicine, end-of-life issues, infectious disease, may be rotated each year. Objectives: Students will be able to *Describe how religious views and interests affect policymaking with respect to a variety of health-related issues *Enunciate strategies for the reconciliation of bioethics perspectives stemming from diverse religious interests in a pluralistic society *Compare and contrast the perspective of various world religions with respect to specific bioethics issues Prereq: Open to Graduate Students and Seniors only.

BETH 407. Interprofessional Integrative Seminar. 0 Unit.
This is an integrative seminar for dual professional degree students in Bioethics, e.g. Bioethics and Law, Bioethics and Public Health, Bioethics and Medicine. It is required for all dual professional degree students in Bioethics who were admitted to Bioethics on or after January 1, 2013. Students are required to take the seminar for two semesters at any time during their Bioethics program. The course focuses on the study of selected texts with respect to ethical issues and interprofessional relationships. Prereq: Must be a dual professional degree student.

BETH 408. Ethics, Law and Health Research. 3 Units.
This course focuses on an examination of issues arising at the juncture of law, ethics, and health research, such as informed consent, the assessment of risks and benefits, conflict of interest, and scientific misconduct. Particular attention is placed on issues arising in the context of study design and community based research. To the extent possible, the class will utilize a case-focused approach.

BETH 410. Foundations of Medicine, Society and Culture. 3 Units.
Topics will include comparative medical systems and concepts of health, medical history, illness narratives and narrative ethics, social determinants of health and health inequalities, analysis of representations of illness and medicine in literature and the arts, and medical rhetoric. Students who complete the course should develop a command of the basic problems, approaches, and literatures in the social and cultural contexts of health sickness, and medicine. Students will be able to identify epistemology, theory, methodology and data from neighboring disciplines and understand affordances and costs in each.
BETH 411. Narrative Medicine: Methodology in patient-centered medical education. 3 Units.
Narrative Medicine, or medicine practiced with narrative skills (as defined by Rita Charon, MD, PhD), is a methodology in patient-centered medical education. Narrative medicine is informed by the theory and practice of reading, writing, telling, and receiving of stories as a clinically empowering practice for anyone engaged (or planning to engage) in the field of healthcare. This course will employ various methods of learning and experiencing narrative, including fundamental skills of close reading and reflective writing and other forms of self-representation. Narrative competence is an important skill that enables a person to “recognize, absorb, interpret, represent, and be moved by the stories of illness”. Major themes throughout the course will include caregivers’ and patients’ empowerment, empathy, narrative ethics, testimony, reflexive writing, and illness and medical stories. The course will be conducted in a seminar-type format. Each session will have readings that relate to the theory of narrative (primarily from the Charon textbook but also from other sources in the Ethics and Humanities professional literature) and related health humanities. Many of the sessions will also include the application of reflective practice/close reading. Additional elements will be writing workshops and use of film and visual art as narrative. The class will meet once weekly for a 3 hour session. This class is open to graduate students in any humanities or healthcare field, and will be especially useful to those who intend to have a future career in which direct care of patients/clients is a part of their work.

BETH 412. Ethical Issues in Genetics/Genomics. 3 Units.
This course is designed to familiarize graduate students with the major controversies over the generation and use of new human genetic information. Topics will include the spread of predictive genetic testing, prenatal diagnosis, genetic discrimination, human genetic variation research, eugenics, genetic counseling, and the limits of human gene therapy. The course will be conducted as a seminar, involving discussions of readings, guest speakers, and student presentations.

BETH 414. International Health Research Ethics. 3 Units.
This course will introduce students in the health and social sciences to key ethical issues that arise in international health research. The course will include intensive reading and case-based discussion of current ethical and moral quandaries posed by research conducted in the international arena. Five full-day sessions are planned. Each day will be divided into a series of formal presentations and active, group-based discussions around topics that include: the historical context of international health research; current international ethics principles, standards, and declarations; key tools and concepts for unpacking ethical issues in international health research; issues in informed consent and conflict of interest; “reasonable availability” and the conduct of clinical trials; cutting-edge international genetics research; and, the responsibility of researchers to the international health community. Course evaluation is based on class participation, a written exercise, and a case analysis.

BETH 415. International Bioethics: Policy and Practice. 3 Units.
Taught by Case and international faculty, this course will include 7-10 days of intensive didactic and experiential learning in one of several “host” countries. Examples of sites include: Free University of Amsterdam and University of Utrecht in the Netherlands; University of Paris in France; and Ben Gurion University in Israel. It will afford a unique opportunity to gain perspective on important bioethics issues in different societies, i.e., euthanasia, public health policies, access to healthcare, and stem cell research. At the international site, students will spend 6 hours per day (5 days) in seminar (involving didactics, discussion, and guided-observation clinical experience). There will be two 3-hour preparatory sessions, required reading, and two 3-hour post trip sessions. Requirements: preparation, attendance, and class participation, a 12-15 page paper (undergraduate credit) and a 15-20 page paper (graduate credit). Graduate credit will also require students to prepare a presentation for a post-intensive session. Enrollment will be capped at 25. This course has an additional fee to cover costs of travel and lodging. Limited scholarships are available. Offered as BETH 315 and BETH 415.

BETH 415A. International Bioethics Policy and Practice: Women’s Health in the Netherlands. 3 Units.
This 3-credit course allows students to familiarize themselves with social policies and practices related to women’s health in the United States and the Netherlands. Issues covered in the course include birth control and family planning, abortion, prenatal testing, childbirth, health care disparities, cosmetic surgery, prostitution and trafficking in women. This course also addresses the US and Dutch national policies regarding the provision of health care for women. The course places an emphasis on the ways in which social norms shape policies over time, which political actors are involved in shaping women’s health policy, and the balance between women’s health as a matter of the public good or individual responsibility. This course substantively explores gender-specific cultural values and practices in relation to women’s health in the United States and the Netherlands and will help students develop the analytical skills necessary for evaluating social policy and ethical issues related to women’s health. Offered as BETH 315A, BETH 415A and WGST 315A. Counts for CAS Global & Cultural Diversity Requirement.

BETH 415B. International Bioethics Policy and Practice: Public Health in the Netherlands. 3 Units.
This one week 3-credit intensive course will be held in Amsterdam, The Netherlands. Taught by faculty from Case and Utrecht University, this course offers students a cross-cultural perspective on ethical dilemmas raised by the practice of public health in the United States and Northern Europe. Additionally, this course examines policies related to prostitution, drug use, sex education, infectious disease prevention, and access to health care and how they differ in the cultural and political settings of U.S. and the Netherlands. We will examine both the rationales and outcomes of Dutch and American policies, stimulating course participants to consider their own views on these often controversial issues. Prior to the trip, students will attend lectures at Case, which will acquaint them with the theoretical approaches to public health ethics and major issues raised in the practice of public health. In these pre-trip sessions, students will also analyze and report on a case study designed to stimulate critical thinking on comparative public health ethics. In Amsterdam, students will attend lectures that will be supplemented by site visits and discussion sessions aimed at exploring the ethics of public health policy and practice in the Netherlands. Following the intensive week in Amsterdam, students will meet with instructors at Case for two hours to discuss their experiences and compare policies and practices in the U.S. and the Netherlands. Offered as BETH 315B and BETH 415B. Counts for CAS Global & Cultural Diversity Requirement.
BETH 415C. International Bioethics Policy and Practice: Health Care Costa Rica. 3 Units.
This 3-credit course gives students the unique opportunity to observe patients and practitioners encounter in a radically different health care system. Costa Rica has one of the most comprehensive health care systems in the Western hemisphere, featuring the innovative use of mid-level health care workers organized in basic comprehensive health care teams. This has resulted in a longer life expectancy than the United States, despite a per capita GDP of only $10,000 per person. Students will gain first-hand experience of Costa Rican health care through field experiences at sites including a national hospital in the capital city, San Jose; a peripheral treatment clinic in a smaller town; and observation of the work of an integrated basic health care team in an indigenous reserve. Following each visit, students will discuss the practical and ethical dilemmas that practitioners face in the context of the Costa Rican health care system. Specific topics include: health inequalities within and between nations; the ethics of transplantation, medical research, and end-of-life care; and health care in rural environments and with indigenous populations. Offered as BETH 315C and BETH 415C. Counts for CAS Global & Cultural Diversity Requirement.

BETH 415D. French Connections, A Cross-Cultural Comparison of Medical Ethics. 3 Units.
This 3-credit course is collaboration between Case Western Reserve University and the University of the Basque Country. Taught by faculty from CWRU and University of the Basque Country, this course offers students a cross-cultural perspective on bioethics in the United States and Spain. This course uses the medium of film, complemented by readings in bioethics, film criticism, and medical research, to introduce students to a number of compelling bioethics problems facing physician-scientists today, including: when life begins, the nature and limits of informed consent, use of randomization without equipoise, medical imperialism (or the appearance thereof), the treatment of so-called “orphan” diseases, use of deception in research, and financial conflicts of interests caused by among other things, the involvement of the pharmaceutical industry in the drug invention process. Offered as BETH 315F and BETH 415F. Counts for CAS Global & Cultural Diversity Requirement.

BETH 415G. Death, Dying & Euthanasia: Netherlands & the USA. 3 Units.
Is it ever permissible for physicians to kill their patients? In the Netherlands, the answer is yes. In the United States, it is no. Are the Dutch sliding down a moral slippery slope? Are the Americans compromising the rights and dignity of dying patients? This 3-credit course is a unique opportunity to examine a range of Dutch and American end-of-life policies and practices with special focus on the unique ethical, cultural, religious, and legal contexts in which they developed. This course will compare how two liberal democracies, the United States and the Netherlands, have handled difficult end-of-life issues, including: The Dutch regulation of euthanasia; Regulation of physician-assisted suicide in the state of Oregon; Terminal sedation; End-of-life decisions in newborns; Withholding and withdrawing of artificially-provided fluids and nutrition; The legal basis for end-of-life decision making in the USA; Palliative care and hospice; Public trust in medicine and physicians. Taught by faculty from CWRU and University of the Basque Country, this course offers students a cross-cultural perspective on bioethics in the United States and Spain. This course uses the medium of film, complemented by readings in bioethics, film criticism, and medical research, to introduce students to a number of compelling bioethics problems facing physician-scientists today, including: when life begins, the nature and limits of informed consent, use of randomization without equipoise, medical imperialism (or the appearance thereof), the treatment of so-called “orphan” diseases, use of deception in research, and financial conflicts of interests caused by among other things, the involvement of the pharmaceutical industry in the drug invention process. Offered as BETH 315F and BETH 415F. Counts for CAS Global & Cultural Diversity Requirement.

BETH 415H. Bioethics Themes as Expressed in Spanish and American Culture: Film, Television, and Literature. 3 Units.
This 3-credit intensive course will be held in San Sebastian, Spain. Taught by faculty from CWRU and University of the Basque Country, this course offers students a cross-cultural perspective on bioethics in the United States and Spain. This course uses the medium of film, complemented by readings in bioethics, film criticism, and medical research, to introduce students to a number of compelling bioethics problems facing physician-scientists today, including: when life begins, the nature and limits of informed consent, use of randomization without equipoise, medical imperialism (or the appearance thereof), the treatment of so-called “orphan” diseases, use of deception in research, and financial conflicts of interests caused by among other things, the involvement of the pharmaceutical industry in the drug invention process. Offered as BETH 315F and BETH 415F. Counts for CAS Global & Cultural Diversity Requirement.
BETH 415H. Water Security and Social Justice in Brazil. 3 Units.
CWRU, through the Center for Global Health and Diseases, has had projects, student exchanges and courses with institutions in Brazil and especially with the state of Bahia for over 30 years. In that time, personal and professional relationships have been developed with branches of the Ministry of Health (Oswaldo Cruz Foundation, the Municipal and State Health Departments), the Federal University of Bahia, and the Bahiana School of Medicine and Public Health. Brazil is the second largest country in the Western Hemisphere and the 7th or 8th largest economy in the world. There are more people who speak Portuguese in South America than Spanish. Despite newly discovered oil, enormous natural and human resources, development in Brazil has been uneven with the Northeast remaining the least developed. The Northeastern state of Bahia ranked 22nd out of 27 states on the UN’s Index of Human Development (http://www.pnud.org.br/IDH/DH.aspx# and http://www.atlasbrasil.org.br/2013/pt/home/). The State capital, Salvador, ranks 14th out of 20 major metropolitan regions and is one site for this study abroad program. The second site, the rural town of Ubaíra, is ranked 4590 out of 5555 municipalities. Even with large social inequities and health care disparities, the Brazilian government and society have produced remarkable social policies, have shown a willingness to implement these policies and have the resources to significantly improve the lives of its most impoverished citizens. Critical basic infrastructure for health and development is water. Its consumption is essential; it is a mechanism for waste disposal, industry and agriculture are dependent on its supply. The problem of water quantity and quality are common all human societies (witness the drought in California and the burning Cuyahoga). Individuals from all walks of life will need to assess issues of water at some time, from doctors, engineers, urban planners, lawyers and politicians. In Brazil the issues of water are more exposed and easier to examine on different scales than in the U.S. The problem also resides within a social, health care, and political context that compares well and at the same time contrasts sharply with that of the USA. As a student in this course, you will gain firsthand knowledge of the social and public health challenges regarding water security in Brazil. Through field experiences in the capital city of Salvador and the rural town of Ubaíra, you will immerse yourself in interdisciplinary perspectives on the public health, scientific, political, and bioethical dimensions of water security in Brazil. This immersive experience will be facilitated by faculty from the CWRU Dept. of Bioethics and the Center for Global Health and Diseases, the Brazilian Ministry of Health, the Federal University of Bahia, the Bahiana School of Medicine and Public Health, and Brazilian graduate student participants. Offered as: INTH 315, INTH 415, BETH 315H, and BETH 415H. Counts for CAS Global & Cultural Diversity Requirement.

BETH 415J. Dutch Perspectives: Drugs, Decriminalization and Detention. 3 Units.
This course will offer students the opportunity to compare and contrast the ways in which the Netherlands and the United States approach drug use. In particular, students will be asked to carefully examine the ethical dimensions of harm reduction programs, policies regarding the availability and the decriminalization of drugs, and the critical role of detention and correctional medical care in addressing drug use. The course will include an introduction to the Dutch and U.S. health care and health insurance systems and will consider how the construction of the patient-physician relationship impacts the prevalence and treatment of drug use in each country. In addition, students will explore the ethics of public health initiatives and social programs aimed at drug users in both settings, including those designed for particular populations such as immigrants and older users. The course will pay special attention to the unique challenges and ethics of the opioid crisis in the U.S. Offered as: BETH 315J and BETH 415J. Counts for CAS Global & Cultural Diversity Requirement.

BETH 415Y. Conservation, Compassion and Awe in Yellowstone National Park: Environmental Ethics and Human Health. 3 Units.
This class brings together the study of conservation, ethics and human well-being in a hands-on investigation at Yellowstone National Park. The course returns to the original meaning of the term bioethics as including the biome. It covers conservation ethics and human relationships with the environment and other species as they impact human health across multiple levels. The course draws on theories, models, and methods from psychological anthropology and political ecology to frame the complex dynamics of interaction. The evolution and psychology of compassion and awe are engaged in processual models of human interaction with the natural world and other species. Both have important implications for human health in everyday behavioral practice and in clinical settings. The course involves pre-departure study and then will integrate the materials in the field in Yellowstone National Park looking at contemporary and historical issues in partnership with Yellowstone Forever Institute instructors. In particular, the case of the conservation of the American bison will be used to understand multi-level issues over time in culture, politics, environment, human behavior, and health. The course requires papers, participation, attendance and a field journal. Offered as: BETH 315Y and BETH 415Y.

BETH 417. Introduction to Public Health Ethics. 3 Units.
The course will introduce students to theoretical and practical aspects of ethics and public health. This course will help students develop the analytical skills necessary for evaluating of ethical issues in public health policy and public health prevention, treatment, and research. Will include intensive reading and case-based discussions. Evaluation based on class participation, a written exercise and a case analysis. Open to graduate students with permission from instructors.
BETH 419. Medical Science and Technology in Society. 3 Units.
Science, Technology, and Society (STS) is an interdisciplinary field of
scholarship that examines how social, cultural, historical, ethical, and
political forces impact scientific research and technological development:
and, in turn, how our beliefs, values, and perspectives change in response
to scientific and technological innovation. This course will take an STS
approach to the study of human health and medicine. We will explore
how advances in contemporary biomedicine have affected society
and culture, and in turn, how society and culture influence medical
science, technology, and clinical practice. Topics we will explore include
reproductive technologies, genetics, disability, cyborgs and human
enhancement, pharmaceuticals, medical practice, and end-of-life care.
The course will prepare students to think critically about scientific and
medical knowledge, to thoughtfully examine the relationships between
science, technology and culture at large, and to consider the ways that
new medical technologies shape and re-shape our understandings
of illness, health, and the human body. Weekly course meetings will
implement a blend of lectures, discussions, and in-class exercises.
Offered as BETH 319 and BETH 419.

BETH 421. Research Ethics Practicum. 1.5 Unit.
The Research Ethics Practicum (80 hours,1.5 CREDITS) is designed to
complement the theoretical and conceptual training received in the
course, Critical Issues in Research Ethics. By way of a series of
campus-wide rotations, students learn about the practical, everyday
side of research administration, compliance, and scientific review.
Students will work with key staff in research ethics centers, and observe
their day-to-day operations, as well as attend institutional review
board (IRB) and Institutional Animal Care and Use Committee (IACUC)
meetings. They will become familiar with human subjects, animal, and
tissue research regulations and policies as these are applied in an
institutional/academic research context. Students will also spend time
in a clinical trials unit and tour animal care facilities. The practicum
has the following overall objectives: (1) students will be able to identify,
analyze, and understand research ethics issues as they develop in
the context of actual institutional research governance (2) students
will gain an understanding of methods of ethical research design and
implementation.

BETH 422. Clinical Ethics: Theory & Practice. 3 Units.
This course will focus on both theoretical and practical issues in clinical
ethics. Clinical ethics will be distinguished from other areas of bioethics
by highlighting distinctive features of the clinical context which must be
taken into account in clinical ethics policy and practice. Fundamental
moral and political foundations of clinical ethics will be examined, as
will the role of bioethical theory and method in the clinical context.
Topical issues to be considered may include informed consent; decision
capacity; end of life decision making; confidentiality and privacy; the
role and function of ethics committees; ethics consultation; the role
of the clinical ethicist; decision making in various pediatric settings
(from neonatal through adolescent); the role of personal values in
professional life (e.g., rights of conscience issues, self disclosure and
boundary issues); dealing with the chronically non-adherent patient;
ethical issues in organ donation and transplant; health professional-
patient communication; medical mistakes; and other ethical issues that
emerge in clinical settings.

BETH 423. Neuroethics. 3 Units.
This course is designed to provide an overview of ethical issues related
to current and future neurotechnologies as they are applied clinical
and research settings. We will cover many topics related to medical
care for patients with neurological disorders, including cognitive
vulnerability, neurodiversity, stigma and biases in mental health, brain
implants, consciousness, selfhood in neurodegenerative disease, and
enhancement. Classroom activities will primarily consist of discussion
of selected readings related to a topic in neuroethics, moderated by the
instructor. In addition, experts will be invited to visit the classroom to
assist in the dialogue. Students will actively participate in discussion,
debate, written scholarship and presentation to peers. Evaluation
will be based on classroom participation, short writing assignments, and
an independent project that will be designed in collaboration with the
instructor culminate in both a written and oral presentation.

BETH 430. Bioethics in Literature. 1 Unit.
This course complements the Foundation course in the MA bioethics
program by introducing students to narrative literature (fiction, nonfiction
and poetry) that addresses ethical issues in medicine. The material
is frequently the work of physicians and patients who narrate their
respective experiences. As such, narrative provides direct insights into
the practice of modern medicine tested against both accepted and
controversial moral norms and serves as a vehicle for discussion and
analysis of ethical issues. These issues involve topics such as death
and dying, reproduction, pediatrics, women as patients and clinicians,
public health and medicine as a profession and its practice as a privilege.
Students will sample the work, among others, of William Carlos Williams,
Lewis Thomas, Toni Morrison, Margaret Atwood, John Donne, Dylan
Thomas and Abraham Verghese.

BETH 440. Science and Society Through Literature. 3 Units.
This course will examine the interaction of scientific investigation and
discovery with the society it occurred in. What is the effect of science
on society and, as importantly, what is the effect of society on science?
An introduction will consider the heliocentric controversy with focus on
Galileo. Two broad areas, tuberculosis and the Frankenstein myth, will
then be discussed covering the period 1800-present. With tuberculosis,
fiction, art and music will be examined to understand the changing views
of society towards the disease, how society's perception of tuberculosis
victims changed, and how this influenced their treatments and research.
With Frankenstein, the original novel in its historical context will be
examined. Using fiction and film, the transformation of the original
story into myth with different connotations and implications will be
discussed. Most classes will be extensive discussions coupled with
student presentations of assigned materials. Offered as PHRM 340,
BETH 440, PHRM 440, and HSTY 440.

BETH 453. Hindu and Jain Bioethics. 3 Units.
This course will provide both an introduction to basic Hinduism and
Jainism and an introduction to Hindu and Jain bioethics. We will ask:
How would a Hindu or a Jain respond to issues concerning euthanasia,
abortion, and other topics of controversy. Are these answers altered in the
North American context or in the light of recent technological changes?
Offered as RLGN 353, RLGN 453. BETH 353, and BETH 453. Counts for
CAS Global & Cultural Diversity Requirement.
BETH 460. Science and Society. 3 Units.
This course examines the complex ethical and other value relationships that exist between science and society. Students will be encouraged to question the simplistic view that science proceeds independently of societal values and contentious ethical commitments. A range of other social factors, such as ethical belief systems, political forces, and large-scale financial interests all influence new scientific and technological developments. In order to illuminate each of these larger themes, this course focuses on three exciting areas of scientific inquiry: stem cell research; synthetic biology; and nanotechnology. Each of these contentious scientific fields provides an excellent view into the challenging ethical, cultural, social, political, and economic issues that will face students, both as scholars and as citizens. No prior technical knowledge is necessary for any of these scientific areas. All relevant scientific information will be provided during the course by the professor. Offered as BETH 360, BETH 460 and PHIL 360.

BETH 466. Promoting Health Across Boundaries. 3 Units.
This course examines the concepts of health and boundary spanning and how the synergy of the two can produce new, effective approaches to promoting health. Students will explore and analyze examples of individuals and organizations boundary spanning for health to identify practice features affecting health, compare and contrast practices and approaches, and evaluate features and context that promote or inhibit boundary spanning and promoting health. Offered as MPH 466, PQHS 466, SOCI 466, NURS 466 and BETH 466. Prereq: Graduate student status or instructor consent.

BETH 503. Research Ethics and Regulation. 1.5 - 3 Units.
This course will introduce students to key ethical requirements and issues that arise in the design and implementation of scientific research. Historical developments leading to the establishment of national and international guidelines for ethical conduct in research with human subjects will be addressed. Specific international and national guidelines for ethically responsible research will be explored with attention to their merits and limitations in the conduct of research. Informed consent, a fundamental requirement for ethical research will be examined. The function and role of institutional review boards (IRBs) will be described with attention to challenges faced by investigators in adhering to regulatory requirements. Ethical issues associated with risk assessment and recruitment strategies will be examined. Ethical issues that arise in the implementation of biobanks and stem cell research will be discussed. Challenges associated with the development and production of pharmaceuticals will be assessed. The importance of scientific integrity in the conduct of research will be examined with special attention to conflicts of interest and scientific misconduct such as research fraud. The role of advocacy in promoting research will be addressed. Research ethics and human rights will be explored. The course will end with a discussion of emerging issues in research ethics. Case examples will be used to illustrate ethical complexities surrounding the topics discussed. Offered as BETH 503, CRSP 603 and LAWS 5225.

BETH 505. Methods Normative Bioethics. 3 Units.
The purpose of this intensive graduate seminar is to master and to critique core philosophical concepts that are implicit in a wide array of bioethical issues. We will critically examine in a range of contemporary ethical theories beginning with modern conceptions of individual autonomy and concluding with theories of ethical justification. While no advanced knowledge of ethical theories is presupposed, students are expected to come to class prepared with the course readings and to engage in rigorous philosophical discussions with one another and the professor.

BETH 602. Special Topics in Bioethics. 1 - 3 Units.
Students will explore particular issues and themes in biomedical ethics in depth through independent study and research under the direction of a faculty member.

BETH 603. Bioethics Research. 6 Units.
Research leading toward the MD/MA degree is Bioethics.

BETH 604. Advanced Research Ethics Seminar. 0 Unit.
This course meets for two hours each month and is focused on the following topics and the development of the stated competencies: September Introduction; How to critically analyze the literature; Facilitator critique of assigned manuscript; Designing re-entry projects Critical analysis of literature. October Trainee #1 critique of assigned manuscript; Methodological and ethical issues in designing and reviewing research; Trainee presentation of concept papers for re-entry projects Critical review of research protocols and manuscripts; Issues in designing research. November Trainee #2 critique of assigned manuscript; How to prepare and present professional presentations Critical analysis of literature; Oral presentation skills December Trainee #3 critique of assigned manuscript; Principles of adult education Critical analysis of literature; Oral presentation skills; Development of teaching skills. January Trainee #1 critique of assigned manuscript; Principles of adult education Critical analysis of literature; Oral presentation skills. February Trainee #2 critique of assigned manuscript; Developing submissions for IRB review Critical analysis of literature; Oral presentation skills; Identifying and addressing ethical issues in research; Preparation of IRB submissions. March Trainee #3 critique of assigned manuscript; Update on development of re-entry projects; Logistical issues related to re-entry projects; Manuscript preparation Critical analysis of literature; Oral presentation skills; Implementing research; Preparing work for publication; Negotiation skills. April Re-entry issued implementing research; Readjustment. This course is only open to trainees in the Fogarty-funded Training Program in International Research Ethics.

BETH 605. Special Study: IRB Administration. 1.5 Unit.
This course is limited to Fogarty-sponsored trainees in the Training Program in International Research Ethics. The course, which meets 1.5 hours per week, focuses on issues relevant to the management and administrations of the various functions of research ethics review committees. Topics to be covered include identification and selection of appropriate community representatives for membership and/or consultation, utilization of independent experts/consultants, recordkeeping, approaches to communication with investigators, and others. Regular guest lectures will be provided by members of the various local IRBs, staff members of local IRBs, and senior investigators. The course will utilize a case-based approach

BETH 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Environmental Health Sciences
Phone: 216.368.5957
Jonathan Haines, PhD, Interim Chair jonathan.haines@case.edu

Programs in Environmental Health Sciences are on hiatus and are being reevaluated as part of the merger of the Department of Environmental Health Sciences and the Department of Epidemiology & Biostatistics into the new Department of Population & Quantitative Health Sciences (http://bulletin.case.edu/schoolofmedicine/epidemiologyandbiostatistics).


**General Medical Sciences**

The Division of General Medical Sciences was established in 1986 to provide an organizational home for units pursuing interdisciplinary research and education objectives. The division is the equivalent of an academic department, and its constituent units are characterized as Centers. The Dean of the School of Medicine serves as the Chair of the division; each Center is led by a director. The unique nature of each of the General Medical Sciences centers is described in the paragraphs below. (Centers are listed in alphabetical order by full title, and associated academic programs including certificate, MS and PhD programs described in top navigation tabs).

**Case Comprehensive Cancer Center**

Phone: 216.844.8797  
http://cancer.case.edu  
Stanton L. Gerson, MD, Director, Case Comprehensive Cancer Center

The Case Comprehensive Cancer Center (Case CCC) based at Case Western Reserve University (CWRU) is a partnership organization supporting cancer-related research efforts at CWRU, University Hospitals Cleveland Medical Center, and Cleveland Clinic. Located in Cleveland, Ohio, the Case CCC serves the cancer research and clinical needs of an urban manufacturing and rural agricultural region containing over 4 million people in Northern Ohio.

The Case CCC provides a unique forum and academic network for cancer researchers across our community to accomplish more than they may individually. Through the Case CCC, our medical institutions are linked in a stronger and more unified effort to understand the causes and progression of cancer and to use that understanding to develop treatments and to reduce the likelihood that our population will develop cancer and suffer from its consequences. The Cancer Center advocates for cancer research support across the institutions; provides funding for promising pilot grants, shared resource development, training programs, and recruitment; and catalyzes multidisciplinary and transdisciplinary cancer research across institutions, emphasizing innovative discovery that will have an impact on cancer patients.

The mission of the Case CCC is to:

- Improve the prevention, diagnosis and therapy of cancer through discovery, evaluation and dissemination.
- Stimulate and support innovative, coordinated interdisciplinary clinical research on cancer diagnosis, treatment, prevention and control.
- Develop clinical applications of discovery and make these available to Northern Ohio residents as quickly as possible through the integrated efforts of the major health systems in the region.
- Develop cancer prevention and control activities that build on the expertise of the Center and result in a reduction of cancer morbidity and mortality in Northern Ohio and the nation.

The research efforts of the Case CCC members are organized into seven interdisciplinary scientific programs. The clinical research effort is supported by 12 Clinical Trials Disease Teams that develop and prioritize clinical trials, and a single Protocol Review and Monitoring System, Data Safety and Monitoring Plan integrate cancer research, cancer therapeutics, and prevention services at the partner institutions and throughout the region.

Research programs of the Case CCC are also extending into community medical centers operated by University Hospitals and Cleveland Clinic. Outreach programs for clinical practice-based prevention and screening initiatives, educational programs, minority recruitment, and facilitation of patient referrals are also supported by the partner institutions.

In addition to successfully competing for a Cancer Center Support Grant from the National Cancer Institute, the Center must meet specific criteria for:
- Breadth and depth of basic cancer research; clinical cancer research; and prevention, control and population/behavioral sciences research in cancer; and
- Strength of interaction among these three major research areas.

The Case Comprehensive Cancer Center is one of only 50 NCI-designated Comprehensive Cancer Centers in the nation. Learn more about the National Cancer Institute's Cancer Centers program at cancercenters.cancer.gov (http://cancercenters.cancer.gov).

**Center for Clinical Investigation**

Phone: 216.368.3286  
James Spilsbury, PhD, Academic Development Core Director

The Center for Clinical Investigation (CCI) was founded in 2007 and is part of Case Western Reserve University School of Medicine’s Division of General Medical Sciences. The CCI serves as the academic home of Cleveland’s Clinical & Translational Science Collaborative, a partnership of 4 local institutions (Case Western Reserve University, the Cleveland Clinic Foundation, the MetroHealth System, and University Hospitals) and member of a national consortium of approximately 66 institutions funded by the National Institutes of Health to increase the efficiency and speed of clinical and translational research across the country.

The CCI’s mission is to enhance clinical and translational research efforts across the Cleveland area by: (1) spurring advances in knowledge of risk factors, outcomes and treatment effectiveness in the population; (2) facilitating the transfer of scientific advances to the community; and (3) developing a new generation of clinical researchers equipped with the skills needed to efficiently design, implement and interpret novel studies that address important public health questions. To accomplish its mission, the CCI provides computer systems and applications support for basic science and clinical research activities and works closely with basic science and clinical investigators in the CWRU Schools of Medicine, Nursing, and Dental Medicine, as well as the University Hospitals Case Medical Center, Cleveland Clinic, and MetroHealth System. The CCI has supported hundreds of clinical research and epidemiology projects, including local and national multicenter, longitudinal studies. The CCI has two cores that provide research support to all investigators: the Academic Development Core and Statistical Sciences Core.

The Academic Development Core manages the newly created PhD Program in Clinical Translational Science, the Master's Degree Program in Clinical Research (Clinical Research Scholars Program - see "Clinical Research" tab above), and the Graduate Certificate Program in Clinical Research. The Academic Development Core also delivers seminars and short courses in clinical research and works to coordinate educational activities in interdisciplinary clinical research across the CTSC’s institutional members. The programs target investigators and other key members of the research team, including data managers and study coordinators. Training efforts in research design, research data
management, statistical sciences, statistical software, and scientific communication are emphasized.

Center for Global Health and Diseases
Phone: 216.368.6321
https://case.edu/medicine/globalhealth/node/1
James W. Kazura, MD, Director

The Center for Global Health and Diseases was formed in 2002 as a result of a merger between the Center for International Health (first established in 1987) and the Division of Geographic Medicine. The new center is located on the fourth floor of the Biomedical Research Building on the Case Western Reserve University’s School of Medicine campus in Cleveland, Ohio. The center provides a coordinating structure to help link the numerous international health resources of the university, its affiliated institutions, and the Northern Ohio community in a multidisciplinary program of research, training and clinical application related to global health. The center brings together many disciplines at CWRU to make life better in developing countries, and thus facilitates international collaborations throughout the institution.

The mission of the Center for Global Health and Diseases is to promote health in the world and enrich the community around CWRU.

This is accomplished by:

• bringing together experts from the university’s community that specialize in infectious diseases, epidemiology, anthropology, tropical diseases, neglected tropical diseases (dengue, dracunculiasis [guinea-worm disease], lymphatic filariasis, onchocerciasis [river blindness], rabies, schistosomiasis, and various helminthiases), nursing, pediatrics, etc.
• uniting university faculty in programs of collaborative research and education, student and faculty international exchanges, and community enrichment to promote health in the world and enrich the international community.

The center focuses on three main objectives that have been present throughout its history.

• developing a critical mass of creative investigators with multidisciplinary capabilities and providing them with appropriate resources and environments for basic, clinical and epidemiological research, in order to develop linkages within and beyond the university community.
• establishing an education and training program to ensure the continuing replenishment of the pool of intellectual talent in this country and to enhance the scientific proficiency of scientists from developing countries via an educational program based at the university, reaching a wide audience.
• advancing a collaborative interdisciplinary application program in international health overseas to bring together diverse disciplines, adaptation, and adoption of practices and the application of technology to underserved populations of the world.

A certificate in Global Health is available (https://case.edu/medicine/globalhealth/training-courses/certificate-in-global-health).

Center for Medical Education
Phone: 216.368.1948
Patricia A. Thomas, MD, FACP Director

Klara Papp, PhD, Director, CAML

The Center for Medical Education, established in 2010, provides an organizational home for teaching and learning programs in the School of Medicine and a supportive environment for those who want to develop special skills in medical education.

The Center also sponsors faculty appointments, both full- and part-time, for faculty whose roles are predominantly focused on teaching medical students and physician assistant students. These include community clinicians who welcome medical students into their clinics and practices. The Center for the Advancement of Medical Learning (“CAML”) operates its programs under the auspices of the CMEd. CAML supports and promotes the development of teaching and lifelong-learning skills among students, faculty, staff, residents, and alumni. CAML pursues research into educational innovations to advance our knowledge of medical learning and teaching. The Center offers workshops to faculty locally, regionally, and nationally to enhance faculty teaching, research and evaluation skills.

Center for Proteomics and Bioinformatics
Phone: 216.368.0291
http://proteomics.case.edu
Mark R. Chance, PhD, Director
Biomedical Research Building, Ninth Floor

The Case Center for Proteomics and Bioinformatics was created, in part, to strengthen Cleveland’s presence in modern proteomics and bioinformatics research to make the region a leader in the field. The vision for the Center has been shaped over the past several years by the leadership of the Center’s Director, Mark Chance, PhD, with over $120 million in grants awarded to the Center and its collaborators since its inception in February 2006. One of the primary goals of the CPB is to develop an infrastructure of sophisticated equipment that facilitates and maximizes shared equipment usage, as well as to offer a wide array of proteomics, and metabolomic services including protein and small molecule mass spectrometry, protein expression/interactions, systems biology, and biostatistical analyses.

The CPB has expanded its vision to include education of graduate students in systems biology and bioinformatics. The Center for Proteomics and Bioinformatics developed a graduate program in Systems Biology and Bioinformatics in collaboration with Schools and Departments across the campus. For more information regarding the SYBB graduate program please see ”Systems/Bioinformatics” tab above. You may also visit http://bioinformatics.case.edu/.

In studying proteins and metabolites, bioinformatics analysis enables researchers to take an integrated pan-omics approach for discovering networks involved in human disease. The School of Medicine has established the Center for Proteomics and Bioinformatics to perform research to better understand the genetic and environmental bases of disease as well as provide new technologies to diagnose diseases such as cancer, heart disease, and diabetes. Utilizing bioinformatics enables researchers to take an integrated -omics approach for discovering networks involved in human disease.

New technologies in mass spectrometry are also allowing protein expression, localization, structure, post-translational modifications, and interactions to be studied in increasing detail and on a genome-wide scale. The Center is also developing and applying state-of-the-art-structural proteomics technology, metabolomic and small molecule
analysis, especially for pharmacokinetic (PK) studies to support clinical, translational, and structural research.

The CPB has three major research areas: Proteomics and Bioinformatics, Metabolomics, and Macromolecular Structure.

Proteomics and Bioinformatics faculty and staff support research in protein expression analysis, protein modifications, and protein interactions in a wide variety of biological contexts as well as develops new bioinformatics tools in Proteomics research. This includes multiple Proteomics Cores to support these activities.

Metabolomics faculty and staff support metabolite small molecule quantification research in the CWRU community. The services provided range from drug PK studies to quantification of endogenous metabolites in clinical and preclinical samples.

Macromolecular Structure faculty and staff supports interdisciplinary research in new methods of structure determination, the combination of computational and experimental structural biology approaches and developing and maintaining the infrastructure for macromolecular structure determination.

The CPB also offers a wide range of seminars, workshops, and possibilities for individual training. These activities are posted on the CPB Web site. For a list of services and to explore opportunities to collaborate, please visit the Web site: https://case.edu/medicine/nutrition/case-center-proteomics-and-bioinformatics

Center for Psychoanalytic Child Development

Phone: 216.991.4472
Kimberly Bell (kmb207@case.edu), PhD, John A. Hadden Jr. Assistant Professor of Psychoanalytic Child Development

The Center for Psychoanalytic Child Development was established in 2001 as a memorial to John A. Hadden Jr., past President of the Board of Trustees of the Cleveland Center for Research in Child Development and of the Hanna Perkins School. The mission of the center is to advance the science of psychoanalytic child development at the School of Medicine.

The Center offers medical students and residents who are interested in working with children the opportunity for observational learning in the Hanna Perkins school. In addition, didactic courses, case conferences and supervision are available to deepen students’ understanding of the relationship between physical and psychological development in the first 5 years of life.

The Center for RNA Science and Therapeutics

Phone: 216.368.0299
https://www.rnacenter.org/
Jeffery M. Coller, PhD, Director

The Center for RNA Science and Therapeutics is a free standing academic unit in the basic sciences within the School of Medicine at Case Western Reserve University. The RNA Center was established in the mid-nineties as a core entity in recognition of the strong cadre of research laboratories devoted to studying post-transcriptional mechanisms of gene expression focusing on various aspects of RNA Biology. The current mission of the RNA Center is to parlay the strengths of RNA Center scientists towards the development of unique therapeutic initiatives. The RNA Center is combining the usage of nanoparticle technology with RNA science to develop new classes of drugs, leading towards the amelioration of a variety of diseases. Current efforts are focused on metabolic disorders, cancer immunotherapies, immunity, and protein replacement. In addition, we are developing new technologies that promise to improve diagnostics, allowing for earlier detection of a variety of human diseases, especially cancer.

The RNA Center contains one of the largest concentrations of RNA scientists in the nation. The faculty of the RNA Center cover nearly every aspect of RNA research. Current research in the Center focuses on several problems ranging from extremely basic questions such as the mechanism of RNA catalysis and how proteins interact with RNA to the roles of RNA processing in disease. Specific research interests include splicing and its regulation, RNA editing, tRNA maturation, mechanisms of translation regulation, RNA degradation, RNA trafficking, RNA interference and regulation of gene expression by microRNAs and non-coding RNAs.

Collectively, the RNA Center provides a valuable resource for collaborative efforts within the University and its affiliated institutions: the Cleveland Clinic Foundation, MetroHealth Medical Center, the Cleveland VA Medical Center, and University Hospitals Cleveland Medical Center. In addition, the official journal of the RNA Society “RNA” was founded and continues to be housed in the RNA Center. The members of the RNA Center have an excellent funding record and the research performed is regularly published in highly visible journals such as Science, Nature, Molecular Cell, NSMB, Molecular Cell, etc.

Center for Science, Health and Society

Phone: 216.368.2059
http://casemed.case.edu/cshs/
Nathan A. Berger, MD, Director

Recognizing that the successful futures of Case Western Reserve University, the City of Cleveland, and Cuyahoga County are integrally related, the Center for Science, Health and Society (CShS) was created in 2002 to focus the efforts of the University and the community in a significant new collaboration to impact the areas of health and healthcare delivery systems through community outreach, education, and health policy. The Center, based in the School of Medicine, with university wide associations, is engaging the many strengths of the University and the community to improve the health of the community.

The Center has engaged the community at the level of the individual and the neighborhood, in public and private schools, at civic and faith-based organizations, and at the level of governmental agencies and community leadership to identify community problems, perceptions, assets and resources; advise the community of faculty skills, assets and expertise; and, catalyze that community service based scholarship that benefits community interests and promotes mutual enhancement. The Center coordinates the Scientific Enrichment Opportunity outreach program that brings Cleveland high school students on to the medical school campus in the summer to work along with our distinguished faculty in their research labs, to introduce and stimulate the students and help prepare them to enter careers in the health career professions and biomedical workforce. The Center also coordinates the Mini Medical School Program presented every Spring and Fall to educate the community on the latest developments in healthcare, particularly those developed at CWRU. The overall goal of these programs is to educate and empower the community to become better consumers of healthcare and more informed and
stronger advocates for healthcare policy and legislation in their own interests.

**Center for the Study of Kidney Biology and Disease**

Phone: 216.444.8415  
John R. Sedor, MD, Director  
Thomas H. Hostetter, MD, Co-director  
Jeffrey Garvin, MD, PhD, Co-director  
Jeffrey Schelling, MD, Co-director

Chronic Kidney Disease (CKD) is a growing public health problem in the United States. More than seventeen percent of US adults—more than 30 million Americans—have CKD. CKD generally progresses over time and can cause cardiovascular disease, anemia, bone disease, fluid overload, and eventually end-stage kidney disease (ESKD). Patients with ESKD need renal replacement therapy, either from dialysis or a kidney transplant, to live. The risk of death for patients receiving dialysis is nearly eight times higher than the non-ESRD population, leading to a 20% annual probability of death. Kidney disease disproportionately affects minorities and vulnerable populations. Kidney disease treatment is expensive and uniquely tied to federal expenditures through the Medicare entitlement program. The cost of care for ~ 550,000 ESKD patients is nearly $34 billion annually, exceeding the total NIH budget. Treating all health conditions of CKD and ESRD patients consumes nearly 25% of Medicare's budget.

The Center's mission is to accelerate discovery and its translation for treatment and cure of kidney diseases in an interdisciplinary environment within the rich, research environment of the CWRU School of Medicine. The faculty is an accomplished and highly interactive group of investigators, based in the adult or pediatric Divisions of Nephrology in CWRU-affiliated hospitals as well as other clinical and basic science departments. Research interests of the faculty include digital pathology image analysis, glomerular diseases, diabetic and other chronic kidney diseases, epithelial cell biology and ion transport, tubular physiology, genetic epidemiology, health services research, renal transplantation, health disparities research and clinical trials. Center faculty are members of the NIDDK-funded Kidney Precision Medicine Project. Research projects use cellular, molecular, biological, computational, genetic, genomic and epidemiological methods to study in vitro and animal models and/or patients. Many projects by Center investigators use health data, culled from electronic health records, and biological samples from patients with kidney diseases in order to generate novel hypotheses, which can then tested with animal models and cell lines. Training opportunities are available for undergraduate, pre- and post-doctoral students.

**National Center for Regenerative Medicine**

Phone: 216.368.0846  
http://www.ncrm.us/  
Stanton L. Gerson, MD, Director

The National Center for Regenerative Medicine (NCRM) is a platform to facilitate translational research, clinical application, and commercialization of regenerative medicine, tissue engineering, and stem cell therapeutics across a consortium of institutions. NCRM is driven by four nationally ranked, medical research powerhouses, Case Western Reserve University, Cleveland Clinic, University Hospitals Cleveland Medical Center and Ohio State University. Through this network of researchers and clinicians, research discoveries are actively being translated into cell-based therapies for patient care.

NCRM is leading the way in Northeast Ohio in the following areas:

- Regenerative medicine and stem cell research
- Cellular manufacturing
- Clinical trials for cellular therapeutics

Global partnerships have been established with academic institutions and biotechnology companies to further expand research and discovery efforts.

**NCRM Goals:**

- **Translational Research:** To support stem cell and regenerative medicine research across various disciplines, institutions and commercial entities.
- **Education and Training:** To develop cutting-edge education programs for researchers, clinicians, trainees and the general public. For more information regarding the RGME graduate program please visit https://case.edu/medicine/ncrm/training-education.
- **Strategic Partnership:** To build networks across academic, clinical, commercial and public sectors.
- **Commercialization:** To translate innovative technologies and cell-therapies into business opportunities.

**Case Western Reserve University offers three areas of study in Clinical Research/Clinical Translational Science:**

1. Graduate Certificate in Clinical Research (p. 81)
2. Master’s in Clinical Research
3. PhD in Clinical Translational Science

Each of the aforementioned programs was designed to fit an even growing need for well-trained clinical investigators. The curriculum for each program was designed to make the student a more effective, ethical, and efficient researcher.

**The Graduate Certificate in Clinical Research** (https://case.edu/medicine/crsp/programs/certificate-program)  
This 11 credit hour program provides the foundational training in clinical research methods to those individuals who are seeking an alternative to the Master of Science in Clinical Research. It is geared towards clinicians and other health-science professions who are interested in conducting clinical research and/or collaborating with other clinician-scientists who are conducting clinical research. This program is also beneficial to health-science students, basic-science researchers, and other health science professionals who would like to enhance their skills in patient-oriented research.

**Clinical Research Scholars Program (CRSP)** (http://casemed.case.edu/CRSP)  
The Clinical Research Scholars Program (CRSP) is designed for individuals committed to a career in clinical investigation in an academic or related field. CRSP offers a Master's Degree in Clinical Research through two pathways.

Training in both clinical research and career development provides CRSP Scholars with an educational experience that prepares them to identify a
research question and critically evaluate relevant literature; transform the question into a feasible and valid study design; develop and execute the study protocol; and analyze and effectively communicate the findings.

The PhD in Clinical Translational Science Program (https://case.edu/medicine/crsp/programs/phd-clinical-translational-science-cts)

The goal of this program is to train and graduate clinical-translational scientists to meet the need for a transformed clinical and translational enterprise. Students in the program will be rigorously educated in the theory and practice of clinical translational science in order to make significant clinical discoveries and to move these discoveries across the translational continuum. The curriculum is based on a set of nationally-developed core competencies to guide the nationwide training of clinical and translational scientists and will provide students with the required knowledge, skills, and experience to become productive and innovative researchers in the field of Clinical Translational Science.

Faculty

The program resides in the Department of Population and Quantitative Health Sciences (PQHS) (http://epibiwww.case.edu/) in the School of Medicine. The academic units involved include the School of Medicine, Nursing, Management, and Dentistry. The faculty is selected for their expertise and commitment to teaching and mentorship in clinical investigation. They are primarily drawn from the Departments of Medicine, Pediatrics, and PQHS from the School of Medicine.

For Questions and Information Please Contact:
Angela Bowling (angela.bowling@case.edu), MA
Clinical Research Scholars Program
Case Western Reserve University
10900 Euclid Ave., W-G74A
Cleveland, OH 44106-4945

216.368.2601

Clinical Research Scholars Program (CRSP) (http://casemed.case.edu/CRSP)

The Clinical Research Scholars Program (CRSP) is designed for individuals committed to a career in clinical investigation in an academic or related field.

CRSP offers a Master’s Degree in Clinical Research through two pathways:

1. CRSP Type A (Thesis) - (https://case.edu/medicine/crsp/programs/ms-clinical-research-crsp/crsp-courses)
   - Curriculum was developed for those with an existing degree in medicine, dentistry, nursing, or an allied science such as pharmacy or biomedical engineering.
   - This pathway is to prepare a new generation of clinical investigators for leadership roles in academia, government, and industry.

2. CRSP Type B (Capstone) - (https://case.edu/medicine/crsp/programs/ms-clinical-research-crsp/crsp-courses)
   - Curriculum was created for individuals who may not be playing a principal investigator or clinical research study, but who:
     - desire strong preparation in clinical research methods and associated statistical approaches
     - envision themselves playing a critical role on the clinical research team as a research assistant, study coordinator, or data manager
     - This pathway is to provide the student with fundamental knowledge and/or experience in important tasks related to the clinical research endeavor.

Training in both clinical research and career development provides CRSP Scholars with an educational experience that prepares them to identify a research question and critically evaluate relevant literature; transform the question into a feasible and valid study design; develop and execute the study protocol; and analyze and effectively communicate the findings.

The CRSP program consists of three parts:

- Formal didactic modular and semester-long course work
- A seminar series that focuses on communication skills required for career development
- An intensive mentored experience centered on a specific clinical research problem (Type A Pathway) or a Capstone Project (Type B Pathway)

It is expected that individuals so trained can master fully the challenges in clinical investigation of the next decade, particularly the new translational opportunities being developed. As such, they should be attractive candidates for positions in clinical science departments, research institutes, or industry.

A dual degree track has also been established for medical students interested in obtaining dual MD/MS degree. The dual MD/MS program:

- seeks individuals committed to a career in clinical investigation in an academic or related environment
- consists of a total of 30 credits: 21 credit hours of coursework, 9 credit hours of mentored research and a formal oral thesis defense
- both focus and flexibility in its curriculum -
  - Focus is provided through a core curriculum (15-16 credit hours) highlighting clinical research methods, the ethical conduct of research, and a seminar series that introduces the skills necessary for scholarly success.
  - Flexibility is provided through elective coursework. Students typically have special interests in a particular area of clinical research, both clinically and methodologically. This program facilitates pursuit of different methodological interests guided by seasoned CWRU research faculty and addressed partly with choice of appropriate electives (5-6 credit hours).

Requirements for the dual MD/MS degree differ to reflect integration with the medical school curriculum. Most graduates of this program are currently working in academic medical settings, with smaller numbers located in research positions in the private sector or private practice.

**CURRICULUM FOR THE TYPE A (THESIS) MASTER’S DEGREE IN CLINICAL RESEARCH**

30 credit hours are required (of which 15-16 are core coursework; 9 of thesis research; and 5-6 of elective coursework) for completion of this Master of Science in Clinical Research degree.
## Core Courses and Thesis Requirement

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>CRSP 401</td>
<td>Introduction to Clinical Research Summer Series</td>
<td>3</td>
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<tr>
<td>PQHS 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
<td>3</td>
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<tr>
<td>CRSP 412</td>
<td>Communication in Clinical Research</td>
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<td>CRSP 413</td>
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<tr>
<td>CRSP 431</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>CRSP 432</td>
<td>Statistical Methods II</td>
<td>3</td>
</tr>
<tr>
<td>CRSP 603</td>
<td>Research Ethics and Regulation</td>
<td>1 - 2</td>
</tr>
<tr>
<td>CRSP 651</td>
<td>Clinical Research Scholars Thesis</td>
<td>9</td>
</tr>
</tbody>
</table>

Total Units: **24-25**

## CURRICULUM FOR THE TYPE B (CAPSTONE) MASTER’S DEGREE IN CLINICAL RESEARCH

30 credit hours are required (of which 11-12 are core coursework; 3 Capstone; and 15-16 are elective coursework) for completion of this Master of Science in Clinical Research degree.

### Core Courses and Capstone

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CRSP 401</td>
<td>Introduction to Clinical Research Summer Series</td>
<td>1 - 3</td>
</tr>
<tr>
<td>PQHS 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
<td>3</td>
</tr>
<tr>
<td>CRSP 413</td>
<td>Communication in Clinical Research</td>
<td>1</td>
</tr>
<tr>
<td>CRSP 431</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>CRSP 603</td>
<td>Research Ethics and Regulation</td>
<td>1 - 2</td>
</tr>
<tr>
<td>CRSP 651</td>
<td>Clinical Research Scholars Thesis</td>
<td>9</td>
</tr>
</tbody>
</table>

Total Units: **9-12**

Each scholar is encouraged to develop his/her own area of concentration based on personal interests and needs. Typical areas of concentration include: Clinical Research Trials, Health Services Research and Outcomes, and Multidisciplinary/Translational Clinical Research. Please consult with CRSP faculty and your Research Mentor on which electives will best suit your needs.

The choices of electives listed below are for illustrative purposes and include but are not limited to:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CRSP 406</td>
<td>Introduction to R Programming</td>
<td>2</td>
</tr>
<tr>
<td>CRSP 410</td>
<td>Independent Study in Clinical Research</td>
<td>1 - 3</td>
</tr>
<tr>
<td>CRSP 440</td>
<td>Translational &amp; Patient-Oriented Research Theory</td>
<td>3</td>
</tr>
<tr>
<td>CRSP 450</td>
<td>Seminar in Multidisciplinary Clinical &amp; Translational Research</td>
<td>0</td>
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<td>CRSP 500</td>
<td>Design and Analysis of Observational Studies</td>
<td>3</td>
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<td>CRSP 501</td>
<td>Team Science - Working in Interdisciplinary Research Teams</td>
<td>1</td>
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<td>CRSP 502</td>
<td>Leadership Skills for Clinical Research Teams</td>
<td>2</td>
</tr>
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<td>CRSP 503</td>
<td>Innovation and Entrepreneurship</td>
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<td>CRSP 504</td>
<td>Managing Research Records - A System’s Approach</td>
<td>2 - 3</td>
</tr>
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<td>CRSP 505</td>
<td>Investigating Social Determinants of Health</td>
<td>2 - 3</td>
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<td>CRSP 510</td>
<td>Health Disparities</td>
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<td>PQHS 411</td>
<td>Introduction to Health Behavior</td>
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<td>PQHS 450</td>
<td>Clinical Trials and Intervention Studies</td>
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<td>PQHS 467</td>
<td>Comparative and Cost Effectiveness Research</td>
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## MS Clinical Research Type A (Thesis), Plan of Study

### Prep Year

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<th>Units</th>
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### First Year

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<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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</thead>
<tbody>
<tr>
<td>Epidemiology: Introduction to Theory and Methods (PQHS 490)</td>
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<td>Research Ethics and Regulation (CRSP 603)</td>
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<tr>
<td>Statistical Methods I (CRSP 431)</td>
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</tr>
<tr>
<td>Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media (CRSP 413)</td>
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<td>Statistical Methods II (CRSP 432)</td>
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<tr>
<td>Introduction to Clinical Research Summer Series (CRSP 401)</td>
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Year Total: **8-9**

### Second Year

<table>
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<th>Summer</th>
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<tbody>
<tr>
<td>Clinical Research Scholars Thesis (CRSP 651)</td>
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<tr>
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Year Total: **6**

Total Units in Sequence: **30-31**

## MS Clinical Research Type B (Capstone Experience), Plan of Study

### Prep Year

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### First Year

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<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td>Clinical Research Scholars Thesis (CRSP 651)</td>
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Year Total: **6**

Total Units in Sequence: **30-31**
GMSc Year Total:

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<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<td>Epidemiology: Introduction to Theory and Methods (PQHS 490)</td>
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<td>Research Ethics and Regulation (CRSP 603)</td>
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<tr>
<td>Statistical Methods I (CRSP 431)</td>
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Total Units in Sequence: 30-38

**MD/MS Biomedical Investigation-Clinical Research Track**

For information about Program Admission and MD requirements, please see MD Dual Degrees section (p. 27). The Clinical Research track includes formal instruction in methods common to all fields of clinical investigation along with mentored research. In addition to medical school credits, students must complete the track-specific courses and electives listed below.

All students in this track must complete the CRSP Core Curriculum or equivalents:

- IBIS 434 Integrated Biological Sciences in Medicine (**or IBIS 401 and 402**)
- CMED 401 Intro to Clinical Research and Scientific Writing
  - or CRSP 401 Introduction to Clinical Research Summer Series
- PQHS 490 Epidemiology: Introduction to Theory and Methods
- CMED 403 Introduction to Clinical Epidemiology
  - or CRSP 402 Study Design and Epidemiologic Methods
- CMED 404 Clinical Research Seminars (*)
  - or CRSP 412 Communication in Clinical Research - Grant Writing
- CMED 405 Clinical Research Seminars (*)
  - or CRSP 413 Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media
- CMED 450 Clinical Trials
- CMED 458 Statistical Modeling with Applications in Clinical Research
- CMED 500 Scientific Integrity in Biomedical Research
  - or IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research
- CMED 601 Clinical Research Project
- IBIS 600 Exam in Biomedical Investigation

Program Advisors: Dr. Chris Moravec (moravec@ccf.org) (College students) and Dr. William Merrick (wcm2@case.edu) (University students).

**PhD in Clinical Translational Science** ([https://case.edu/medicine/crsp/programs/phd-clinical-translational-science-cts](https://case.edu/medicine/crsp/programs/phd-clinical-translational-science-cts))

The goal of the PhD in Clinical Translational Science program is to train and graduate clinical-translational scientists to meet the need for a transformed clinical and translational enterprise. Students in the program will be rigorously educated in the theory and practice of clinical translational science in order to make significant clinical discoveries and to move these discoveries across the translational continuum.

The program’s curriculum is based on a set of nationally-developed core competencies to guide the nationwide training of clinical and translational scientists and is purposefully designed to furnish our students with the required knowledge, skills and experience to become productive and innovative researchers in the field of clinical translational science.

**Program graduates will be able to:**

- Independently lead, design, execute, manage and interpret multidisciplinary clinical-translational research in a conceptually, methodologically, ethically and regulatory sound manner
- Assume leadership roles in both academic and industry settings
- Establish national reputations as leaders in a given area of expertise.

**Eligible applicants include:**

- Individuals with an advanced clinical degree (e.g., MD, DMD, DRNP)
- Individuals enrolled in dual clinical-research degree programs, such as CWRU’s MD-PhD and DMD-PhD programs
- Individuals with an existing Master’s degree in a health-related field (e.g., MS, MSN, MPH)
- Individuals with other scientific or clinical backgrounds to be evaluated on a case-by-case basis.

**Curriculum Requirements:**

Curriculum requirements are based on student’s previous education and training:

- **Student with No Existing Advance Research Degree**
  - Students will complete a minimum of 54 credit hours
  - 36 credit hours is coursework, of which a minimum of 24 must be graded.
19 credit hours will be required coursework
17 credit hours are elective coursework
18 credit hours of Dissertation

Students with an Advanced Research Degree (e.g. MS, MPH, MNS) -
Students with a relevant advanced degree must petition the PhD Steering Committee to obtain a waiver for required coursework. For the waiver, the student must submit transcripts showing the course and grade, as well as the syllabus for the course.

Per the School of Graduate Studies, curriculum for individual with relevant advanced degree:
• Minimum of 18 credit hours of coursework, of which 12 must be graded. The courses used to achieve the 18 credit hours will depend on individual needs and require the academic advisor’s (mentor’s) approval.
• 18 credit hour of Dissertation

Students Seeking Dual Degree MD/PhD Through Case Western Reserve University's Medical Scientist Training Program and Clinical Translational Science Training Program: [https://case.edu/medicine/crsp/programs/phd-clinical-translational-science-cts/program-study-tracks/seeking-dual-degree](https://case.edu/medicine/crsp/programs/phd-clinical-translational-science-cts/program-study-tracks/seeking-dual-degree)

Curricula of the two-degree programs are integrated.

Curriculum for Dual-Degree students:
• 39 credit hours of coursework, as follows:
  • 16 credit hours of required courses (CRSP 401, "Introduction to Clinical Research", is waived as course material is covered in medical school's curriculum)
  • 2 credit hours of core electives
  • 6 credit hours of research rotations
  • Up to 18 credit hours of CRSP 601, “Research Practicum”, or electives

The PhD in Clinical Translational Science Curriculum:
• REQUIRED COURSES:
  CRSP 401 Introduction to Clinical Research Summer Series 3
  PQHS 490 Epidemiology: Introduction to Theory and Methods 3
  CRSP 412 Communication in Clinical Research - Grant Writing 1
  CRSP 413 Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media 1
  CRSP 431 Statistical Methods I 3
  CRSP 432 Statistical Methods II 3
  CRSP 440 Translational & Patient-Oriented Research Theory 3
  CRSP 450 Seminar in Multidisciplinary Clinical & Translational Research 0
  CRSP 501 Team Science - Working in Interdisciplinary Research Teams 1
  CRSP 550 Meta-Analysis & Evidence Synthesis 2 - 3

Total Units 21-23

CORE ELECTIVES
Student must take a minimum of 2 credit hours of courses from the list below, depending on their specific needs and mentor approval.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CRSP 502</td>
<td>Leadership Skills for Clinical Research Teams</td>
<td>2</td>
</tr>
<tr>
<td>SYBB 421</td>
<td>Fundamentals of Clinical Information Systems</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 450</td>
<td>Clinical Trials and Intervention Studies</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 467</td>
<td>Comparative and Cost Effectiveness Research</td>
<td>1</td>
</tr>
</tbody>
</table>

Total Units 9

ELECTIVES:
Students will take electives and CRSP 601, "Research Practicum," to satisfy the graded and pass/fail course requirements and to advance to candidacy. These courses are selected based on students’ needs and mentor approval. Any CWRU credit-bearing course may qualify. The courses could be “field specific” or include other core elective courses not taken as part of the requirement above. The following list is for illustrative purposes only and is not limited to those listed.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>PQHS 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
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<td>CRSP 410</td>
<td>Independent Study in Clinical Research</td>
<td>1 - 3</td>
</tr>
<tr>
<td>CRSP 500</td>
<td>Design and Analysis of Observational Studies</td>
<td>3</td>
</tr>
<tr>
<td>CRSP 504</td>
<td>Managing Research Records - A System's Approach</td>
<td>2 - 3</td>
</tr>
<tr>
<td>CRSP 505</td>
<td>Investigating Social Determinants of Health</td>
<td>2 - 3</td>
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<tr>
<td>CRSP 510</td>
<td>Health Disparities</td>
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<tr>
<td>NURS 518</td>
<td>Qualitative Nursing Research</td>
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<td>PQHS 411</td>
<td>Introduction to Health Behavior</td>
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<td>SASS 614</td>
<td>Models of Qualitative Research</td>
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Total Units 23-27

RESEARCH COMPONENT

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<th>Course</th>
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<tbody>
<tr>
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<tr>
<td>CRSP 701</td>
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Total Units 2-18

==============================================
SAMPLE TRACK OF STUDENT WITH NO EXISTING ADVANCE RESEARCH DEGREE:

<table>
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<th>Units</th>
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<tbody>
<tr>
<td>Summer</td>
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CRSP Program starts in the Summer Term of First Year
### Introduction to Clinical Research Summer Series (CRSP 401)

<table>
<thead>
<tr>
<th>Units</th>
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**Year Total:** 1-3

### First Year

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<tbody>
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<tr>
<td>Statistical Methods I (CRSP 431)</td>
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<td>Translational &amp; Patient-Oriented Research Theory (CRSP 440)</td>
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<tr>
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<td>Epidemiology: Introduction to Theory and Methods (PQHS 490)</td>
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<td>Meta-Analysis &amp; Evidence Synthesis (CRSP 550)</td>
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**Year Total:** 9 - 12

### Second Year

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<tr>
<td>Seminar in Multidisciplinary Clinical &amp; Translational Research (CRSP 450)</td>
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<tr>
<td>Team Science - Working in Interdisciplinary Research Teams (CRSP 501)</td>
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**Year Total:** 4 - 12

### Third Year

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**Year Total:** 1-9

### Fourth Year

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<tr>
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CRSP Program starts in the Summer Term of First Year

**Year Total:** 1-9

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### Total Units in Sequence: 38-98

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#### SAMPLE TRACK OF STUDENT WITH ADVANCE RESEARCH DEGREE:

**Prep Year**

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CRSP Program starts in the Summer Term of First Year

**Year Total:**

### First Year

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<td>Translational &amp; Patient-Oriented Research Theory (CRSP 440)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Seminar in Multidisciplinary Clinical &amp; Translational Research (CRSP 450)</td>
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<td></td>
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<tr>
<td>Research Practicum (CRSP 601)</td>
<td>1 - 9</td>
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<tr>
<td>Meta-Analysis &amp; Evidence Synthesis (CRSP 550)</td>
<td>2 - 3</td>
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<tr>
<td>Research Practicum (CRSP 601)</td>
<td>1 - 9</td>
<td></td>
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<tr>
<td>Introduction to Clinical Research Summer Series (CRSP 401)</td>
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</table>

**Year Total:** 4 - 12

### Second Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
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<th>Summer</th>
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<tbody>
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<td>Clinical Research Scholars Thesis (CRSP 651)</td>
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**Year Total:** 4 - 12

### Third Year

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</tr>
<tr>
<td>Dissertation Ph.D. (CRSP 701)</td>
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**Year Total:** 1-9

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### Fourth Year

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<tr>
<td>Seminar in Multidisciplinary Clinical &amp; Translational Research (CRSP 450)</td>
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<tr>
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**Year Total:** 1-9

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Dissertation Ph.D. (CRSP 701) | 1 - 9 | 1 - 9

CRSP Program starts in the Summer Term of First Year

**Year Total:** 1-9

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**Total Units in Sequence:** 38-98
### SAMPLE TRACK OF STUDENT SEEKING DUAL DEGREE MD/PHD

#### Prep Year

<table>
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<td>Research Rotation in Medical Scientist Training Program (MSTP 400)</td>
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**Year Total:**

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#### First Year

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<th>Summer</th>
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<td>Integrated Biological Sciences I (IBIS 401)</td>
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<tr>
<td>Clinical Science II (IBIS 412)</td>
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<td>Research Rotation in Medical Scientist Training Program (MSTP 400)</td>
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<td>Integrated Biological Sciences II (IBIS 402)</td>
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<td>Research Rotation in Medical Scientist Training Program (MSTP 400)</td>
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<td>Introduction to Clinical Research Summer Series (CRSP 401)</td>
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#### Second Year

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<tr>
<td>Integrated Biological Sciences III (IBIS 403)</td>
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<td>Clinical Science III (IBIS 413)</td>
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<tr>
<td>Translational &amp; Patient-Oriented Research Theory (CRSP 440)</td>
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<td>Seminar in Multidisciplinary Clinical &amp; Translational Research (CRSP 450)</td>
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<tr>
<td>Seminar in Multidisciplinary Clinical &amp; Translational Research (CRSP 450)</td>
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<tr>
<td>Meta-Analysis &amp; Evidence Synthesis (CRSP 550)</td>
<td>2 - 3</td>
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<tr>
<td>Research Practicum (CRSP 601)</td>
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**Year Total:**

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**Total Units in Sequence:**

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<tr>
<th>Units</th>
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</tr>
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#### Certificate in Global Health

Ronald Blanton, MD, Director  
216.368.4814

Daniel Tisch, PhD, Co-Director  
216.368.0875

The Certificate is the centerpiece of the Framework for Global Health Curricula comprised of faculty from across the Case Western Reserve University campus, whose objective is to promote education in global health issues. Nearly every department at CWRU offers multiple educational activities in global health. Rather than attempt to own all of these activities, the group at CWRU (representing Applied Social Sciences, Anthropology, Bioethics, Biology, Engineering, Mathematics, Medicine, Nursing, Population and Quantitative Health Sciences) elected to develop a structure within which each department could develop independently while taking advantage of what the others had to offer. The organizing structure for this became the certificate program rather than a separate degree. This approach recognizes that student’s need to graduate within a recognized discipline as well as recognition of a student’s focus, time and effort in training.

Each student in the Certificate program will be grounded in global health by a core course (INTH 301 Fundamentals of Global Health/INTH 401 Fundamentals of Global Health) that will allow them to understand concepts and vocabulary across disciplines and that will facilitate meaningful communication with others based in a different discipline. In addition to the Certificate, the Framework for Global Health Curricula had identified and is annotating all global health related courses at CWRU. It has supported the recent revival of Medical Spanish and new courses and electives in Global Health.

**Requirements for Certificate in Global Health:**

**Anthropology**
Undergraduate:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 301</td>
<td>Fundamentals of Global Health</td>
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<tr>
<td>ANTH 215</td>
<td>Health, Culture, and Disease: An Introduction to Medical Anthropology</td>
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</tr>
<tr>
<td>ANTH 359</td>
<td>Introduction to Global Health</td>
<td>3</td>
</tr>
</tbody>
</table>

And one elective selected from list of approved electives in the Anthropology Department

Contact: Vanessa M. Hildebrand (vanessa.hildebrand@case.edu), 216.368.2630

Graduate:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
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<tr>
<td>ANTH 459</td>
<td>Introduction to Global Health</td>
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</tr>
<tr>
<td>ANTH 511</td>
<td>Seminar in Anthropology and Global Health: Topics</td>
<td>3</td>
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</table>

And one elective selected from list of approved electives in the Anthropology Department

Contact: Janet McGrath (janet.mcgrath@case.edu), 216.368.2287

Bioethics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
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<tr>
<td>BETH 414</td>
<td>International Health Research Ethics</td>
<td>3</td>
</tr>
</tbody>
</table>

And complete one elective selected from list of approved electives in the Bioethics Department

Contact: Patricia Marshall (patricia.marshall@case.edu), 216.368.6196

Population and Quantitative Health Sciences

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
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</tr>
<tr>
<td>PQHS 484</td>
<td>Global Health Epidemiology</td>
<td>1 - 3</td>
</tr>
</tbody>
</table>

And complete an epidemiology research project with global perspective (may be substituted with other course work).

Contact: Daniel Tisch (daniel.tisch@case.edu), 216.368.0875

Math/Applied Math specialization:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 301</td>
<td>Fundamentals of Global Health</td>
<td>3</td>
</tr>
<tr>
<td>or INTH 401</td>
<td>Fundamentals of Global Health</td>
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</tr>
<tr>
<td>PQHS 431</td>
<td>Statistical Methods I</td>
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<tr>
<td>or PQHS 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
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<tr>
<td>MATH 449</td>
<td>Dynamical Models for Biology and Medicine</td>
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</tr>
<tr>
<td>or EECS 397/600</td>
<td>Special Topics</td>
<td></td>
</tr>
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</table>

Complete a heal related modeling project with global perspective (may be substituted with other course work).

Contact: David Gurarie (david.gurarie@case.edu), 216.368.2857

Medicine

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
<td>3</td>
</tr>
</tbody>
</table>

Complete a global health related project (may be student's thesis or may be substituted with other course work)

Contact: Ronald Blanton (ronald.blanton@case.edu), 216.368.4814

Nursing

Undergraduate:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 301</td>
<td>Fundamentals of Global Health</td>
<td>3</td>
</tr>
<tr>
<td>NURS 372</td>
<td>Health in the Global Community</td>
<td>3</td>
</tr>
<tr>
<td>NURS 394</td>
<td>Global Health Seminar</td>
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Complete a global health related project (may be substituted with other course work)

Graduate:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
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</tr>
<tr>
<td>NURS 394</td>
<td>Global Health Seminar</td>
<td>3</td>
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</tbody>
</table>

Complete a global health related project (may be substituted with course work)

Contact: Elizabeth Madigan (elizabeth.madigan@case.edu), 216.368.8532

Biology

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTH 301</td>
<td>Fundamentals of Global Health</td>
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</tr>
<tr>
<td>or INTH 401</td>
<td>Fundamentals of Global Health</td>
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</table>

Additional Biology electives from approved list

Contact: Christopher Cullis (christopher.cullis@case.edu), 216.368.5362

Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>INTH 301</td>
<td>Fundamentals of Global Health</td>
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</tr>
<tr>
<td>or INTH 401</td>
<td>Fundamentals of Global Health</td>
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Approved electives Engineering related courses

Contact: N. Sree Sreenath (n.sreenath@case.edu), 216.368.6219

Mandel School of Applied Social Sciences

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
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</table>

Additional MSASS elective from approved list

Contact: Sharon Milligan (sharon.milligan@case.edu), 216.368.2335

Certificate in Cancer Biology

216.844.5375
Stanton Gerson, MD, Director
Damian J. Junk (djj40@case.edu), PhD, Assistant Director Cancer Training and Education, Case Comprehensive Cancer Center
http://www.case.edu/cancer/
The Clinical Oncology Research Career Development Program (CORP) provides interdisciplinary training in clinical and translational oncology research for clinical oncology junior faculty physicians who are interested in pursuing academic research careers as physician scientists. This training addresses the need for clinician investigators to translate fundamental cancer research discoveries into medical care of cancer patients. Eligible candidates are physicians (MD, DO or MD/PhD) with a clinical training background in one of a number of oncology disciplines, including medical, surgical, pediatric, dermatological, gynecological and radiation oncology. Scholars select one of three areas of concentration:

- Mechanism Based Therapeutics and Clinical Trials
- Stem Cell Biology and Hematopoietic Malignancy Clinical Trials
- Prevention, Aging and Cancer Genetics and Clinical Trials

The Scholars’ individual training plan consists of a 2-year certificate program which includes a didactic curriculum designed to provide basic background and highly individualized advanced training in both clinical and methodological components of clinical and translational cancer research.

Each Scholar is co-mentored by both a basic or behavioral scientist and a clinical investigator. A mentoring committee comprised of faculty in the Scholar’s focus of oncology research provides additional guidance and support. During the period of mentored laboratory training, the Scholars develop original hypothesis-based experiments related to disease mechanisms at a molecular or cellular level. As the Scholars build on their laboratory conclusions to create and implement clinical trials, they are mentored by clinical investigators. Clinical trials are aimed at developing new methods for diagnosis and testing promising ideas for novel therapeutic interventions. These components come together with the Scholar’s presentations at a national conference, publications in peer review journals and application for independent funding as a physician scientist.

This two-year certificate program is administered through the Case Comprehensive Cancer Center. The overall goal of the K12 CORP certificate program is to foster interdisciplinary training in clinical and translational oncology therapeutic research for physicians. Upon completion of this 15-19 hour two year training, scholars will earn the K12 CORP Certificate.

The formal didactic program includes a course in responsible conduct of Research (0) or CRSP 603 Research Ethics and Regulation (2 hr); CNCR 501 Translational Cancer Research A (Translational Cancer Research Course (1 hr/semester); and one elective (1-3). Additional required activities include Clinical Protocol Tutorials, Intensive Mentored Research Project, Ongoing seminars, Meetings and Presentations; and applications for independent funding.

### Formal Didactic Curriculum Coursework *

<table>
<thead>
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<th>Course Title</th>
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<td>IBMS 500</td>
<td>On Being a Professional Scientist: The Responsible Conduct of Research</td>
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<tr>
<td>or CRSP 603</td>
<td>Research Ethics and Regulation</td>
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*Additionally, choose one course from following core courses for credit towards certificate:

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<th>Course Code</th>
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<th>Credits</th>
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<td>Introduction to Clinical Research Summer Series</td>
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<tr>
<td>CRSP 402</td>
<td>Study Design and Epidemiologic Methods</td>
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</tr>
<tr>
<td>CRSP 406</td>
<td>Introduction to R Programming</td>
<td>2</td>
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<tr>
<td>CRSP 413</td>
<td>Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media</td>
<td>1</td>
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<td>CRSP 412</td>
<td>Communication in Clinical Research - Grant Writing</td>
<td>1</td>
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<tr>
<td>CRSP 500</td>
<td>Design and Analysis of Observational Studies</td>
<td>3</td>
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<tr>
<td>CRSP 501</td>
<td>Team Science - Working in Interdisciplinary Research Teams</td>
<td>1</td>
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### Graduate Certificate in Clinical Research

James Spilsbury (james.spilsbury@case.edu), PhD, Director
Angela Bowling (angela.bowling@case.edu), Education Administrator
Center for Clinical Investigation
http://case.edu/medicine/crsp/programs/certificate-program/
216.368.2601

The Clinical Research Certificate program is a four course, 11 credit hour program. Students who successfully complete the required coursework will receive a Certificate in Clinical Research. Coursework includes: Introduction to Clinical and Translational Research; Study Design and Epidemiologic Methods; Advanced Statistics: Linear Models; and a course on Research Ethics and Regulation.

Admissions will be administered by the Clinical Research Scholars program in the Populations and Quantitative Health Science Department. Individuals who want to participate in the program will complete an online application form that includes a brief personal statement describing the reason(s) for seeking clinical research training and a recent CV or resume. Per CWRU School of Graduate Studies requirements, individuals who are not already graduate-degree-seeking students at CWRU must submit to the School of Graduate Studies a completed non-degree application form. Individuals who are not faculty, staff, or employees of CWRU must also submit a transcript or copy of their diploma, documenting completion of a baccalaureate degree. Once accepted into the Certificate program, participants will register for the courses through the Student Information System. The program will have rolling admissions, and students will be able to start taking courses in the summer or fall semester. The coursework for the Certificate will be listed on the official CWRU transcript. However, the Certificate in Clinical Research will be issued by the Clinical Research Scholars Program, not the University, and will not appear on the official CWRU transcript.

Performance Standards: A grade of B or higher in each graded course will be required for successful completion of the Certificate program. Enrollees will be responsible for keeping track of the courses they take.

Required Courses:
PRIME Program:
The PRIME program is highly flexible. To earn the certificate, students must complete at least 24 credit hours. A program of study must be approved by the program director. Each student will work closely with the program director to tailor the program to their needs. Based on previous coursework taken, some students may need to take more than 24 credit hours to complete the prerequisite courses for medical school and earn the PRIME certificate. This program can be completed in 1-2 years, depending on a student’s individual needs.

**Required Program Coursework:**
- MGRD 310 Introduction to Clinical Inquiry (IQ) 3
- MGRD 311 Introduction to Clinical Inquiry (IQ) II 3

**Required Medical School Coursework:**
- BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science 4
- BIOL 214 Genes, Evolution and Ecology 3
- BIOL 214L Genes, Evolution and Ecology Lab 1
- BIOL 215 Cells and Proteins 3
- BIOL 215L Cells and Proteins Laboratory 1
- BIOL 216L Development and Physiology 1
- CHEM 105 Principles of Chemistry I 3
- CHEM 106 Principles of Chemistry II 3
- CHEM 113 Principles of Chemistry Laboratory 2
- CHEM 223 Introductory Organic Chemistry I 3
- CHEM 224 Introductory Organic Chemistry II 3
- CHEM 233 Introductory Organic Chemistry Laboratory I 2
- CHEM 234 Introductory Organic Chemistry Laboratory II 2
- MATH 125 Math and Calculus Applications for Life, Managerial, and Social Sci I 4
- MATH 126 Math and Calculus Applications for Life, Managerial, and Social Sci II 4
- or STAT 201 Basic Statistics for Social and Life Sciences 3
- PHYS 115 Introductory Physics I 4
- PHYS 116 Introductory Physics II 4
- PSCL 101 General Psychology I 3
- SOCI 101 Introduction to Sociology 3

Students may have completed some of these required courses prior to the start of this program and thus the students would be eligible for exemption from taking these courses for the certificate. Depending on course grades, students, with approval of the program director, may waive the required courses. Students may also elect to retake these courses for reference and/or to improve their undergraduate GPA.

**Elective Coursework**
In consultation with the program director, students will develop the best program of study for their needs. Typically, if a student has already taken the medical school prerequisites, but needs to improve their overall undergraduate GPA, taking upper level undergraduate courses would show more rigor compared to retaking lower level courses. With successful grades, a student’s undergraduate GPA will also improve.

Students may take additional elective coursework (http://casemed.case.edu/gradprog/PRIME/electives.php) across the university with program director and instructor approval. Although science and math classes will be the primary focus for most students, some students...
may also seek to take graduate coursework to demonstrate academic rigor. Further, some students may also elect to take other courses based on interests or a desire to improve technical skills (such as writing or language skills).

**Systems Biology and Bioinformatics MS and PhD Programs**

BRB 9th Floor, School of Medicine
http://bioinformatics.case.edu/
Phone: 216.368.6971
David T. Lodowski, PhD, Co-Director
Mark Chance, PhD, Co-Director
Program email: sybb@case.edu (sybb@case.edu)

---

Do you want to convert big data into understandable models that just might change the world? With a graduate degree in systems biology and bioinformatics, you can combine your love of math, statistics, computers and biology to develop computational models with which to provide new insight and understanding of big data, leading to big discoveries in both laboratory or clinical settings.

Data science is the convergence of data engineering, math, statistics, advanced computing, the scientific method and subject-matter expertise. It involves the collection, management and transformation of "big data" into actionable information that can answer some of the world's most pressing problems. Yet there is a distinct need for data science experts who can efficiently interpret data into information that is useful for strategic decision-making. It is the goal of the Systems Biology and Bioinformatics program to produce the scientists that are needed to assist in extracting meaning from the burgeoning biological 'omics field.

The SYBB program offers a multidisciplinary training program personally customized to the student leading to an MS or PhD. The program draws training faculty (currently 38 trainers) from more than 12 departments and 6 schools across the CWRU campus, ensuring students in the program acquire the core competencies needed to succeed in the bioinformatic analysis of biological big data.

The Systems Biology and Bioinformatics PhD program at CWRU offers trainees the opportunity to combine both experimental and computational or mathematical disciplines to understand complex biological systems. The SYBB program will train scientists who are able to generate and analyze experimental data for biomedical research and to develop physical or computational models of the molecular components that drive the behavior of a biological system. The goal of the program is to produce scientists who are familiar with multiple disciplines and equipped to conduct interdisciplinary research.

The Case Western Reserve University (CWRU) graduate program in **Systems Biology and Bioinformatics (SYBB)** has two tracks:

**Translational Bioinformatics** - The SYBB track in Translational Bioinformatics poises students to work at the interface of applied 'omics research and clinical medicine. From integrating genomic and functional genomic data into electronic medical records, to developing meta-analysis tools for communicating genomic risk to patients to utilizing this data in personalized medicine. Students trained in the Translational Bioinformatics track work to integrate bioinformatics tools and technologies into clinical workflows. Graduates of this training track will find ample opportunities within industry and, as genomics enters the clinical arena, within hospitals, as well.

**Molecular and Computational Biology** - The SYBB track in Molecular and Computational Biology embraces the pursuit of basic science research, employing the application and development of computational approaches to address difficult questions derived from today’s "Big data" derived from 'omics approaches. This track equips students in the acquisition of experimental data utilizing approaches including proteomics, metabolomics, genomics and structural biology and extends this work with interpretation provided by computational analysis. Graduates of this training track will find ample opportunities within the pharmaceutical industry, contract research organizations as well as more traditional academic career paths.

Students can choose either track for both the MS and PhD programs.

The SYBB participating departments and centers include:

- Biology
- Biomedical Engineering
- Case Comprehensive Cancer Center
- Cleveland Clinic Lerner College of Medicine
- Center for Proteomics and Bioinformatics
- Center for Systems Immunology
- Electrical Engineering and Computer Science
- Epidemiology and Biostatistics
- Genetics and Genome Sciences
- Mathematics
- Nutrition
- Physiology and Biophysics
- Pharmacology

**Program Competencies**

The specific academic requirements of the SYBB Program are intended to provide students with a required core curriculum in Systems Biology and a set of electives designed both to assure minimum competencies in **Fundamental Core Competencies** and equip them for their particular thesis research discipline. Each trainee will be guided in their customized course of study by a mentoring committee to ensure the completion of training in the program competencies as well as maintenance of a focus on molecular systems theory. These competencies include:

- Evaluation of the scientific discovery process and of the role of bioinformatics in it in detail, including data generation steps and understanding the biology.
- Application of computational and statistical methods appropriate to solve a given scientific problem.
- Construction of software systems of varying complexity based on design and development principles.
- Effective teamwork to accomplish a common scientific goal.
- Building knowledge in local and global impact of bioinformatics and systems biology on individuals, organizations, and society.
- Effective communication of bioinformatics and systems biology problems to a range of audiences, including, but not limited to, other bioinformatics professionals.

**Masters Degree Plan A Summary**

The minimum requirements for the master's degree under Plan A are 21 semester hours of course work plus a thesis equivalent to at least 9 semester hours of registration for 30 hours total. These must include **SYBB 501** Biomedical Informatics and Systems Biology Journal Club, and a minimum of 9 hours of **SYBB 651** Thesis MS. Additional
required courses for the Translational Bioinformatics and Molecular and 
Computational Biology tracks are SYBB 459 Bioinformatics for Systems 
Biology and SYBB 555 Current Proteomics. The curriculum plan must 
be approved by the program steering committee and include appropriate 
coverage of the core competencies in genes and proteins, bioinformatics, 
and quantitative modeling and analysis. At least 18 semester hours 
of course work, in addition to thesis hours, must be at the 400-level or 
higher.

Each student must prepare an individual thesis that must conform 
to regulations concerning format, quality, and time of submission as 
established by the dean of graduate studies as well as conforming to the 
SYBB program guidelines. For completion of master's degrees under Plan 
A, an oral examination (defense) of the master's thesis is required, where 
the examination is conducted by a committee of at least three members 
of the university faculty.

**Masters Degree Plan B Summary**
The minimum requirements for the master's degree under Plan B are 
30 semester hours of course work (with at least 18 semester hours of 
course work at the 400 level or higher) and a written comprehensive 
examination or major project with report to be administered and 
evaluated by the program steering committee. The coursework must 
include SYBB 501 Biomedical Informatics and Systems Biology 
Journal Club. Additional required courses for the Translational 
Bioinformatics and Molecular and Computational Biology tracks are 
SYBB 459 Bioinformatics for Systems Biology and SYBB 555 Current 
Proteomics. The curriculum plan must be approved by the program 
steering committee and include appropriate coverage of the core 
competencies in genes and proteins, bioinformatics, and quantitative 
modeling and analysis.

**Sample Plan of Study for MS Degree in Molecular and 
Computational Biology**

<table>
<thead>
<tr>
<th>Plan of Study includes required courses as well as electives.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Year</strong></td>
</tr>
<tr>
<td>Survey of Bioinformatics: Technologies in Bioinformatics (SYBB 411A)</td>
</tr>
<tr>
<td>Survey of Bioinformatics: Data Integration in Bioinformatics (SYBB 411B)</td>
</tr>
<tr>
<td>Survey of Bioinformatics: Translational Bioinformatics (SYBB 411C)</td>
</tr>
<tr>
<td>Biomedical Informatics and Systems Biology Journal Club (SYBB 501)</td>
</tr>
<tr>
<td>Statistical Methods I (PQHS 431)</td>
</tr>
<tr>
<td>Topical Elective from Elective Course List</td>
</tr>
<tr>
<td>Survey of Bioinformatics: Programming for Bioinformatics (SYBB 412)</td>
</tr>
<tr>
<td>Biomedical Informatics and Systems Biology Journal Club (SYBB 501)</td>
</tr>
<tr>
<td>Current Proteomics and Bioinformatics (SYBB 555)</td>
</tr>
<tr>
<td>Additional 3 Credit Course TBD</td>
</tr>
<tr>
<td><strong>Total Units in Sequence:</strong></td>
</tr>
</tbody>
</table>

**PhD Program Summary**
The Systems Biology and Bioinformatics program differs from current 
CWRU programs in the comprehensive requirement for an understanding 
of biological systems, bioinformatics, and quantitative analysis & 
modeling. The program includes a minimal set of required courses 
including (SYBB 501) Biomedical Informatics and Systems Biology Journal Club and 
a course in the Responsible Conduct of research (IBMS 500 On Being a 
Professional Scientist: The Responsible Conduct of Research). Additional 
required courses for the Translational Bioinformatics and Molecular and 
Computational Biology tracks are SYBB 459 Bioinformatics for Systems 
Biology and SYBB 555 Current Proteomics. At least six additional 
courses will be required based up on individualized student interests. 
Other requirements include a qualifier exam, a PhD Dissertation, and 
oral defense. The total credits required for the PhD is at least 54 credits: 
24 graded credits, 12 pre-dissertation research credits, and at least 
18 dissertation research credits. Admissions to this program may be 
obtained through the integrated Biomedical Sciences Training Program, 
by direct admission to the department in rare cases or via the Medical 
Scientist Training Program.

**Sample Plan of Study for PhD Degree**

<table>
<thead>
<tr>
<th>Plan of study includes required courses as well as electives. Visit <a href="http://bioinformatics.case.edu/">http://bioinformatics.case.edu/</a> for information regarding Plan of Study for all SYBB Tracks.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan of Study Grid for Translational Bioinformatics</strong></td>
</tr>
<tr>
<td><strong>Track</strong></td>
</tr>
<tr>
<td>Biomedical Informatics and Systems Biology Journal Club (SYBB 501)</td>
</tr>
<tr>
<td>Survey of Bioinformatics: Technologies in Bioinformatics (SYBB 411A)</td>
</tr>
<tr>
<td>Survey of Bioinformatics: Data Integration in Bioinformatics (SYBB 411B)</td>
</tr>
<tr>
<td>Survey of Bioinformatics: Translational Bioinformatics (SYBB 411C)</td>
</tr>
<tr>
<td>Cell Biology I (IBMS 453)</td>
</tr>
<tr>
<td>Molecular Biology I (IBMS 455)</td>
</tr>
<tr>
<td>Systems Biology and Bioinformatics Research (SYBB 601)</td>
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</table>
**Survey of Bioinformatics: Programming for Bioinformatics (SYBB 412)** 3
**Current Proteomics and Bioinformatics (SYBB 555)** 3
**Bioinformatics for Systems Biology (SYBB 459)** 3
**Systems Biology and Bioinformatics Research (SYBB 601/651)** 1-9
**Biomedical Informatics and Systems Biology Journal Club (SYBB 501)** 0
**On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)** 1

<table>
<thead>
<tr>
<th>Year Total:</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>10-18</td>
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<td>11-19</td>
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**Second Year**

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<tr>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Contemporary Approaches to Drug Discovery (SYBB 528)</td>
<td>3</td>
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<tr>
<td>Fundamentals of Clinical Information Systems (SYBB 421)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Statistical Methods I (PQHS 431)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Biomedical Informatics and Systems Biology Journal Club (SYBB 501)</td>
<td>0</td>
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<tr>
<td>BioDesign (SYBB 472)</td>
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<tr>
<td>Biomedical Informatics and Systems Biology Journal Club (SYBB 501)</td>
<td>0</td>
<td></td>
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<tr>
<td>Systems Biology and Bioinformatics Research (SYBB 601)</td>
<td>3</td>
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<tr>
<td>Statistical Methods II (PQHS 432)</td>
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**Third Year**

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<tr>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Dissertation Ph.D. (SYBB 701)</td>
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</tr>
<tr>
<td>Dissertation Ph.D. (SYBB 701)</td>
<td>1-9</td>
<td>1-9</td>
</tr>
<tr>
<td>Year Total:</td>
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<td>1-9</td>
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**Fourth Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissertation Ph.D. (SYBB 701)</td>
<td>1-9</td>
<td></td>
</tr>
<tr>
<td>Dissertation Ph.D. (SYBB 701)</td>
<td>1-9</td>
<td>1-9</td>
</tr>
<tr>
<td>Year Total:</td>
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<td>1-9</td>
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</table>

**Fifth Year**

<table>
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<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissertation Ph.D. (SYBB 701)</td>
<td>1-9</td>
<td></td>
</tr>
<tr>
<td>Dissertation Ph.D. (SYBB 701)</td>
<td>1-9</td>
<td>1-9</td>
</tr>
<tr>
<td>Year Total:</td>
<td>1-9</td>
<td>1-9</td>
</tr>
</tbody>
</table>

**Total Units in Sequence:** 45-109

**Footnotes**

* MSTP would take MSTP 400 for research rotations

---

**Required Core Courses for the Molecular and Computational Biology and Translational Bioinformatics Tracks of the MS and PhD programs**

**Course List**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>SYBB 459</td>
<td>Bioinformatics for Systems Biology</td>
<td>3</td>
</tr>
<tr>
<td>SYBB 555</td>
<td>Current Proteomics and Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>SYBB 501</td>
<td>Biomedical Informatics and Systems Biology Journal Club</td>
<td>0</td>
</tr>
<tr>
<td>SYBB 601</td>
<td>Systems Biology and Bioinformatics Research</td>
<td>up to 9</td>
</tr>
<tr>
<td>SYBB 651</td>
<td>Thesis M.S. (For MS Students only)</td>
<td>*</td>
</tr>
<tr>
<td>SYBB 701</td>
<td>Dissertation Ph.D. (For PhD students only)</td>
<td>18</td>
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</table>

**Elective Courses for MS and PhD programs**

**Genes and Proteins Courses**

**Course List**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PHOL/CHM/PHRM/BIOC/NEUR 475</td>
<td>Protein Biophysics</td>
<td>3</td>
</tr>
<tr>
<td>PHOL 456</td>
<td>Conversations on Protein Structure and Function</td>
<td>2</td>
</tr>
<tr>
<td>PHOL 480</td>
<td>Physiology of Organ Systems</td>
<td>4</td>
</tr>
<tr>
<td>IBMS 453</td>
<td>Cell Biology I</td>
<td>3</td>
</tr>
<tr>
<td>IBMS 455</td>
<td>Molecular Biology I</td>
<td>3</td>
</tr>
<tr>
<td>BIOC 452</td>
<td>Nutritional Biochemistry and Metabolism</td>
<td>3</td>
</tr>
<tr>
<td>BIOC 412</td>
<td>Proteins and Enzymes</td>
<td>3</td>
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<tr>
<td>BIOC 420</td>
<td>Current Topics in Cancer</td>
<td>3</td>
</tr>
<tr>
<td>BIOC 454</td>
<td>Biochemistry and Biology of RNA</td>
<td>3</td>
</tr>
<tr>
<td>SYBB 528</td>
<td>Contemporary Approaches to Drug Discovery</td>
<td>3</td>
</tr>
<tr>
<td>BETH 412</td>
<td>Ethical Issues in Genetics/Genomics</td>
<td>3</td>
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</table>

**Bioinformatics and Computational Biology Courses**

**Course List**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOC/ECON 419</td>
<td>Applied Probability and Stochastic Processes for Biology</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 451</td>
<td>A Data-Driven Introduction to Genomics and Human Health</td>
<td>3</td>
</tr>
<tr>
<td>EEC5 488</td>
<td>Introduction to Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>NEUR 578/BIOL 378/COS/G/MATH 378/BIOI 478/EBME 478</td>
<td>Computational Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>SYBB 411A</td>
<td>Survey of Bioinformatics: Technologies in Bioinformatics</td>
<td>1</td>
</tr>
<tr>
<td>SYBB 411B</td>
<td>Survey of Bioinformatics: Data Integration in Bioinformatics</td>
<td>1</td>
</tr>
<tr>
<td>SYBB 411C</td>
<td>Survey of Bioinformatics: Translational Bioinformatics</td>
<td>1</td>
</tr>
<tr>
<td>SYBB 412</td>
<td>Survey of Bioinformatics: Programming for Bioinformatics</td>
<td>3</td>
</tr>
</tbody>
</table>
**Quantitative Analysis and Modeling**

**Course List**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPHP 405</td>
<td>Statistical Methods in Public Health</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 431</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 432</td>
<td>Statistical Methods II</td>
<td>3</td>
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<tr>
<td>EECS 435</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 515</td>
<td>Secondary Analysis of Large Health Care Data Bases</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 480</td>
<td>Introduction to Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>EECS 440</td>
<td>Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>MATH 441</td>
<td>Mathematical Modeling</td>
<td>3</td>
</tr>
<tr>
<td>EBME 300/MATH 449</td>
<td>Dynamics of Biological Systems: A Quantitative Introduction to Biology</td>
<td>3</td>
</tr>
<tr>
<td>MIDS 301</td>
<td>Introduction to Information: A Systems and Design Approach</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 457</td>
<td>Current Issues in Genetic Epidemiology: Design and Analysis of Sequencing Studies</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 451</td>
<td>A Data-Driven Introduction to Genomics and Human Health</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 452</td>
<td>Statistical Methods for Genetic Epidemiology</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 453</td>
<td>Categorical Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 459</td>
<td>Longitudinal Data Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

**Part-time SYBB MS program**

The program in systems biology and bioinformatics offers a flexible curriculum with a minimal number of required classes (SYBB 501 Biomedical Informatics and Systems Biology Journal Club, SYBB 459 Bioinformatics for Systems Biology, SYBB 555 Current Proteomics and Bioinformatics are the only required classes); the majority of classes taken toward the MS are tailored to the student’s research interests and thesis project. This flexibility enables students that are interested in pursuing the MS on a part time basis to maximize employee tuition benefits. A CWRU employee (or spouse) has a total of 15 credit hours/year (6 per semester and 3 per summer session) with which to pursue a degree. Taking only this number will net a part time student a MS in 5 semesters and 2 summer sessions; not taking a class during the summer sessions will result in taking 6 semesters to get the MS, and if a student were to take a single class a semester, it would take 11 semesters to reach the requisite number of classes needed for the MS.

**Master’s of Science in Regenerative Medicine & Entrepreneurship (RGME)**

Stanton L. Gerson, MD ([https://case.edu/medicine/ncrm/node/276](https://case.edu/medicine/ncrm/node/276))
Associate Professor, Pediatrics
Director, Case Comprehensive Cancer Center
Director, National Center for Regenerative Medicine
Professor, Medicine-Hematology/Oncology
slug5@case.edu

Associate Professor, Pediatrics
tracey.bonfield@case.edu (Tracey.Bonfield@case.edu)

Associate Professor, Biomedical Engineering
horst.vonrecum@case.ed (horst.vonrecum@case.edu)

https://case.edu/medicine/ncrm/training-education/masters-program-rgme

The RGME is the first two-year master’s level program in Ohio focused on Regenerative Medicine and Entrepreneurship. Students enrolled in the RGME program will have access to cutting-edge clinical and research facilities along with small biotechnology companies within the network of the National Center for Regenerative Medicine (NCRM).

This unique, interdisciplinary program will provide a rigorous educational pathway targeting individuals seeking the advanced skills and training required to excel in the unique workforce necessary to support the exponential growth and application of the field of regenerative medicine. The Master’s program in RGME will train individuals to work in academic, commercial, and clinical settings to support cellular manufacturing, biotechnology innovation, legal and compliance, financial analyst and venture capital, and business development activities taking advantage of our strengths across the disciplines of regenerative medicine as a whole.

**Core Courses**

18 required core credits across disciplines

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGME 525</td>
<td>Current Topics in Regenerative Medicine</td>
<td>2</td>
</tr>
<tr>
<td>RGME 535</td>
<td>Foundations in Regenerative Medicine</td>
<td>3</td>
</tr>
<tr>
<td>RGME 545</td>
<td>Stem Product Biology, Bench to Bedside Development and Therapeutic Translation</td>
<td>3</td>
</tr>
<tr>
<td>RGME 560</td>
<td>Regenerative Medicine Independent Study, Research Project</td>
<td>3</td>
</tr>
<tr>
<td>RGME 565</td>
<td>Regenerative Medicine Independent Study, Internship</td>
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<tr>
<td>BIOL 491</td>
<td>Contemporary Biology and Biotechnology for Innovation I</td>
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</tr>
<tr>
<td>BIOL 492</td>
<td>Contemporary Biology and Biotechnology for Innovation II</td>
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</table>

**Electives**

6 credits of science electives

6 credits of business electives (strongly recommended to be GENE 467, LAWS 5366, or PHYS 491)

**Total Credit Hours Required for Degree:**

30

**Sample Curriculum**

**Fall Semester 1**

RGME 535
BIOL 491
Science Elective

Seminars

Spring Semester 1
RGME 545
BIOL 492
Science Elective

Fall Semester 2
RGME 560
Business Development Elective (Strongly Recommended - GENE 467: Commercialization and IP Management)

Seminars

Spring Semester 2
RGME 565
Business Development Elective (Recommended - LAWS 5366: Venture Finance and Transactions; PHYS 491: Modern Physics for Innovation)

Questions? Contact Melanie Prestage (mxp449@case.edu) for more information.

CRSP Courses

CRSP 401. Introduction to Clinical Research Summer Series. 1 - 3 Units.
This course is designed to familiarize one with the language and concepts of clinical investigation and statistical computing, as well as provide opportunities for problem-solving, and practical application of the information derived from the lectures. The material is organized along the internal logic of the research process, beginning with mechanisms of choosing a research question and moving into the information needed to design a protocol, implement it, analyze the findings, and draw and disseminate the conclusion(s). Prereq: M.D., R.N., Ph.D., D.D.S., health professionals.

CRSP 402. Study Design and Epidemiologic Methods. 3 Units.
This course will cover the methods used in the conduct of epidemiologic and health services research and considers how epidemiologic studies may be designed to maximize etiologic inferences. Topics include: measures of disease frequency, measures of effect, cross-sectional studies, case-control studies, cohort studies, randomized controlled trials, confounding, bias, effect modification, and select topics. Recommended preparation: CRSP 401 or permission of instructor.

CRSP 406. Introduction to R Programming. 2 Units.
This course will provide students with an introduction to R. Major topics will include session management, data objects, reading and writing data, restructuring and combining data frames, handling missing data, working with dates, statistical analysis concepts, and R traditional graphics. Students will learn R programming conventions, how to create, manage and edit R scripts programs, and how to interpret output. Each class will consist of a demo on each lesson followed by a practice session when time permits. Small research datasets will be used both in class examples and in the exercises for each lesson. Students will be expected to complete all homework assignments on time and submit a take-home final exam.

CRSP 407. Logistic Regression and Survival Analysis. 3 Units.
This course will focus on the conceptual understanding and practical application of multivariable modeling in the context of binary and time to event outcomes. Particular emphasis will be placed on model specification, assessment of model assumptions and proper interpretation and visualization of model results. Classes will generally involve a conceptual discussion of the topic in question, followed by a practical application using R statistical software. Planned topics include contingency tables, logistic regression models, Kaplan-Meier curves, Cox proportional hazard models, and sample size estimation for binary and time to event outcomes. Students will be expected to complete biweekly assignments and two course projects involving problem specification, data collection, analysis using R, and a presentation. Prior to taking this course students should have working knowledge of linear regression and its application using R. Students must have the latest software version of R installed on their laptops. Recommended preparation: CRSP 406. Prereq: NURS 630.

CRSP 410. Independent Study in Clinical Research. 1 - 3 Units.
Independent Study in Clinical Research enables the student to undertake study of advanced topics in clinical research that are not offered as standing courses at Case Western Reserve University. The student(s) and a member of the Clinical Research Scholars Program faculty, or another faculty member at CWRU, submit a 1-2 page proposal for independent study to the CRSP Program Director. The proposal should include a descriptive title (e.g., research method or clinical topic area) to be studied; a list of up to 5 student-centered objectives of the study; how the subject matter will be learned; and how success in achieving the objectives will be measured (e.g., research method or clinical topic area) to be studied. Prereq: CRSP 401 or equivalent.

CRSP 412. Communication in Clinical Research - Grant Writing. 1 Unit.
Written communication is a critical skill in clinical science. We disseminate our work to others through publications, and we obtain the resources to conduct research through grant proposals. This course has been developed for Kl2 and CRSP scholars. The course focuses on writing grant proposals and, in particular, specific sections of an NIH-style grant. However, the principles discussed in the course apply to any type of proposal. Prereq: CRSP 401 or equivalent.

CRSP 413. Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media. 1 Unit.
To move their work forward, investigators must be able to present their research effectively to both scientific and lay audiences. Although “the written word” is probably the first medium that comes to mind when we think of communication in scientific circles, other modes of communication are also vital. The main objective of this course is to help scholars improve their oral and poster presentation skills, as well as interaction with the mass media. We disseminate our work to others through publications, and we obtain the resources to conduct research through grant proposals. This course has been developed for Kl2 and CRSP scholars. The course focuses on writing grant proposals and, in particular, specific sections of an NIH-style grant. However, the principles discussed in the course apply to any type of proposal. Prereq: CRSP 401 or equivalent.

CRSP 431. Statistical Methods I. 3 Units.
Application of statistical techniques with particular emphasis on problems in the biomedical sciences. Basic probability theory, random variables, and distribution functions. Point and interval estimation, regression, and correlation. Problems whose solution involves using packaged statistical programs. First part of year-long sequence. Offered as ANAT 431, BIOL 431, CRSP 431, PQHS 431 and MPH3 431.
CRSP 432. Statistical Methods II. 3 Units.
Methods of analysis of variance, regression and analysis of quantitative data. Emphasis on computer solution of problems drawn from the biomedical sciences. Design of experiments, power of tests, and adequacy of models. Offered as BIOL 432, PQHS 432, CRSP 432 and MPHP 432. Prereq: PQHS/EPBI 431 or equivalent.

CRSP 440. Translational & Patient-Oriented Research Theory. 3 Units.
Clinical (patient-oriented) and translational science has emerged as a new scientific discipline aimed to accelerate scientific discovery into effective practice. This course provides an overview of the theoretical framework, rationale, process, methodologies, and ethics of clinical and translational research. An integral feature of this course is the participation of a multidisciplinary teaching team, whose expertise and perspective will contribute to providing real-world insights into the complexities of translational and patient-oriented research.

CRSP 450. Seminar in Multidisciplinary Clinical & Translational Research. 0 Unit.
The purpose of this monthly seminar is to introduce students to the processes and challenges of multidisciplinary clinical/translational science, through which discoveries in the laboratory or in early clinical studies are transformed into interventions, treatments, and ultimately, best practices and policies on national and international levels. The seminar will use a case-based approach. Examination of active projects at Case Western Reserve University, Cleveland Clinic Foundation, the MetroHealth Medical Center, University Hospitals Case Medical Center, and the Louis Stokes Veterans Administration Medical Center will enable students to learn first-hand about clinical translational science in action.

CRSP 500. Design and Analysis of Observational Studies. 3 Units.
An observational study investigates treatments, policies or exposures and the effects that they cause, but it differs from an experiment because the investigator cannot control assignment. We introduce appropriate design, data collection and analysis methods for such studies, to help students design and interpret their own studies, and those of others in their field. Technical formalities are minimized, and the presentations will focus on the practical application of the ideas. A course project involves the completion of an observational study, and substantial use of the R statistical software. Topics include randomized experiments and how they differ from observational studies, planning and design for observational studies, adjustments for overt bias, sensitivity analysis, methods for detecting hidden bias, and focus on propensity score methods for selection bias adjustment, including multivariate matching, stratification, weighting and regression adjustments. Recommended preparation: a working knowledge of multiple regression, some familiarity with logistic regression, with some exposure to fitting regression models in R. Offered as CRSP 500 and PQHS 500.

CRSP 501. Team Science - Working in Interdisciplinary Research Teams. 1 Unit.
This course will assist learners to understand how different professional disciplines, each representing a body of scientific knowledge, can best work together to develop and disseminate translational knowledge. Learners will develop a set of skills specific to be an effective member and leader of an interdisciplinary research team, including working with different value and knowledge sets across disciplines, understanding the mental models of other disciplines, creating shared mental models, running effective meetings, managing conflict, giving and receiving feedback, and group decision making techniques. Using the small group seminar approach and case studies, learners will practice individual and group communication, reflective and self-assessment techniques, and engage in experiential learning activities regarding effective teamwork in interdisciplinary research teams. Techniques to increase group creativity and frame new insights will be discussed.

CRSP 502. Leadership Skills for Clinical Research Teams. 2 Units.
Leadership Assessment and Development is for participants to learn a method for assessing their knowledge, abilities, and values relevant to management; and for developing and implementing plans for acquiring new management related knowledge and abilities. The major goals of this course include generating data through a variety of assessment methods designed to reveal your interests, abilities, values, and knowledge related to leadership effectiveness; learning how to interpret this assessment data and use it to design/plan developmental activities; small group sharing of insights from the various assessments. Recommended preparation: K grant appointment or consent of instructor.

CRSP 503. Innovation and Entrepreneurship. 1 Unit.
The purpose of this module is to acquaint and ultimately engage clinical researchers with the business of innovation and entrepreneurship. Goals include: (1) to provide researchers with many of the skills that they would need to translate academic research into commercial uses; (2) to sensitize clinical researchers to the goals of the business community and facilitate their ability to work with the private sector on technology development; and (3) to make clinical researchers aware of the processes of academic technology development and transfer. Sessions consist of a lecture and case discussion facilitated by one of the co-directors.

CRSP 504. Managing Research Records - A System's Approach. 2 - 3 Units.
This course will provide an approach to managing data for research studies. Major topics include a discussion of a research study system including database design and development, data management, and clinical data management; how to evaluate the data needs of a study including the impact of required regulations; summary of key regulations; the role of the data manager including protocol review, development of a data management plan, CRF design, data cleaning, locking studies and ensuring best practices. Each session will include a lecture, class discussion, and student presentation.
CRSP 505. Investigating Social Determinants of Health. 2 - 3 Units.
The biopsychosocial model highlights the inter-related roles that biological, psychological, and social factors play in health and illness. This course is geared towards clinical research scholars who would like to incorporate aspects of the "social context" in their research. The course will examine the conceptualization, measurement, and effects of several key socio-cultural determinants of health and illness. Sample studies that incorporate social determinants of health will be reviewed. The course will also consider strategies and techniques to conduct clinical research involving social factors in socially and ethnically diverse settings. Students will be encouraged to develop a prototypical study design to incorporate social determinants in their research. To earn an optional third credit hour for this course, students will be required to complete additional assignments tailored to the students' research needs and interests upon mutual agreement with the instructor at the beginning of the course. Recommended preparation: CRSP 401.

CRSP 510. Health Disparities. 3 Units.
This course aims to provide theoretical and application tools for students from many disciplinary backgrounds to conduct research and develop interventions to reduce health disparities. The course will be situated contextually within the historical record of the United States, reviewing social, political, economic, cultural, legal, and ethical theories related to disparities in general, with a central focus on health disparities. Several frameworks regarding health disparities will be used for investigating and discussing the empirical evidence on disparities among other subgroups (e.g., the poor, women, uninsured, disabled, and non-English speaking populations) will also be included and discussed. Students will be expected to develop a research proposal (observational, clinical, and/or intervention) rooted in their disciplinary background that will incorporate materials from the various perspectives presented throughout the course, with the objective of developing and reinforcing a more comprehensive approach to current practices within their fields. Offered as CRSP 510, PQHS 510, MPHP 510, NURS 510, and SASS 510.

CRSP 550. Meta-Analysis & Evidence Synthesis. 2 - 3 Units.
Systematic reviews use reproducible methods to systematically search the literature and synthesize the results of a specific topic area. Meta-analysis is a specific analytic technique used to pool results of individual studies. Systematic reviews are useful ways to establish one's knowledge in a particular field of study, and can highlight gaps in research which can be pursued in future work. They can also inform the background of a grant. This course is designed to introduce students to the methods of conducting a high quality systematic review and meta-analysis of intervention studies. We will cover the design, methods, and analytic techniques involved in systematic reviews. These concepts will prepare students to conduct their own systematic review or evaluate the systematic reviews of others. Sessions will be lectures, labs, and presentations. Topics include developing a search strategy, abstracting key data, synthesizing the results qualitatively, meta-analytic techniques, grading the quality of studies, grading the strength of the evidence, and manuscript preparation specific to systematic reviews and meta-analysis of intervention studies. Caveat: If you would like to conduct a systematic review of your own that can be published after the course ends, you will need to have several other class members or colleagues willing to work with you on the project. The systematic review should be on a topic where you expect no more than 20-30 included studies in order to be able to complete the review soon after the course ends. Offered as CRSP 550 and PQHS 550. Prereq: CRSP 401, PQHS/EPBI 431, MPHP 405, NURS 532 or Requisites Not Met permission.

CRSP 560. Special Topics in Clinical Research. 1 Unit.
In this 1 credit hour course, students will explore particular issues and themes related to Clinical Research. The course content will vary and is designed to explore content not covered in other CRSP courses or to expand student knowledge on topics introduced by other CRSP courses.

CRSP 601. Research Practicum. 1 - 9 Units.
Research practicum and/or laboratory rotation.

CRSP 603. Research Ethics and Regulation. 1 - 2 Units.
This course is designed to introduce students to the ethical, policy, and legal issues raised by research involving human subjects. It is intended for law students, post-doctoral trainees in health-related disciplines and other students in relevant fields. Topics include (among others): regulation and monitoring of research; research in third-world nations; research with special populations; stem cell and genetic research; research to combat bioterrorism; scientific misconduct; conflicts of interest; commercialization and intellectual property; and the use of deception and placebos. Course will meet once per week for 2 hours throughout the semester. Grades will be given based on class participation and a series of group projects and individual short writing assignments. Offered as BETH 503, CRSP 603 and LAWS 5225.

CRSP 650. Capstone Experience. 3 Units.
The Capstone will provide hands-on experience in conducting clinical research. To complete the Capstone project the student will register for 3 credit hours and dedicate at least 160 hours over the course of a semester, typically 20 hours per week for 8 weeks. Under the guidance of a Capstone Advisor the student will develop a Capstone project or internship/practicum, which may take diverse forms: A study project; Internship/Practicum: A combination of tasks necessary for the successful implementation of a study, such as attending team meetings, developing an IRB protocol, designing study forms, assisting with recruitment, study procedures, data management/cleaning, descriptive analysis, secondary analysis; Another format, with approval of CRSP director and Capstone Advisor.

CRSP 651. Clinical Research Scholars Thesis. 1 - 18 Units.
CRSP Thesis M.S.

CRSP 701. Dissertation Ph.D.. 1 - 9 Units.
Ph.D. Dissertation credits. Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

RGME Courses

RGME 525. Current Topics in Regenerative Medicine. 2 Units.
Current Topics in Regenerative Medicine, will be an elective course in the newly approved Master's Program in Regenerative Medicine and Entrepreneurship. The objective of this course is for each student to develop a general understanding of concepts and current topics related to Regenerative Medicine, Stem Cell research, entrepreneurship and product development. -To expose students to principles in Cell Biology and Tissue Engineering relevant to the field -To review the current landscape and spectrum of topics which makes up the field of regenerative medicine -To explore current and emerging technologies supporting regenerative medicine research -To discuss federal regulatory and compliance issues related to clinical research and the development of therapeutics -To explore cellular manufacturing approaches for regenerative medicine products -Discuss ethical and societal issues related to regenerative medicine research and technologies
**RGME 535. Foundations in Regenerative Medicine. 3 Units.**

Foundations in Regenerative Medicine is a team-taught course using multiple faculty content experts. The objective of this course is for each student to develop a general understanding of the foundations and concepts related to Regenerative Medicine and Stem Cell research. To expose students to foundational principles in Cell Biology and Tissue Engineering relevant to the field. To review the current landscape and spectrum of topics which makes up the field of regenerative medicine. To explore current and emerging technologies supporting regenerative medicine research. To discuss federal regulatory and compliance issues related to clinical research and the development of therapeutics. To explore cellular manufacturing approaches for regenerative medicine products. Discuss ethical and societal issues related to regenerative medicine research and technologies.

**RGME 545. Stem Product Biology, Bench to Bedside Development and Therapeutic Translation. 3 Units.**

This course is a team-taught course using multiple faculty content experts. The objective of this course is for each student to understand the concept of stem cell biology from procurement to therapeutic development. This course will provide an overview of the regulatory framework, concepts, lab operations, and biologic techniques to support cell and regenerative medicine product manufacturing. To work in this emerging field, students must understand the scientific and regulatory development of biologic therapies as well as operational issues related to manufacturing in the cleanroom space under quality systems. The goals are to: 1) Develop an understanding of the infrastructure and compliance required to manufacture biologics for clinical use of stem cells. 2) Identify and critically analyze key operational issues related to clinical development and use of biologics from expansion to pre-clinical validation and therapeutic use. 3) Perform hands on activities using current techniques. 4) Discuss ethical and societal issues related to regenerative medicine research and technologies.

**RGME 560. Regenerative Medicine Independent Study, Research Project. 3 Units.**

The RGME 560 Independent Study-Research Project allows students to explore a topic of interest under the close supervision of a RGME program director and mentor. The course may include directed readings, applied work, assisting a faculty member with a research project, carrying out an independent research project, or other activities deemed appropriate. Regardless of the activities, the work must culminate in a formal paper. The specific course requirements are described in the Independent Studies Proposal form to be completed by the student, project mentor and program director prior to enrollment in the course. Prereq: RGME 535 and RGME 545.

**RGME 565. Regenerative Medicine Independent Study, Internship. 3 Units.**

The RGME 565 Independent Study-Industry Internship provides students with the opportunity to gain practical experience within an industry environment. Course objectives are: - Acquire knowledge of the industry sector in which the internship is completed. - Translate knowledge and skills learned in the classroom into a work environment. - Explore additional career options available with the designated industry sector. - Identify areas for future knowledge and skill development. Prereq: RGME 535 and RGME 545.

**Department of Genetics and Genome Sciences**

Biomedical Research Building
http://genetics.case.edu/
exploit the discoveries in genomics, epidemiology, ethics, pharmacology, genetics, and physiology to revolutionize the practice of medicine.

**MS Genetic Counseling (plan B)**

The Genetic Counseling Training Program is a 40 credit hour program that spans four academic semesters and an intervening summer. Acquisition and mastery of clinical competencies are reflected in the Program's didactic coursework, clinical rotations, research process, and supplementary experiences. The sequence of medical genetics courses and genetic counseling courses are designed to introduce concepts regarding medical genetics, general medical practice, counseling theory and clinical skills such that they build from beginning skills to a more advanced skill set in the order needed for clinical experiences. The goal of the program is to provide students with the knowledge and clinical skills to function as competent and empathetic genetic counselors in a wide range of settings and roles. All of these activities enable successful graduates to meet the clinical competencies as outlined by the Accreditation Council for Genetic Counseling (ACGC) and successfully pass the American Board of Genetic Counseling certification examination (ABGC).

Experiential professional training occurs concurrently with formal coursework and over the summer between years one and two. Clinical settings include a variety of clinics and inpatient services at the Center for Human Genetics at University Hospitals Cleveland Medical Center, the Genomic Medicine Institute at the Cleveland Clinic, Genetic Services at MetroHealth Medical Center and Medical Genetics at Akron Children's Hospital. Students also rotate at the Cleveland Clinic Molecular Laboratory which includes experiences in cytogenetics, molecular genetics, and cancer cytogenetics as well as learning the roles and responsibilities of laboratory genetic counselors. Student participation in these and other departmental professional and educational activities such as lectures, seminars, journal club, grand rounds, genetics conferences, and various research, counseling and patient management conferences is expected throughout the program. Coursework and clinical experiences are designed to develop the competencies expected by the ACGC.

**The First Year**

The major activities during the first year consist of course work (in the plan of study below), clinical observations and defining a research question and preparing a research proposal. Observational clinical rotations begin early in fall semester with students observing in prenatal genetics, cancer genetics, and general genetics clinics at the program's three affiliated institutions. Additionally, students meet several times over the fall semester to discuss the research process, potential topics, development of a research question and are introduced to the faculty's research areas of interest.

In addition to continuing clinical observational rotations and research, students continue with course work including an introduction to research methods and more in-depth theory and practice in the psychosocial aspects of counseling during spring semester.

During the intervening summer of years 1 and 2, students begin clinical rotations at the Medical Genetics Division at Akron Children's Hospital to gain exposure in various clinical settings including prenatal, general genetics, pediatrics, specialty clinics, and cancer genetics clinic. They also rotate through the Cleveland Clinic Molecular Laboratory to become familiarized with the clinical aspects of a diagnostic cytogenetics and molecular genetics laboratory.

**The Second Year**

The major focus of the second year is continued clinical experiences, research and taking the comprehensive written and oral examinations. Students also complete their coursework, taking one course each semester.

At the beginning of spring semester in January, the students sit for the written comprehensive examination (covering the didactic and clinical genetic counseling material covered to date in the program) and the oral section of the examination, which is given shortly after the written portion. Both examinations are intended to allow students to expand on their knowledge base of human and medical genetics and genetic counseling. Students are expected to pass both sections of the examination in order to meet graduation requirements by the Program. The written portion of the examination is patterned after the national certification examination given by the American Board of Genetic Counseling.

Students continue to work on data collection and analyses for their research projects, which should result in a publishable document. They meet with the Program Director periodically to review their progress as well as with their research committee and of course, are meeting with their mentor on a more frequent basis. During the fall semester of the second year, the students also attend the National Society of Genetic Counselors annual education meeting. This provides an opportunity for students to meet genetic counselors from across the country, to attend scientific sessions to continue adding to their knowledge base and to meet and discuss job opportunities with prospective employers. Successful completion of the program fulfills the curricular and clinical training requirements for eligibility to sit for the certification examination given by the ABGC.

**The sequence of courses for students is as follows:**

**MS Plan of Study**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td>Intensive: Medical Terminology (1 week)</td>
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<tr>
<td>Embryology (online course)</td>
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<tr>
<td>Advanced Medical Genetics: Molecular &amp; Cytogenetics (GENE 524)</td>
<td>2</td>
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<tr>
<td>Principles and Practices of Genetic Counseling (GENE 528)</td>
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<tr>
<td>Advanced Medical Genetics: Quantitative Genetics &amp; Genomics (GENE 526)</td>
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<tr>
<td>or Advanced Medical Genetics: Biochemical Genetics (GENE 527)</td>
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<tr>
<td>Direct Practice Generalist Methods &amp; Skills (SASS 477)</td>
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<tr>
<td>Intensive: Human Development (1 week)</td>
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<tr>
<td>Psychosocial Issues in Genetic Counseling (GENE 529)</td>
<td>3</td>
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<tr>
<td>Advanced Medical Genetics: Clinical Genetics (GENE 525)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cancer Genetics (GENE 531)</td>
<td>2</td>
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</tr>
</tbody>
</table>
Research in Genetics (GENE 601)  2
Clinical Practicum in Genetic Counseling (GENE 532)  3
Year Total:  10  9  3

Second Year  Units
Advanced Medical Genetics: Biochemical Genetics (GENE 527)  2
or Advanced Medical Genetics: Quantitative Genetics & Genomics (GENE 526)
Clinical Practicum in Genetic Counseling (GENE 532)  4
Research in Genetics (GENE 601)  3
Ethical Issues in Genetics/Genomics (BETH 412)  3
Clinical Practicum in Genetic Counseling (GENE 532)  4
Research in Genetics (GENE 601)  2
Year Total:  9  9

Total Units in Sequence:  40

MS/MA in Genetic Counseling and Bioethics (plan B)

The Departments of Genetics & Genome Sciences and Bioethics offer a dual degree program between the Masters in Genetic Counseling and the Masters in Bioethics Programs. The dual degree program provides a comprehensive curriculum integrating foundational principles of genetics and ethics. The goal of the program is to train Genetic Counselors who wish to apply additional Bioethics expertise into their clinical practice and/or research.

The dual degree program allows graduates to engage in both contemplative analysis and application of knowledge in the counseling of patients and should allow graduates to be more prepared to participate in the ongoing national dialogue about the ethical, legal, and social implications of advances in genomic technology as well as research within their home institutions and with other counselors nationwide regarding issues of new genomic testing technology, concerns about genetic services, and issues related to genetic discrimination, privacy, and the return of genetic and genomic results.

The curriculum for the Dual Genetic Counseling/Bioethics Degree consists of 62 credit hours to be completed in 2.5 years. Students enrolled in the dual degree program will spend their first year taking courses entirely within the Genetic Counseling Program and then will spread out their Bioethics coursework over the next 1.5 years while continuing with required coursework and clinical rotations in the genetic counseling program.

In addition to both a written and oral comprehensive examination as part of the Genetic Counseling Training Program, the dual degree requires a research project be carried out for the completion of both degrees. For the dual degree, students will be required to choose a research project that includes ethical, legal, or social issues of genetic counseling practice, clinical genetics or genomics, or genetic research. Students will also be required to include at least one Bioethics Faculty member on their Research Project Committee.

Students who would like to enroll in the dual degree program will apply and be admitted into each program separately. While admissions committees for each program will communicate with each other regarding applicants, each admissions committee will decide independently about the suitability of the applicant to their program.

Once students have been admitted, the Director of the Genetic Counseling Training Program and the Director of the MA Program in Bioethics will act as student co-advisors for each of the two programs individually as well as collaboratively - meeting monthly to assess student progress, address any student or faculty concerns, and assure that student progress in each of the programs, and their overlapping components, are being achieved.

MS/MA Plan of Study

First Year
Advanced Medical Genetics: Molecular & Cytogenetics (GENE 524)  2
Advanced Medical Genetics: Quantitative Genetics & Genomics (GENE 526)  2
Principles and Practices of Genetic Counseling (GENE 528)  3
Direct Practice Generalist Methods & Skills (SASS 477)  3
Psychosocial Issues in Genetic Counseling (GENE 529)  3
Advanced Medical Genetics: Clinical Genetics (GENE 525)  2
Cancer Genetics (GENE 531)  2
Research in Genetics (GENE 601)  2
Clinical Practicum in Genetic Counseling (GENE 532)  3
Year Total:  10  9  3

Second Year
Clinical Practicum in Genetic Counseling (GENE 532)  4
Advanced Medical Genetics: Biochemical Genetics (GENE 527)  2
Foundations in Bioethics I (BETH 401)  6
Clinical Practicum in Genetic Counseling (GENE 532)  4
Ethical Issues in Genetics/Genomics (BETH 412)  3
Foundations in Bioethics II (BETH 402)  6
Research in Genetics (GENE 601)  3
Year Total:  12  13  3

Third Year
Research in Genetics (GENE 601)  3
Clinical Ethics Rotation (BETH 405) 3  
BETH Elective 3  
BETH Elective 3  
Year Total: 12  

Total Units in Sequence: 62

**PhD Genetics**

Admissions to the Genetics program may be obtained through the integrated Biomedical Sciences Training Program, by direct admission to the department or via the MSTP program. The following summary pertains to most incoming PhD students, regardless of the route through which they enter the program. Exceptions are occasionally made to reflect previous educational experiences (e.g., a prior MS degree).

**The First Year**

Course work, rotations in at least three laboratories, and participation in seminars, journal clubs, and research meetings are the major activities of first year students. During the Fall term, most students take core courses in Cell and Molecular Biology (IBMS 453 Cell Biology I/IBMS 455 Molecular Biology I) that are offered for Biomedical Sciences Training Program departments. Laboratory rotations begin in early July and the choice of a thesis advisor is usually made at the end of December (see below for more details on Choosing an Advisor).

During the Spring term, PhD students take the core Advanced Eukaryotic Genetics course sequence (GENE 500 Advanced Eukaryotic Genetics I/GENE 504 Advanced Eukaryotic Genetics II), which is followed by a written comprehensive examination in late May or early June. This core course is designed to acquaint students with fundamental principles and methodologies used in modern genetic research. The focus is on similarities and differences between different model organisms used in genetics research. Also during the Spring term and continuing into the Summer, students begin formulating a doctoral research proposal.

**The Second Year and Beyond**

During the second year, students participate in a Proposal Writing Workshop (GENE 511 Grant Writing and Reviewing Skills Workshop) and take other advanced elective courses based on the academic background and interest of the student. The remaining elective credits can be satisfied by choosing from the courses offered by departmental faculty or participating training faculty from other departments (see List of Courses below). At the end of the second academic year, students must pass an oral proposal defense in order to advance to candidacy for the PhD degree. An outline of the typical course of study is shown below.

**PhD Genetics, Plan of Study Sample**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
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<tbody>
<tr>
<td>Fall</td>
<td>Spring</td>
</tr>
<tr>
<td>Cell Biology I (IBMS 453)</td>
<td>3</td>
</tr>
<tr>
<td>Molecular Biology I (IBMS 455)</td>
<td>3</td>
</tr>
<tr>
<td>Complete 3 lab rotations (July 1 to Dec 15)</td>
<td></td>
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<tr>
<td>Choose Ph.D. mentor (end December)</td>
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<tr>
<td>Research in Genetics (GENE 601)</td>
<td>1</td>
</tr>
<tr>
<td>CBIO 456 Nobel Prize Biomedical Research</td>
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<tr>
<td>IBMS 450 Biostatistics Rigor and Reproducibility</td>
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</tr>
<tr>
<td>Advanced Eukaryotic Genetics I (GENE 500/504)</td>
<td>3</td>
</tr>
<tr>
<td>Ph.D. Comprehensive exam (end of May or early June)</td>
<td></td>
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<tr>
<td>Advanced Eukaryotic Genetics II (GENE 504)</td>
<td>3</td>
</tr>
<tr>
<td>Research in Genetics (GENE 601)</td>
<td>3</td>
</tr>
<tr>
<td>Program Directors meet with students to discuss status, mentor; students begin assembling PhD thesis committee</td>
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<tr>
<td>Year Total: 9</td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Units</th>
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<tbody>
<tr>
<td>Fall</td>
<td>Spring</td>
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<tr>
<td>Grant Writing and Reviewing Skills Workshop (GENE 511)</td>
<td>3</td>
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<td>Elective course (Genetics or other)</td>
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<td>Research in Genetics (GENE 601)</td>
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<tr>
<td>Elective course (Genetics or other)</td>
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<tr>
<td>Research in Genetics (GENE 601)</td>
<td>3</td>
</tr>
<tr>
<td>Oral Defense of Thesis Proposal (to be completed by June 1)</td>
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<tr>
<td>Elective course (Genetics or other)</td>
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<tr>
<td>Year Total: 9</td>
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<tr>
<th>Third Year</th>
<th>Units</th>
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<tbody>
<tr>
<td>Fall</td>
<td>Spring</td>
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<tr>
<td>Either semester 1 elective course (Genetics or other)</td>
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</tr>
<tr>
<td>Dissertation Ph.D. (GENE 701)</td>
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<tr>
<td>Year Total:</td>
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<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Units</th>
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<tr>
<td>Fall</td>
<td>Spring</td>
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<tr>
<td>Dissertation Ph.D. (GENE 701)</td>
<td>3</td>
</tr>
<tr>
<td>Year Total:</td>
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<table>
<thead>
<tr>
<th>Fifth Year</th>
<th>Units</th>
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<tbody>
<tr>
<td>Fall</td>
<td>Spring</td>
</tr>
<tr>
<td>Dissertation Ph.D. (GENE 701)</td>
<td>3</td>
</tr>
<tr>
<td>Year Total:</td>
<td>3</td>
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Total Units in Sequence: 54

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements).
Other Requirements
- Students meet twice per year with Thesis Committee
- Students meet once per year with Genetics Graduate Education Committee
- Genetics Student Seminar (weekly attendance, yearly presentation)
- Genetics Journal Club (weekly attendance, yearly presentation in spring semester)
- Genetics Retreat (yearly participation, organized by students)
- Two first-author, peer-reviewed publications

Courses
BETH 412. Ethical Issues in Genetics/Genomics. 3 Units.
This course is designed to familiarize graduate students with the major controversies over the generation and use of new human genetic information. Topics will include the spread of predictive genetic testing, prenatal diagnosis, genetic discrimination, human genetic variation research, eugenics, genetic counseling, and the limits of human gene therapy. The course will be conducted as a seminar, involving discussions of readings, guest speakers, and student presentations.

GENE 367. Commercialization and Intellectual Property Management. 3 Units.
This interdisciplinary course covers a variety of topics, including principles of intellectual property and intellectual property management, business strategies and modeling relevant to the creation of start-up companies and exploitation of IP rights as they relate to biomedical-related inventions. The goal of this course is to address issues relating to the commercialization of biomedical-related inventions by exposing law students, MBA students, and Ph.D. candidates (in genetics and proteomics) to the challenges and opportunities encountered when attempting to develop biomedical intellectual property from the point of early discovery to the clinic and market. Specifically, this course seeks to provide students with the ability to value a given technological advance or invention holistically, focusing on issues that extend beyond scientific efficacy and include patient and practitioner value propositions, legal and intellectual property protection, business modeling, potential market impacts, market competition, and ethical, social, and healthcare practitioner acceptance. During this course, law students, MBA students, and Ph.D. candidates in genomics and proteomics will work in teams of five (two laws students, two MBA students and one Ph.D. candidate), focusing on issues of commercialization and IP management of biomedical-related inventions. The instructors will be drawn from the law school, business school, and technology-transfer office. Please visit the following website for more information: fusioninnovate.com. Offered as LAWS 5341, MGMT 467, GENE 367, GENE 467, EBME 467 and EEC 467.

GENE 467. Commercialization and Intellectual Property Management. 3 Units.
This interdisciplinary course covers a variety of topics, including principles of intellectual property and intellectual property management, business strategies and modeling relevant to the creation of start-up companies and exploitation of IP rights as they relate to biomedical-related inventions. The goal of this course is to address issues relating to the commercialization of biomedical-related inventions by exposing law students, MBA students, and Ph.D. candidates (in genetics and proteomics) to the challenges and opportunities encountered when attempting to develop biomedical intellectual property from the point of early discovery to the clinic and market. Specifically, this course seeks to provide students with the ability to value a given technological advance or invention holistically, focusing on issues that extend beyond scientific efficacy and include patient and practitioner value propositions, legal and intellectual property protection, business modeling, potential market impacts, market competition, and ethical, social, and healthcare practitioner acceptance. During this course, law students, MBA students, and Ph.D. candidates in genomics and proteomics will work in teams of five (two laws students, two MBA students and one Ph.D. candidate), focusing on issues of commercialization and IP management of biomedical-related inventions. The instructors will be drawn from the law school, business school, and technology-transfer office. Please visit the following website for more information: fusioninnovate.com. Offered as LAWS 5341, MGMT 467, GENE 367, GENE 467, EBME 467 and EEC 467.

GENE 488. Yeast Genetics and Cell Biology. 3 Units.
This seminar course provides an introduction to the genetics and molecular biology of the yeasts S. cerevisiae and S. pombe by a discussion of current literature focusing primarily on topics in yeast cell biology. Students are first introduced to the tools of molecular genetics and special features of yeasts that make them important model eukaryotic organisms. Some selected topics include cell polarity, cell cycle, secretory pathways, vesicular and nuclear/cytoplasmic transport, mitochondrial import and biogenesis, chromosome segregation, cytoskeleton, mating response and signal transduction. Offered as CLBY 488, GENE 488, MBIO 488, and PATH 488.

GENE 500. Advanced Eukaryotic Genetics I. 3 Units.
Fundamental principles of modern genetics; transmission, recombination, structure and function of the genetic material in eukaryotes, dosage compensation, behavior and consequences of chromosomal abnormalities, mapping and isolation of mutations, gene complementation and genetic interactions. Recommended preparation: BIOL 362.

GENE 503. Readings and Discussions in Genetics. 0 - 3 Units.
(Credit as arranged.) In-depth consideration of special selected topics through critical evaluation of classic and current literature.

GENE 504. Advanced Eukaryotic Genetics II. 3 Units.
Fundamental principles of modern genetics; population and quantitative genetics, dissection of genome organization and function, transgenic, developmental genetics, genetic strategies for dissecting complex pathways in organisms ranging from Drosophila and C. elegans to mouse and human. Recommended preparation: GENE 500 or permission of instructor.

GENE 505. Genetics Journal Club. 1 Unit.
Genetics Journal Club is a graduate level course designed to facilitate discussion of topics in Genetics. Students choose “hot” papers in Genetics and present them to their peers. Group presentations are designed to encourage audience participation. The intent of this class is to expose students to cutting edge topics in Genetics and to instill teaching and leadership skills.
GENE 511. Grant Writing and Reviewing Skills Workshop. 3 Units.
This is an introductory graduate course in grant writing and reviewing skills. During this course each student will write a research grant on a topic of his or her choice. Proposals may form the basis for the written component of the preliminary examination in the Genetics Department. Students will also participate in editing and reviewing the proposals of their classmates. Prereq: GENE 500 and GENE 504 or consent of instructor.

GENE 524. Advanced Medical Genetics: Molecular & Cytogenetics. 2 - 3 Units.
This course provides an in-depth forum for discussion of fundamental principles regarding clinical cytogenetics and molecular genetics and their relevance to medical genetics, genomics and genetic counseling. Following a historical overview, topics include a discussion of numerical and structural aberrations, sex chromosome abnormalities, issues regarding population cytogenetics, clinical relevance of such findings as marker chromosomes, mosaicism, contiguous gene deletions and uniparental disomy. The course will cover principles of molecular genetics including structure, function and regulations of genes (DNA, RNA, proteins), genetic variation, inheritance patterns and both cytogenetic and molecular laboratory techniques (fluorescence in situ hybridization, micro-array, SNP analyses, sequencing) in the clinical laboratory. Students who register for 3.00 credit hours are required to do an additional paper.

GENE 525. Advanced Medical Genetics: Clinical Genetics. 2 - 3 Units.
Fundamental principles regarding congenital malformations, dysmorphology and syndromes. Discussion of a number of genetic disorders from a systems approach: CNS malformations, neurodegenerative disorders, craniofacial disorders, skeletal dysplasias, connective tissue disorders, hereditary cancer syndromes, etc. Discussions also include diagnosis, etiology, genetics, prognosis and management.

GENE 526. Advanced Medical Genetics: Quantitative Genetics & Genomics. 2 - 3 Units.
The purpose of this course is twofold: first, to provide a foundation in quantitative genetics and second, to focus on genomic approaches and technologies which have greatly expanded our understanding of not only rare genetic disorders but common ones as well. We will cover concepts related to risk assessment and calculation and its application to medical genetics including principles and application of Hardy Weinberg equilibrium as well as applying Bayes’ Theorem as a mechanism to refine risk assessment based on data specific to a patient. We will also focus on understanding the clinical implications of the interpretation of next generation sequencing results, identify limitations of genomic technologies, and practice curation / annotation and interpretation of genomic testing results. In addition, we will discuss resources and bioinformatics tools including national databases and clinical labs to aid in the interpretation of genomic test results including variants of uncertain significance. Students who register for 3.00 credit hours are required to do an additional paper.

GENE 527. Advanced Medical Genetics: Biochemical Genetics. 2 - 3 Units.
Fundamental principles of metabolic testing; amino acid disorders; organic acid disorders; carbohydrate disorders; peroxosomal disorders; mitochondrial disorders; etc. Discussion of screening principles and newborn screening as well as approaches to diagnosis, management and therapy for metabolic diseases.

GENE 528. Principles and Practices of Genetic Counseling. 3 Units.
Fundamental principles needed for the practicing genetic counselor. Topics include skills in obtaining histories (prenatal, perinatal, medical, developmental, psychosocial and family); pedigree construction and analysis, physical growth and development; the genetic evaluation; the physical examination and laboratory analyses; prenatal issues, prenatal screening and diagnosis; and teratogenicity.

GENE 529. Psychosocial Issues in Genetic Counseling. 3 Units.
Fundamental principles regarding the psychosocial aspects of genetic disease and birth defects, its psychological and social impact on the individual and family. Topics include the genetic counseling interview process, issues regarding pregnancy and prenatal diagnosis, chronicity, death and loss. Cultural issues and their impact on the genetic counseling session are addressed. Resources for families are also explored. Basic interviewing skills are presented. Students will have an opportunity for practice of skills through role play and actual interviewing situations.

GENE 531. Cancer Genetics. 2 - 3 Units.
This seminar will discuss basic concepts in cancer epidemiology, principles of cancer genetics, inherited cancer syndromes, cytogenetics of cancers, pedigree analysis for familial cancer risk and approaches to the differential diagnosis of inherited and familial cancers. Additionally, topics of risk assessment, genetic testing, screening, management and psychosocial issues in providing genetic counseling to patients with familial and inherited cancers will be discussed.

GENE 532. Clinical Practicum in Genetic Counseling. 1 - 6 Units.
This clinical practicum provides the student an opportunity to function as a genetic counselor by preparing for cases; obtaining appropriate histories; determining risks; performing psychosocial assessments; discussing disease characteristics, inheritance, and natural history; providing anticipatory guidance and supportive counseling; using medical and community resources; and follow-up. Students rotate through four clinical areas and one laboratory and will register for a total of 12 hours over the course of the program. Recommended preparation: Admission to Genetic Counseling Training Program.

GENE 537. Microscopy-Principles and Applications. 3 Units.
This course provides an introduction to various types of light microscopy, digital and video imaging techniques, and their applications to biological and biomedical sciences via lectures and hands-on experience. Topics covered include geometrical and physical optics; brightfield, darkfield, phase contrast, DIC, fluorescence and confocal microscopes; and digital image processing. Offered as GENE 537, MBIO 537, and PHOL 537.

GENE 601. Research in Genetics. 1 - 9 Units.
(Credit as arranged.)

GENE 651. Thesis M.S.. 1 - 9 Units.
(Credit as arranged.) Master’s Thesis Plan A.

GENE 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Molecular Biology and Microbiology
Room W200, School of Medicine
https://case.edu/medicine/microbio/
Phone: 216.368.3420
Jonathan Karn, PhD, Reinberger Professor, Chair
jonathan.karn@case.edu
Brinn Omabegho (brinn.omabegho@case.edu), Manager
The Department of Molecular Biology and Microbiology provides a focus within the School of Medicine for the study of the growth and development of microorganisms at the molecular level and the host’s response to infection. The Department is home to three PhD programs: Cell Biology, Molecular Biology and Microbiology, and Molecular Virology.

Faculty have nationally-funded research programs. Many faculty serve on study sections of national agencies, publish in the most prestigious journals, serve as editors of journals, and take leadership positions throughout the Case Western Reserve University School of Medicine. The department also enjoys numerous collaborations with faculty in the Departments of Biochemistry, Neuroscience, Pathology, Nutrition, and Genetics and Genome Sciences, the Case Comprehensive Cancer Center, the Visual Sciences Research Center, the Center for AIDS Research, and the Center for RNA Science and Therapeutics, and the Department of Cell Biology at the Lerner Research Center at CCF, because of shared research interests. All these activities create a vibrant scientific environment.

Research areas include the study of normal cell functions, microbial systems, viruses, and infectious diseases. It is only by developing a thorough understanding of the fundamental biology of cells and pathogenic microbes, their host organisms, and how the two interact during infection that improved strategies for prevention and treatment of infectious diseases can be achieved.

**PhD in Cell Biology, Molecular Biology and Microbiology, Molecular Virology**

The Department of Molecular Biology and Microbiology is home to three PhD programs: Cell Biology, Molecular Biology and Microbiology, and Molecular Virology. Admissions for all three of these programs occur through the common PhD admissions program, the Biomedical Sciences Training Program (p. 39). In addition, students in the Medical Scientist Training Program (p. 28) (MSTP) can also pursue these three PhD programs.

**PhD Requirements**

Students entering through BSTP begin the first of three research rotations during the summer and participate in the Core Curriculum in Cell and Molecular Biology (C3MB), two integrated courses which provide formal instruction in modern cell and molecular biology. Some exceptional students with strong backgrounds, such as a previous Master's Degree, may be eligible to be exempted from part of the Core Curriculum, and instead enroll in one or more advanced courses during the fall semester. Some students may be eligible to apply for the transfer of credit from their previous institution (please visit here (http://gradstudies.case.edu) for more information). Transfer credit must be requested prior to beginning coursework at CWRU.

A student who chooses a thesis advisor from Cell Biology, Molecular Biology and Microbiology or Molecular Virology can become a member of one of these three PhD programs. To earn a PhD a student must complete 400-level graduate Core and Elective coursework including Responsible Conduct of Research and Research Rigor and Reproducibility as described in the course of study.

Students in each program are expected to attend the joint student seminars (MBIO 435 Seminar in Molecular Biology/Microbiology/MVIR 435 Seminar in Molecular Biology/Microbiology/CLBY 435 Seminar in Molecular Biology/Microbiology) for at least 3 semesters (3 credit hours). Continued participation in the seminars after completion of this requirement is encouraged. Up to 4 credit hours can be allocated to the seminar course (one credit per semester).

Molecular Biology and Microbiology/ Molecular Virology and Cell Biology students should take the MBIO 450 Cells and Pathogens/MVIR 450 Cells and Pathogens/CLBY 450 Cells and Pathogens.

In addition, Cell Biology Students must take both of the following fundamental coursework: CLBY 526 Cell Biology and Human Disease/MBIO 526 Cell Biology and Human Disease and CLBY 488 Yeast Genetics and Cell Biology. Molecular Virology Students must take MVIR 445 Molecular Biology and Pathogenesis of RNA and DNA Viruses.

Beyond that, any combination of graduate courses from within or outside the department can be used to fulfill the requirement as long as the planned program of study has the approval of the student's advisor and committee.

In addition, each PhD student must successfully complete a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. The qualifier is generally completed in the summer after year two. During the dissertation period, students are expected to meet twice a year with the thesis committee, present seminars in the department, and fulfill journal publication requirements. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program.

**Plan of Study**

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatetudies/academicrequirements).

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<th>First Year</th>
<th>Fall</th>
<th>Winter</th>
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Second Year

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<td>Year Total:</td>
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Total Units in Sequence: 23-59

Third Year: Either semester, complete elective coursework so that total graded courses = 24 credits; Research credits switch from 601 to 701 once passed into candidacy

Third Year + Full-time thesis research (701) - 18 total credit hours total

CLBY Courses

CLBY 416. Fundamental Immunology. 4 Units.
Introductory immunology providing an overview of the immune system, including activation, effector mechanisms, and regulation. Topics include antigen-antibody reactions, immunologically important cell surface receptors, cell-cell interactions, cell-mediated immunity, innate versus adaptive immunity, cytokines, and basic molecular biology and signal transduction in B and T lymphocytes, and immunopathology. Three weekly lectures emphasize experimental findings leading to the concepts of modern immunology. An additional recitation hour is required to integrate the core material with experimental data and known immune mediated diseases. Five mandatory 90 minute group problem sets per semester will be administered outside of lecture and recitation meeting times. Graduate students will be graded separately from undergraduates, and 22 percent of the grade will be based on a critical analysis of a recently published, landmark scientific article. Offered as BIOL 316, BIOL 416, CLBY 416, PATH 316 and PATH 416. Prereq: Graduate standing.

CLBY 417. Cytokines: Function, Structure, and Signaling. 3 Units.
Regulation of immune responses and differentiation of leukocytes is modulated by proteins (cytokines) secreted and/or expressed by both immune and non-immune cells. Course examines the function, expression, gene organization, structure, receptors, and intracellular signaling of cytokines. Topic include regulatory and inflammatory cytokines, colony stimulating factors, chemokines, cytokine and cytokine receptor gene families, intracellular signaling through STAT proteins and tyrosine phosphorylation, clinical potential, and genetic defects. Lecture format using texts, scientific reviews and research articles. Recommended preparation: PATH 416 or equivalent. Offered as BIOL 417, CLBY 417, and PATH 417.

CLBY 435. Seminar in Molecular Biology/Microbiology. 1 Unit.
Graduate students will attend the departmental seminar given by all graduate students in the Department of Molecular Biology and Microbiology, in the Molecular Virology Program, and in the Cell Biology Program, as well as give a seminar on their own thesis research. Students will be evaluated by the faculty member in charge of that student's seminar with input from the students' own thesis committee. After each seminar, the student presenter will meet with other graduate students for peer-review of the content, delivery, and style of the seminar. Peer reviewers will also be evaluated for the quality of their input. Offered as CLBY 435 and MBIO 435 and MVIR 435.

CLBY 450. Cells and Pathogens. 3 Units.
Modern molecular cell biology owes a great debt to viral and bacterial pathogens as model systems. In some instances pathogens operate by faithful mimicry of host proteins, and other cases represent the result of extensive molecular tinkering and convergent evolution. This course will also explore numerous mechanisms utilized by pathogens to subvert the host and enhance their own survival. Topics include nuclear regulatory mechanisms, protein synthesis and stability, membrane-bound organelles, endocytosis and phagocytosis, and factors that influence cell behavior such as cytoskeleton rearrangements, cell-cell interactions, and cell migration. Additional topics include cell signaling and co-evolution of pathogens and host cell functions. Students are expected to come to class prepared to discuss pre-assigned readings consisting of brief reviews and seminal papers from the literature. Student assessment will be based on effective class participation (approximately 80%) and successful presentation of an independent research topic (approximately 20%). Offered as CLBY 450, MBIO 450, and MVIR 450. Prereq: CBIO 453 and CBIO 455 or permission of instructor.

CLBY 466. Cell Signaling. 3 Units.
This is an advanced lecture/journal/discussion format course that covers cell signaling mechanisms. Included are discussions of neurotransmitter-gated ion channels, growth factor receptor kinases, cytokine receptors, G protein-coupled receptors, receptor tyrosine kinases, and cytokine and cytokine receptor gene families, intracellular signaling through STAT proteins, ras family GTPases, second messenger cascades, protein kinase cascades, second messenger regulation of transcription factors, microtubule-based motility, actin/myosin-based motility, signals for regulation of cell cycle, signals for regulation of apoptosis. Offered as CLBY 466, PHOL 466 and PHRM 466.
CLBY 488. Yeast Genetics and Cell Biology. 3 Units.
This seminar course provides an introduction to the genetics and molecular biology of the yeasts S. cerevisiae and S. pombe by a discussion of current literature focusing primarily on topics in yeast cell biology. Students are first introduced to the tools of molecular genetics and special features of yeasts that make them important model eukaryotic organisms. Some selected topics include cell polarity, cell cycle, secretory pathways, vesicular and nuclear/cyttoplasmic transport, mitochondrial import and biogenesis, chromosome segregation, cytoskeleton, mating response and signal transduction. Offered as CLBY 488, GENE 488, MBIO 488, and PATH 488.

CLBY 525. Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection. 3 Units.
This is a graduate-level seminar course that familiarizes students with common neurodegenerative conditions of the brain and the eye. The molecular basis of each disorder and associated ophthalmic pathology will be emphasized. Contribution of heavy metals in brain and ocular pathology will be discussed where appropriate. Specific examples include Alzheimer’s Disease, Parkinson’s Disease, prion disorders, Huntington’s Disease, age-related macular degeneration, glaucoma, and others based on popular demand. The students will be expected to discuss relevant research publications in class in an interactive format. Grading will be based on class participation and completion of an R21 grant proposal. Concurrent enrollment in PATH 526 on grant writing skills is strongly recommended but not required. Offered as PATH 525 and CLBY 525.

CLBY 526. Cell Biology and Human Disease. 3 Units.
This course is designed to provide broad base of knowledge regarding cell structure and function. The basic structure of the cell will be discussed, as will the various functional systems that are superimposed upon and interact with this structure. The course will discuss organelle biogenesis, materials movement inside cells, cell interaction with the external environment, cell cycle and cell death regulation, cytoskeleton dynamics, quality control mechanisms, and basic signal transduction concepts. The course will also discuss how abnormal cell function may lead to human disease, and how basic cell function may be harnessed by intracellular pathogens to provide favorable intracellular environments for replication. The major goals of this course are to provide students with a working knowledge of the cell to facilitate understanding of the scientific literature, and to familiarize students with modern experimental approaches in cell biology. The course will rely heavily on student participation. Students will be provided with study guides with the expectation they will come to class prepared to lead interactive group discussions with minimal input from instructors. Offered as CLBY 526, MBIO 526 and MVIR 526.

CLBY 601. Special Problems. 1 - 18 Units.
This is the listing for independent research. Students should enroll in this course once they have selected their laboratory for Ph.D. research. The number of credit hours depends on how many didactic courses they are following at the same time. Once they have passed their qualifying examination they should register for CLBY 701.

CLBY 701. Dissertation Ph.D.. 1 - 9 Units.
This is the listing for independent research toward the Ph.D. The number of credit hours depends on how many didactic courses students are following at the same time. Students may register for this course only once they have passed their qualifying examination. Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

MBIO Courses

MBIO 399. Undergraduate Research. 1 - 3 Units.
Permits qualified undergraduates to work in a faculty member’s laboratory.

MBIO 420. Current Topics in Cancer. 3 Units.
The concept of cancer hallmarks has provided a useful guiding principle in our understanding of the complexity of cancer. The hallmarks include sustaining proliferative signaling, evading growth suppressors, enabling replicative immortality, activating invasion and metastasis, inducing angiogenesis, resisting cell death, deregulating cellular energetics, avoiding immune destruction, tumor-promoting inflammation, and genome instability and mutation. The objectives of this course are to (1) examine the principles of some of these hallmarks, and (2) explore potential therapies developed based on these hallmarks of cancer. This is a student-driven and discussion-based graduate course. Students should have had some background on the related subjects and have read scientific papers in their prior coursework. Students will be called on to present and discuss experimental design, data and conclusions from assigned publications. There will be no exams or comprehensive papers but students will submit a one-page critique (strengths and weaknesses) of one of the assigned papers prior to each class meeting. The course will end with a full-day student-run symposium on topics to be decided jointly by students and the course director. Grades will be based on class participation, written critiques, and symposium presentations. Offered as BIOC 420, MBIO 420, PATH 422, and PHRM 420. Prereq: CBIO 453 and CBIO 455.

MBIO 435. Seminar in Molecular Biology/Microbiology. 1 Unit.
Graduate students will attend the departmental seminar given by all graduate students in the Department of Molecular Biology and Microbiology, in the Molecular Virology Program, and in the Cell Biology Program, as well as give a seminar on their own thesis research. Students will be evaluated by the faculty member in charge of that student's seminar with input from the students' own thesis committee. After each seminar, the student presenter will meet with other graduate students for peer-review of the content, delivery, and style of the seminar. Peer reviewers will also be evaluated for the quality of their input. Offered as CLBY 435 and MBIO 435 and MVIR 435. Prereq: CBIO 453 and CBIO 455.

MBIO 445. Molecular Biology and Pathogenesis of RNA and DNA Viruses. 3 Units.
Through a combination of lectures by Case faculty and guest lecturers, along with student discussion of current literature, this course emphasizes mechanisms of viral gene expression and pathogenesis. RNA viruses to be discussed include positive, negative, and retroviruses. DNA viruses include SV40, adenovirus, herpes, papilloma, and others. Important aspects of host defense mechanisms, antiviral agents, and viral vectors will also be covered. Students will be evaluated based on their quality of presentation of course papers assigned to them and their overall participation in class discussions. Offered as MBIO 445 and MVIR 445.
MBIO 450. Cells and Pathogens. 3 Units.
Modern molecular cell biology owes a great debt to viral and bacterial pathogens as model systems. In some instances pathogens operate by faithful mimicry of host proteins, and other cases represent the result of extensive molecular tinkering and convergent evolution. This course will also explore numerous mechanisms utilized by pathogens to subvert the host and enhance their own survival. Topics covered include nuclear regulatory mechanisms, protein synthesis and stability, membrane-bound organelles, endocytosis and phagocytosis, and factors that influence cell behavior such as cytoskeleton rearrangements, cell-cell interactions, and cell migration. Additional topics include cell signaling and co-evolution of pathogens and host cell functions. Students are expected to come to class prepared to discuss pre-assigned readings consisting of brief reviews and seminal papers from the literature. Student assessment will be based on effective class participation (approximately 80%) and successful presentation of an independent research topic (approximately 20%). Offered as CLBY 450, MBIO 450, and MVIR 450. Prereq: CBIO 453 and CBIO 455 or permission of instructor.

MBIO 488. Yeast Genetics and Cell Biology. 3 Units.
This seminar course provides an introduction to the genetics and molecular biology of the yeasts S. cerevisiae and S. pombe by a discussion of current literature focusing primarily on topics in yeast cell biology. Students are first introduced to the tools of molecular genetics and special features of yeasts that make them important model eukaryotic organisms. Some selected topics include cell polarity, cell cycle, secretory pathways, vesicular and nuclear/cytoplasmic transport, mitochondrial import and biogenesis, chromosome segregation, cytoskeleton, mating response and signal transduction. Offered as CLBY 488, GENE 488, MBIO 488, and PATH 488.

MBIO 513. Bacterial Virulence and Host Interactions. 3 Units.
The goal of this seminar course is to familiarize students with bacterial virulence mechanisms and how they interact with the host. The focus will be on current literature pertaining to this field. While the molecular basis of bacterial virulence mechanisms will be the main focus, some time will be spent on the host immune response. Topics covered will include adhesins/pili, secretion mechanisms, AB toxins, bacterial invasion and intracellular survival, regulation of virulence gene expression. Prereq: CBIO 453 and CBIO 455 or equivalent courses.

MBIO 526. Cell Biology and Human Disease. 3 Units.
This course is designed to provide broad base of knowledge regarding cell structure and function. The basic structure of the cell will be discussed, as will the various functional systems that are superimposed upon and interact with this structure. The course will discuss organelle biogenesis, materials movement inside cells, cell interaction with the external environment, cell cycle and cell death regulation, cytoskeleton dynamics, quality control mechanisms, and basic signal transduction concepts. The course will also discuss how abnormal cell function may lead to human disease, and how basic cell function may be harnessed by intracellular pathogens to provide favorable intracellular environments for replication. The major goals of this course are to provide students with a working knowledge of the cell to facilitate understanding of the scientific literature, and to familiarize students with modern experimental approaches in cell biology. The course will rely heavily on student participation. Students will be provided with study guides with the expectation they will come to class prepared to lead interactive group discussions with minimal input from instructors. Offered as CLBY 526, MBIO 526 and MVIR 526.

MBIO 537. Microscopy-Principles and Applications. 3 Units.
This course provides an introduction to various types of light microscopy, digital and video imaging techniques, and their applications to biological and biomedical sciences via lectures and hands-on experience. Topics covered include geometrical and physical optics; brightfield, darkfield, phase contrast, DIC, fluorescence and confocal microscopes; and digital image processing. Offered as GENE 537, MBIO 537, and PHOL 537.

MBIO 601. Research in Molecular Biology and Microbiology. 1 - 18 Units.
(MBIO 601. Research in Molecular Biology and Microbiology. 1 - 18 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

MVIR Courses
MVIR 435. Seminar in Molecular Biology/Microbiology. 1 Unit.
Graduate students will attend the departmental seminar given by all graduate students in the Department of Molecular Biology and Microbiology, in the Molecular Virology Program, and in the Cell Biology Program, as well as give a seminar on their own thesis research. Students will be evaluated based on their quality of presentation of course papers assigned to them and their overall participation in class discussions. Offered as CLBY 435 and MBIO 435 and MVIR 435.

MVIR 445. Molecular Biology and Pathogenesis of RNA and DNA Viruses. 3 Units.
Through a combination of lectures by Case faculty and guest lecturers, along with student discussion of current literature, this course emphasizes mechanisms of viral gene expression and pathogenesis. RNA viruses to be discussed include positive, negative, and retroviruses. DNA viruses include SV40, adenovirus, herpes, papilloma, and others. Important aspects of host defense mechanisms, antiviral agents, and viral vectors will also be covered. Students will be evaluated based on their quality of presentation of course papers assigned to them and their overall participation in class discussions. Offered as MBIO 445 and MVIR 445. Prereq: CBIO 453 and CBIO 455.

MVIR 450. Cells and Pathogens. 3 Units.
Modern molecular cell biology owes a great debt to viral and bacterial pathogens as model systems. In some instances pathogens operate by faithful mimicry of host proteins, and other cases represent the result of extensive molecular tinkering and convergent evolution. This course will also explore numerous mechanisms utilized by pathogens to subvert the host and enhance their own survival. Topics covered include nuclear regulatory mechanisms, protein synthesis and stability, membrane-bound organelles, endocytosis and phagocytosis, and factors that influence cell behavior such as cytoskeleton rearrangements, cell-cell interactions, and cell migration. Additional topics include cell signaling and co-evolution of pathogens and host cell functions. Students are expected to come to class prepared to discuss pre-assigned readings consisting of brief reviews and seminal papers from the literature. Student assessment will be based on effective class participation (approximately 80%) and successful presentation of an independent research topic (approximately 20%). Offered as CLBY 450, MBIO 450, and MVIR 450. Prereq: CBIO 453 and CBIO 455 or permission of instructor.
MVIR 526. Cell Biology and Human Disease. 3 Units.
This course is designed to provide broad base of knowledge regarding cell structure and function. The basic structure of the cell will be discussed, as will the various functional systems that are superimposed upon and interact with this structure. The course will discuss organelle biogenesis, materials movement inside cells, cell interaction with the external environment, cell cycle and cell death regulation, cytoskeleton dynamics, quality control mechanisms, and basic signal transduction concepts. The course will also discuss how abnormal cell function may lead to human disease, and how basic cell function may be harnessed by intracellular pathogens to provide favorable intracellular environments for replication. The major goals of this course are to provide students with a working knowledge of the cell to facilitate understanding of the scientific literature, and to familiarize students with modern experimental approaches in cell biology. The course will rely heavily on student participation. Students will be provided with study guides with the expectation they will come to class prepared to lead interactive group discussions with minimal input from instructors. Offered as CLBY 526, MBIO 526 and MVIR 526.

MVIR 601. Research. 1 - 18 Units.
Grade of S/U only.

MVIR 701. Dissertation Ph.D.. 1 - 9 Units.
Grade of S/U only. Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Molecular Medicine Program
Lerner Research Institute, ND-46
http://www.lerner.ccf.org/molecmed/phd/
Phone: 216.445.9417
Jonathan Smith, PhD, Program Director

The Molecular Medicine PhD Program is a unique collaborative graduate training opportunity that integrates medical knowledge into graduate training. The goal of this program is to produce scientists trained in translational research: basic or applied research relevant to human health and disease that can lead to new understanding of disease, clinical and diagnostic tools, medications, and therapies.

Students train rigorously to apply basic science discoveries to human health and to the causes and treatments of human disease. The mastery of competencies necessary to translate scientific observations from the research bench to clinical care is the focus of this PhD program. Graduates will be well prepared to collaborate with physicians and for the challenge of using molecular and cellular biology to advance human health.

PhD in Molecular Medicine
Admission into the Molecular Medicine PhD program is obtained through application directly to the program. Graduate students complete didactic coursework, independent research, and other doctoral requirements to earn the PhD. First-year students complete two to four laboratory rotations among the laboratories of training faculty and are exposed to trainer research projects during the Frontiers of Molecular Medicine seminars. The first year begins mid-July. Students from all years present their research and received feedback in the Student Seminar Series.

During subsequent years, students will devote the majority of their time to thesis research while attending advanced graduate courses, and seminars. Advanced elective courses may be chosen from any department or program on campus with the approval of the graduate program director and the student’s thesis committee over the first two years. Students must take a total of 36 semester hours of courses and pre-candidacy thesis research, including 24 graded credit hours, and maintain a B average.

The qualifying exam will be comprised of preparing and defending a grant application in the NIH format. The topic of the grant is the area of the student's thesis research. At least one aim of this proposal will consist of a specific translational or clinical aim.

All efforts should be made to complete the PhD within five years from the date of matriculation. All students are expected to submit two or more first-authored primary research publications in peer-reviewed scientific journals. At least one manuscript must be accepted for publication prior to the thesis defense.

PRISM Program (Physicians Researchers Innovating in Science and Medicine)
NIH recognizes the need for physician on-ramps into research training, including the option for obtaining a PhD during residency / fellowship. The Molecular Medicine PhD Program offers a track for Cleveland Clinic physician trainees in GME accredited programs, who wish to pursue a PhD in laboratory-based research in the Molecular Medicine PhD Program, a program completely housed and administered at the Cleveland Clinic. If you are a Cleveland Clinic physician trainee and have questions about this opportunity, please email molmedphd@ccf.org.

PhD Program Requirements

Coursework
Students begin in July by taking MMED 402 Tools for Research and MMED 410 Introduction to Human Physiology and Disease. The student will follow a progressive curriculum including Cell Biology; Metabolism and Pharmacology; Nucleic Acids, Gene Expression and Gene Regulation; Mammalian Genetics; and Infection and Immunity. In the second summer, students take Principles of Clinical and Translational Research. During year 2, students are required to take MMED 521 Molecular aspects of the diagnosis, pathology, and treatment of selected human diseases, focusing on molecular mechanisms of human disease, and an independent study mentored MMED 612 Clinical Experience.

Research Rotations
The research rotations allow the student to sample areas of research and become familiar with faculty members and their laboratories. The main purpose of these rotations is to aid the student in selecting a laboratory for the thesis work. Students will begin their rotations in July. At least two rotations are highly recommended prior to choosing the thesis advisor.

Choosing a Thesis Advisor
During or after the second semester of the first year, students select an advisor for their dissertation research. The emphasis of the PhD work is on research, culminating in the completion of an original, independent research thesis.

Plan of Study
Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements).

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<td>Research Rotations (MMED 400)</td>
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<td>Host Defense: Infection and Immunity (MMED 416)</td>
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<td>Student Seminar Series (MMED 504)</td>
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**Year Total:** 9

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<tr>
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<td>Dissertation Ph.D. (MMED 701)</td>
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<tr>
<td>Advanced Electives (if necessary)**</td>
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**Year Total:** 1-9

**Total Units in Sequence:** 38-54

* Starts in July  
** Credits vary  
+ Credits may vary to yield 9 credits per semester

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**Courses**

**MMED 400. Research Rotations. 0 Unit.**
Research rotations are conducted to expose the student to several laboratory environments, a variety of research problems and numerous laboratory techniques as well as to assist them in the selection of their Research Advisor. Rotations will begin immediately upon enrollment and continue through the second semester of the first year. Usually rotations will last 12 weeks, however if a student decides that he/she is not interested in the assigned laboratory a shorter rotation is appropriate. The student is responsible for arranging each rotation with an approved trainer with the consultation of the Graduate Program Director. To assist in this endeavor, the Graduate Program Director will provide a list of approved trainers who have space, time and money to support a graduate student. During the rotation, students are expected to participate in all lab and departmental activities, e.g., lab meetings and seminars. At the completion of a rotation the student is required to submit a written Rotation Report including an outline of the problem being studied, a description of the experimental approaches, a discussion of the results of performed experiments as well as future directions.

**MMED 402. Tools for Research. 2 Units.**
The goal of this course is to provide a thorough and comprehensive review of current laboratory technology essential to research in molecular medicine, focusing on basic underlying principles, important controls and caveats. The students will clone a cytokine during a laboratory component of the course, which will involve designing appropriate primers, obtaining RNA from cytokine-expressing cells, performing RT/PCR, and ligating isolated, characterized fragments into cloning- and expression vectors, followed by transfection into mammalian cells. Additional bench work will include characterizing the cloned product using real time PCR, ELISA, western blot analysis, and immunohistochemistry. Seminars on commonly used molecular techniques will be given intermittently by guest lecturers with the relevant expertise. Evaluation will be based on the student's lab techniques, class participation, and contribution to the group learning process.

**MMED 404. Journal Club / Frontiers in Molecular Medicine. 1 Unit.**
This course is a combination of a weekly discussion-based Journal Club with selected articles relevant to the core curriculum of the week and the Frontiers in Molecular Medicine Seminar series. The seminars are presented by Molecular Medicine faculty and guest lecturers to introduce first year students to the opportunities and issues in translational and clinical research.

**MMED 410. Introduction to Human Physiology and Disease. 4 Units.**
The purpose of this course is to give an introduction to the physiology of the major human organ systems, as well as selected associated pathophysiologies. The course will provide a physiological basis for subsequent study and research in Molecular Medicine. The integration of clinical faculty into the course will emphasize the importance of bringing scientific knowledge to bear on clinical problems, a theme which will be stressed throughout the Molecular Medicine curriculum. The course will also acquaint students with medical terminology.

**MMED 412. Metabolism and Introduction to Principles of Pharmacology. 2 Units.**
The course will include a combination of interactive lectures, research presentations, related journal club article, and group projects with presentations. Topics to be covered include: bioenergetics/oxidative phosphorylation, carbohydrate metabolism; lipid and lipoprotein metabolism, amino acid and nucleotide metabolism; integrative regulation of metabolism; and principals of pharmacology.
MMED 413. Nucleic Acids, Gene Expression, and Gene Regulation. 2 Units.
The course will include a combination of interactive lectures and problem-based learning. Each week will conclude with at least one clinical correlation where the weekly topic is presented in the context of a clinical problem. Topics to be covered include: DNA structure, chromosome structure, replication and repair; RNA synthesis and RNA processing, the organization of eukaryotic genes and the genetic code and translation; and gene regulation.

MMED 414. Mammalian Genetics. 2 Units.
The course focuses on genetics, genomics, and bioinformatics, and it will include a combination of interactive lectures, problem-based learning and a week-long group project. Topics to be covered include: genetic variation, linkage studies; association studies; complex traits, linkage disequilibrium, the Hap Map, pharmacogenetics; genome-wide expression studies, and mouse models of human disease, and bioinformatics.

MMED 415. Cell Biology. 2 Units.
The course will include a combination of interactive lectures and problem-based learning. Each week will conclude with at least one clinical correlation where the weekly topic is presented in the context of a clinical problem. Topics to be covered include: cell structure and organelles, prokaryotes/eukaryotes; intracellular compartments and protein sorting; receptors/endocytosis/rafts; the nucleus; cell communication; and mechanics of cell division.

MMED 416. Host Defense: Infection and Immunity. 2 Units.
The course will include a reading program, lectures, and weekly problem-based student-led presentations. Weeks 1 and 2 are dedicated to establishing the scope of the field and forming vocabulary. Week 3 and part of Week 4 will cover immune mechanisms. The remainder of the course will deal with clinical aspects of immunobiology. On a regular basis Clinical Correlations, relevant to weekly topics, are integrated into the material. Topics to be covered include: biology and molecular biology of infectious agents; fundamentals of immunology; innate and adaptive responses to infection, immune effector mechanisms; and clinical aspects of immunobiology.

MMED 501. Principles of Clinical and Translational Research. 4 Units.
To give an introduction to the ethical, statistical, methodologic and informatics basis of clinical and translational research. Topics will include the history of clinical and translational research, regulatory aspects of human subjects research, clinical trials study design, conflicts of interest, human subjects recruitment, research and publication ethics, technology transfer, biobank construction and utilization, and clinical and research database construction and utilization. In addition, students will be introduced to principles of biostatistics and clinical epidemiology relevant to clinical and translational research and gain expertise in statistical tool using problem based learning sets.

MMED 504. Student Seminar Series. 1 Unit.
This course is designed as a weekly seminar series that will include presentations by the MMED graduate students. The format will be as follows: seminar talks by students in years 3 and beyond to provide a research update presentations by second year students involving basic science-clinical case translation topics, and short presentations on lab rotation accomplishments by first year students. The primary goals of this series are to gain experience and improve oral presentation skills, to share results and thoughts with peers during research discussions, and to learn to take the lead in developing and asking questions during seminars.

MMED 521. Molecular aspects of the diagnosis, pathology, and treatment of selected human diseases. 3 Units.
The goal of this course is to integrate medical knowledge into PhD training. This team-taught seminar course focuses on a top down examination of selected human diseases starting with clinical presentations of the manifestations, diagnoses, and treatment of disease. This is followed by study of the pathology, cell biology, and molecular biology of the disease. This information forms the foundation of a final discussion of current treatment strategies and ongoing research to identify new strategies. Three to four separate disease areas will be discussed during each semester, such as diabetes, cancer, and cardiovascular diseases. The specific areas of discussion are selected to demonstrate the strength of an integrated team of clinical and basic scientists; and to provide a model for students to follow in future studies in their own area of expertise. Emphasis will be given to the basic scientific observations that formed the basis of successful clinical practice, and how this was utilized by integrated teams of basic and clinical investigators to provide better patient care. Students will prepare for discussions with close reading of the literature. Faculty will present an overview in a discussion format. It is anticipated that each disease area will be presented by an integrated team of clinical and basic scientists. The final weeks of the semester will be devoted to student preparation of a research proposal based upon the information discussed during the course. The specific topic of this proposal will be of the students choosing. Grading will be based both upon preparation for and participation in discussions, and upon the research proposal. Recommended Preparation: Introductory Graduate or Medical School courses in Cell Biology, Molecular Biology, and Physiology

MMED 522. Grant Proposal Writing. 2 Units.
The goal of this course is to learn about the NIH institutes and grant proposal review and administration, how to compose the various sections of an NIH style grant proposal, and to gain practice in grant proposal writing skills. The course includes weekly writing assignments covering the different sections of an NIH style grant proposal. Upon completion of the grant proposal, students engage in a mock study section to review each other’s proposals. Grading will be based on grant writing assignments and participation in the mock study section.

MMED 560. Dissertation Research. 1 - 9 Units.
Research leading toward the Ph.D. dissertation in Molecular Medicine.

MMED 612. Clinical Experience. 2 Units.
Each student will be assigned a Clinical Mentor who will co-advice the student and serve on both the Qualifying Examination Committee and Thesis Committee. The Clinical Mentor will develop an individualized curriculum for the student in consultation with the Thesis Research Mentor and Program Director. The curriculum will be organized around the integrated, multidisciplinary disease groups at the Clinic. The students will attend and actively participate in the regularly scheduled multidisciplinary clinical conference organized by their disease group (most meet for one hour every week or every other week), usually involving a combination of case presentations and research presentations. At the conclusion of the semester the student will make a presentation to the group focused on a relevant translational research problem. The Clinical Mentor will also organize a series of supervised clinical experiences (with a Mentor) to various locations where students will observe clinician interactions with patients to better understand the disease from the patient perspective and to disease-related diagnostic and research laboratories.
**MMED 701. Dissertation Ph.D.. 1 - 9 Units.**  
Research leading toward the Ph.D. dissertation in Molecular Medicine. Recommended preparation: Advancement to candidacy in MMED. Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

**Department of Neurosciences**

Room E-653, School of Medicine, Robbins Building  
http://case.edu/medicine/neurosciences/  
Phone: 216.368.6252; Fax: 216.368.4650  
Lin Mei, MD, PhD, Chair  
lin.mei@case.edu

Katie Wervey (kathleen.wervey@case.edu), Department Assistant

Understanding how the nervous system develops and functions to process information and mediate behavior and how it is altered by disease, injury and the environment is one of the most exciting frontiers remaining in biological science. Neuroscience is inherently multidisciplinary and integrative and solving the major outstanding problems will require knowledge of molecular, cellular, systems, and behavioral levels of organization. It also requires a multidisciplinary approach combining the tools of electrophysiology, anatomy, biochemistry and molecular biology in studies of animals, brain slices, and tissue culture models.

The department offers a PhD program that provides interdisciplinary training in modern neurosciences through a combination of course work, seminars, and research experience. Medical students are encouraged to pursue research projects with neurosciences faculty. Neuroscientists at CWRU are using state-of-the-art techniques and instrumentation to study diverse aspects of nervous system function, including neural circuitry and plasticity, development and regeneration, and cellular and molecular neurobiology. Techniques used include electrical recording and imaging to study the behavior of neurons from ion channels to how they function in awake, behaving animals; molecular genetic approaches to discover the roles of specific genes in circuit formation, synaptic function, and in neurological disorders; and anatomical, biochemical, computational, and behavioral methods to understand the normal nervous system and how it is affected by disease and injury.

**PhD in Neurosciences**

The Neurosciences graduate program has a strong emphasis on cellular and molecular mechanisms that mediate the function and development of the nervous system. Admissions to the Neurosciences PhD program may be obtained through the integrated Biomedical Sciences Training Program or via the Medical Scientist Training Program. To earn a PhD in Neurosciences, a student must complete rotations in at least three laboratories, followed by selection of a research advisor, and complete Core and Elective coursework including responsible conduct of research as described in the plan of study, below. In general, students must be registered for a total of 9 credit hours each fall and spring semester until they advance to candidacy, at the end of their 2nd year. Students who previously completed relevant coursework, for example, with a Master's of Science, may petition to complete alternative courses. Each graduate program follows the overall regulations established and described in CWRU Graduate Studies and documented to the Regents of the State of Ohio.

In addition, each student must successfully complete a preliminary exam after year one, and a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. The qualifier is generally completed in the summer after year two. During the dissertation period, students are expected to meet at least once a year with their thesis committee, present seminars in the department, and fulfill journal publication requirements. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program. Completion of the PhD degree will require 36 hours of coursework (24 hours of which are graded) and 18 hours of NEUR 701 Dissertation Ph.D.

**Plan of Study**

§ Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

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<th>First Year</th>
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<tr>
<td>Cell Biology I (IBMS 453)</td>
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<td>Research in Neuroscience (NEUR 601) or Research Rotation in Biomedical Sciences Training Program (BSTP 400) or Research Rotation in Medical Scientist Training Program (MSTP 400)</td>
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<td>Fundamental Biostatistics to Enhance Research Rigor &amp; Reproducibility (IBMS 450)</td>
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<td>Research in Neuroscience (NEUR 601)</td>
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<td>Principles of Neural Science (NEUR 402)</td>
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<td>Form Thesis Committee</td>
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**IBMS Courses**

**IBMS 450. Fundamental Biostatistics to Enhance Research Rigor & Reproducibility. 1 Unit.**

This is a required graduate level course for all first year PhD students in the School of Medicine biomedical PhD programs excluding Biomedical Engineering, Population and Quantitative Health Sciences, Molecular Medicine and Clinical Translation Science. This course focuses on providing students with a basic working knowledge and understanding of best practices in biostatistics that can be applied to common biomedical research activities in numerous fields. Weekly sessions involve a combination of basic programming activities, lectures, exercises, hands-on data manipulation and presentation. Topics include experimental design and power analysis, hypothesis testing, descriptive statistics, linear regression, and others with an emphasis on when and in which experimental design a particular test is properly used. The overall goal of the course is to empower students to use these biostatistics to enhance the rigor of their experimental design and reproducibility of their primary data. The major focus is not on theory, but on a practical acquisition of a working knowledge of basic data processing analysis, interpretation, and presentation skills.

**IBMS 453. Cell Biology I. 3 Units.**

Part of the first semester curriculum for first year graduate students along with IBMS 455. This course is designed to give students an intensive introduction to prokaryotic and eukaryotic cell structure and function. Topics include membrane structure and function, mechanisms of protein localization in cells, secretion and endocytosis, the cytoskeleton, cell adhesion, cell signaling and the regulation of cell growth. Important methods in cell biology are also presented. This course is suitable for graduate students entering most areas of basic biomedical research. Undergraduate courses in biochemistry, cell and molecular biology are excellent preparation for this course. Recommended preparation: Undergraduate biochemistry or molecular biology.

**IBMS 455. Molecular Biology I. 3 Units.**

Part of the first semester curriculum for first year graduate students along with IBMS 453. This course is designed to give students an intensive introduction to prokaryotic and eukaryotic molecular biology. Topics include protein structure and function, DNA and chromosome structure, DNA replication, RNA transcription and its regulation, RNA processing, and protein synthesis. Important methods in molecular biology are also presented. This course is suitable for graduate students entering most areas of basic biomedical research. Undergraduate courses in biochemistry, cell and molecular biology are excellent preparation for this course. Recommended preparation: Undergraduate biochemistry or molecular biology.

**IBMS 456A. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A. 1 Unit.**

This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456A section will cover Nobel Prizes related to the areas of Genetics & Genome Science, Systems Biology & Bioinformatics, and RNA Biology. These include: 1) 2012 Prize, J. Gurdon and S. Yamanaka: Mechanisms of pluripotent stem cell development and reprogramming; 2) 2010 Prize, R. Edwards: Development of in vitro fertilization; 3) 2009 Prize, E. Blackburn, C. Greider, and J Szostack: Mechanisms of chromosome protection by telomeres and telomerase; 4) 2009 Prize, Y. Ramakrishnan, T. Steitz, and A. Yonath: Structure/function analysis of ribosomes; 5) 2007 Prize, M. Capecechi, M. Evans, and O. Smithies: Discovery/development of transgenic and gene-deletion methods in mice; 6) 2006 Prize, A. Fire and C. Mello: Discovery/development of RNA interference-gene silencing methods; 7) 2006 Prize, R. Kornberg: Mechanisms of eukaryotic transcription; 8) 1995 Prize, E. Lewis, C. Nusslein-Volhard, and W. Wieschaus: Mechanisms of genetic control in early embryonic development.
IBMS 456B. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section B. 1 Unit.

This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456B section will cover Nobel Prizes related to the areas of Molecular Biology & Microbiology, Molecular Virology, Pathology-Immunology, and Cell Biology. These include: 1) 2016 Prize, Y. Ohsumi: Mechanisms of Autophagy; 2) 2015 Prize, W. Campbell, S. Omura, and Y. Tu: Therapies against roundworms & malaria; 3) 2011 Prize, B. Beutler, J. Hoffman, and R. Steinman: Mechanisms underlying innate immunity and adaptive immunity; 4) 2008 Prize, H. zur Hausen, F. Barre-Sinoussi, and L. Montagnier: Discovery of human immunodeficiency virus and oncogenic papilloma viruses; 5) 2008 Prize, O. Shimomura, M. Chalfie, and R. Tsien: Discovery/development of green fluorescent protein for biological applications; 6) 2005 Prize, B. Marshall and J. Warren: Discovery of Helicobacter pyloris as pathogenic mechanism in peptic ulcers/gastritis; 7) 1999 Prize, G. Blobel: Mechanisms of protein sorting and subcellular trafficking; 8) 1996 Prize, P. Doherty and R. Zinkernagel: Mechanisms of cell-mediated immune defense.

IBMS 456C. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section C. 1 Unit.

This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456B section will cover Nobel Prizes related to the areas of Biochemistry, Nutrition, Pharmacology, and Pathology-Cancer. These include: 1) 2015 Prize, T. Lindahl, P. Modrich, and A. Sancar: Mechanisms of DNA Repair; 2) 2014 Prize, E. Betzig, S. Hell, W. Moerner: Development of super-resolution fluorescence microscopy; 3) 2012 Prize, R. Lefkowitz and B. Koblika: Structure/function analysis of G protein-coupled receptors; 4) 2004 Prize, A. Ciechanover, A. Hershko, and I. Rose: Mechanisms of ubiquitin-mediated protein degradation; 5) 2003 Prize, P. Lauterbur and P. Mansfield: Development of magnetic resonance imaging (MRI) methods; 6) 2002 Prize, S. Brenner, H.R. Horvitz, and J. Sulston: Mechanisms for genetic regulation of organ development and programmed cell death; 7) 2002 Prize, J. Fenn, K. Tanaka, and K. Wuthrich: Development of mass spec and NMR methods for biological macromolecules; 8) 2001 Prize, L. Hartwell, T. Hunt, and P. Nurse: Mechanisms of cell cycle regulation.

IBMS 456D. Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section D. 1 Unit.

This course is one of four sections that will cover major advances in biomedical research by review of Nobel Prize-winning topics from the past 21 years. Each section will cover 8 Nobel prize topics (1 topic/2 hour session/week for 8 weeks). Students will read critical research papers of the Nobel prize scientist(s) in preparation for guided in-class discussion led by the faculty mentor. The IBMS 456D section will cover Nobel Prizes related to the areas of Neuroscience, Physiology & Biophysics, and Pathology-Molecular Basis of Disease. These include: 1) 2014 Prize, J. O'Keefe, M-B. Moser, and E. Moser: Mechanisms of nerve cell spatial positioning in the brain; 2) 2013 Prize, J. Rothman, R. Scheckman, and T. Sudhof: Mechanisms of intracellular vesicle trafficking and biomolecule secretion; 3) 2004 Prize, R. Axel and L. Buck: Structure/function of odorant receptors and organization of olfactory system; 4) 2003 Prize: P. Agre and R. MacKinnon: Structure/function analysis of channel proteins in cell membranes; 5) 2000 Prize, A. Carlsson, P. Greengard, and E. Kandel: Mechanisms of signal transduction in the nervous system; 6) 1998 Prize, R. Furchgott, L. Ignarro, and F. Murad: Discovery/mechanisms of nitric oxide as signaling molecule in cardiovascular system; 7) 1997 Prize, S. Prusiner: Discovery/prions as new biological principle of infection in neurological disease; 8) 1997 Prize, P. Boyer, J. Walker, and J. Skou: Mechanisms of mitochondrial ATP synthesis and Na, K-ATPase pump function.

IBMS 500. On Being a Professional Scientist: The Responsible Conduct of Research. 1 Unit.

The goal of this course is to provide graduate students with an opportunity to think through their professional ethical commitments before they are tested, on the basis of the scientific community's accumulated experience with the issues. Students will be brought up to date on the current state of professional policy and federal regulation in this area, and, through case studies, will discuss practical strategies for preventing and resolving ethical problems in their own work. The course is designed to meet the requirements for "instruction about responsible conduct in research" for BSTP and MSTP students supported through NIH/ADAMHA institutional training grant programs at Case. Attendance is required.

NEUR Courses

NEUR 166. Explorations in Neuroscience. 1 Unit.

This survey course provides students with an opportunity to learn about some of the most exciting and timely concepts in neuroscience, including topics in basic and translational research, as well as perspectives on neuroscience as a profession, through a series of 14 lectures given by members of the Neurosciences Department in the Case Western Reserve University School of Medicine. Topics are presented in a way that can be understood by students who have taken a high school biology class. Every effort is made to explain any new concepts that are included in the lectures. Each lecturer will provide general background reading material for the topics they discuss.
NEUR 301. Biological Mechanisms of Brain Disorders. 3 Units.
This course is designed to introduce students to a broad range of neurological and neuropsychiatric diseases and disorders in order to understand how genetic and environmental perturbations can disrupt normal brain function. The primary focus will be on understanding the biological bases of nervous system dysfunction. For each disease discussed, the subject matter will be organized to explain how normal brain function is impacted, the biological mechanisms underlying dysfunction (including still-unanswered questions) and current efforts to develop effective treatments (translational research). With this approach, students will gain an understanding of disease presentation, how animal models and human studies are being used to elucidate pathophysiological mechanisms, and opportunities and challenges in the development of new therapies. The class format will be a mix of lecture-based sessions and discussions of scientific journal articles. Offered as NEUR 301 and NEUR 401. Prereq: BIOL 216 or PSCL 352.

NEUR 401. Biological Mechanisms of Brain Disorders. 3 Units.
This course is designed to introduce students to a broad range of neurological and neuropsychiatric diseases and disorders in order to understand how genetic and environmental perturbations can disrupt normal brain function. The primary focus will be on understanding the biological bases of nervous system dysfunction. For each disease discussed, the subject matter will be organized to explain how normal brain function is impacted, the biological mechanisms underlying dysfunction (including still-unanswered questions) and current efforts to develop effective treatments (translational research). With this approach, students will gain an understanding of disease presentation, how animal models and human studies are being used to elucidate pathophysiological mechanisms, and opportunities and challenges in the development of new therapies. The class format will be a mix of lecture-based sessions and discussions of scientific journal articles. Offered as NEUR 301 and NEUR 401.

NEUR 402. Principles of Neural Science. 3 Units.
Lecture/discussion course covering concepts in cell and molecular neuroscience, principles of systems neuroscience as demonstrated in the somatosensory system, and fundamentals of the development of the nervous system. This course will prepare students for upper level Neuroscience courses and is also suitable for students in other programs who desire an understanding of neurosciences. Recommended preparation: CBIO 453. Offered as BIOL 402 and NEUR 402.

NEUR 415. Neuroscience Seminars. 1 Unit.
Current topics of interest in neurosciences. Students attend weekly seminars. From this series, students prepare critiques. No credit is given for less than 75% attendance.

NEUR 419. Critical Thinking in Neuroscience. 3 Units.
The goal of this course is to develop the student’s critical reasoning skills through reading and discussing primary research papers. Each year, the course will focus on 3-4 different topics selected by participating Neuroscience faculty members. Students will receive a letter grade based on their contributions to discussions, and at the discretion of the faculty, performance on exams and/or term paper. Prereq: NEUR 402.

NEUR 432. Current Topics in Vision Research. 3 Units.
Vision research is an exciting and multidisciplinary area that draws on the disciplines of biochemistry, genetics, molecular biology, structural biology, neuroscience, and pathology. This graduate level course will provide the student with broad exposure to the most recent and relevant research currently being conducted in the field. Topics will cover a variety of diseases and fundamental biological processes occurring in the eye. Regions of the eye that will be discussed include the cornea, lens, and retina. Vision disorders discussed include age-related macular degeneration, retinal ciliopathies, and diabetic retinopathy. Instructors in the course are experts in their field and are members of the multidisciplinary visual sciences research community here at Case Western Reserve University. Students will be exposed to the experimental approaches and instrumentation currently being used in the laboratory and in clinical settings. Topics will be covered by traditional lectures, demonstrations in the laboratory and the clinic, and journal club presentations. Students will be graded on their performance in journal club presentations (40%), research proposal (40%), and class participation (20%). Offered as NEUR 432, PATH 432, PHRM 432 and BIOL 466.

NEUR 466. Cell Signaling. 3 Units.
This is an advanced lecture/journal/discussion format course that covers cell signaling mechanisms. Included are discussions of neurotransmitter-gated ion channels, growth factor receptor kinases, cytokine receptors, G protein-coupled receptors, steroid receptors, heterotrimeric G proteins, ras family GTPases, second messenger cascades, protein kinase cascades, second messenger regulation of transcription factors, microtubule-based motility, actin/myosin-based motility, signals for regulation of cell cycle, signals for regulation of apoptosis. Offered as CLBY 466, PHOL 466 and PHRM 466.

NEUR 473. Introduction to Neurobiology. 3 Units.
How nervous systems control behavior. Biophysical, biochemical and molecular biological properties of nerve cells, their organization into circuitry, and their function within networks. Emphasis on quantitative methods for modeling neurons and networks, and on critical analysis of the contemporary technical literature in the neurosciences. Term paper required for graduate students. This course satisfies a lab requirement for the B.A. in Biology, and a Quantitative Laboratory requirements for the B.S. in Biology. Offered as BIOL 373, BIOL 473, and NEUR 473.

NEUR 474. Neurobiology of Behavior. 3 Units.
In this course, students will examine how neurobiologists interested in animal behavior study the linkage between neural circuitry and complex behavior. Various vertebrate and invertebrate systems will be considered. Several exercises will be used in this endeavor. Although some lectures will provide background and context on specific neural systems, the emphasis of the course will be on classroom discussion of specific journal articles. In addition, students will each complete a project in which they will observe some animal behavior and generate both behavioral and neurobiological hypotheses related to it. In lieu of examinations, students will complete three written assignments, including a theoretical grant proposal, a one-page Specific Aims paper related to the project, and a final project paper. These assignments are designed to give each student experience in writing biologically-relevant documents. Classroom discussions will help students understand the content and format of each type document. They will also present their projects orally to the entire class. Offered as BIOL 374, BIOL 474 and NEUR 474. Counts as SAGES Departmental Seminar.
NEUR 475. Protein Biophysics. 3 Units.
This course focuses on in-depth understanding of the molecular biophysics of proteins. Structural, thermodynamic and kinetic aspects of protein function and structure-function relationships will be considered at the advanced conceptual level. The application of these theoretical frameworks will be illustrated with examples from the literature and integration of biophysical knowledge with description at the cellular and systems level. The format consists of lectures, problem sets, and student presentations. A special emphasis will be placed on discussion of original publications. Offered as BIOL 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.

NEUR 478. Computational Neuroscience. 3 Units.
Computer simulations and mathematical analysis of neurons and neural circuits, and the computational properties of nervous systems. Students are taught a range of models for neurons and neural circuits, and are asked to implement and explore the computational and dynamic properties of these models. The course introduces students to dynamical systems theory for the analysis of neurons and neural learning, models of brain systems, and their relationship to artificial and neural networks. Term project required. Students enrolled in MATH 478 will make arrangements with the instructor to attend additional lectures and complete additional assignments addressing mathematical topics related to the course. Recommended preparation: MATH 223 and MATH 224 or BIOL 300 and BIOL 306. Offered as BIOL 378, COGS 378, MATH 378, BIOL 478, EBME 478, EECS 478, MATH 478 and NEUR 478.

NEUR 540. Advanced Topics in Neuroscience Ethics. 0 Unit.
This course offers continuing education in responsible conduct of research for advanced graduate students. The course will cover the nine defined areas of research ethics through a combination of lectures, online course material and small group discussions. Six 2-hr meetings per semester. Maximum enrollment of 15 students with preference given to graduate students in the Neurosciences program. All neurosciences graduate students must complete this course during their 3rd or 4th year.

NEUR 601. Research in Neuroscience. 1 - 18 Units.

NEUR 651. Master’s Thesis (M.S.). 1 - 6 Units.
(Credit as arranged.) Recommended preparation: M.S. candidates only.

NEUR 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Department of Nutrition

School of Medicine, Room WG 48
https://case.edu/medicine/nutrition/
Phone: 216.368.2440; Fax: 216.368.6846
Hope Barkoukis, PhD, RDN, LD, FAND, Chair
hdh@case.edu

For general questions please email nutrition@case.edu.

The department’s focus is on human nutrition and the application of the science of nutrition to health promotion and disease prevention. Undergraduate programs are designed for students interested in nutritional biochemistry and metabolism, clinical nutrition, professional study in dietetics, public health nutrition, medicine, physical therapy, pharmacy or dentistry. Graduate programs emphasize dietetics, public health nutrition, nutritional biochemistry and clinical nutrition.

The Department of Nutrition offers programs leading to the bachelor of arts degree in nutrition, the bachelor of science degree in nutrition, the bachelor of arts degree in nutritional biochemistry and metabolism, the bachelor of science degree in nutritional biochemistry and metabolism, the master of science degree in nutrition, the dual degree of master of public health/master of science nutrition, and the doctor of philosophy degree. The master of science in nutrition is approved as a Post-baccalaureate Premedical Program (https://apps.aamc.org/postbac/#/program/542). Three minors are available: the minor in nutrition, the minor in sports nutrition, and the minor in environmental nutrition. Graduate certificate programs, which are designated on the student’s transcript, are available in areas such as maternal and child nutrition and nutrition for health care professionals. The certificates are in addition to the basic graduate degree. Students are able to pursue certificates at no additional cost to the student.

Major Programs

The undergraduate degree in nutrition is appropriate for students who wish to:
1. pursue graduate programs in nutritional biochemistry, dietetics, public health and community nutrition or other biomedical sciences
2. enter professional schools of dentistry, medicine, physical therapy, or pharmacy
3. apply to dietetic internships or approved experience programs in order to prepare for the professional practice of dietetics
4. pursue careers with the government or in the food or pharmaceutical industry

This major offers flexibility in course selection within a framework of general program requirements. The selection of courses depends on the student’s choice of emphasis. Students wishing to qualify for admission to professional or graduate programs need to include specific courses considered prerequisites for admission. Students interested in applying to dietetic internships must meet specific course requirements (Didactic Program in Dietetics) as required by the Accreditation Council for Education in Nutrition and Dietetics of the Academy of Nutrition and Dietetics. These requirements are met in the courses that comprise the Didactic Program in Dietetics (DPD). The DPD at Case Western Reserve University is currently granted Accreditation by the Accreditation Council for Education in Nutrition and Dietetics of the Academy of Nutrition and Dietetics, 120 South Riverside Plaza, Suite 2000, Chicago, IL 60606-6995, 800.877.1600. A department advisor should be consulted in the freshman year to plan the dietetics coursework.

Human Nutrition

Bachelor of Science degree requires:

Required Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>NTRN 201</td>
<td>Nutrition</td>
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<tr>
<td>NTRN 342</td>
<td>Food Science</td>
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<tr>
<td>NTRN 342L</td>
<td>Food Science Lab</td>
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<td>NTRN 343</td>
<td>Dietary Patterns</td>
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<td>NTRN 363</td>
<td>Human Nutrition I: Energy, Protein, Minerals</td>
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<td>NTRN 364</td>
<td>Human Nutrition II: Vitamins</td>
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<tr>
<td>NTRN 397</td>
<td>SAGES Capstone Proposal Seminar</td>
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<td>NTRN 398</td>
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<td>Three nutrition electives chosen from:</td>
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<tr>
<td>NTRN 300</td>
<td>Healthy Lifestyles as Preventive Medicine</td>
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<tr>
<td>NTRN 328</td>
<td>Child Nutrition, Development and Health</td>
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</table>
Department of Nutrition

NTRN 338 Dietary Supplements
NTRN 341 Food as Medicine: How what we eat influences how we feel, think, and our health status
NTRN 351 Food Service Systems Management
NTRN 360 Clinical Assessment and Diagnosis: Nutritional, Functional, Physical
NTRN 361 Metabolic Dysregulation of Energy from Obesity to Anorexia
NTRN 362 Exercise Physiology and Macronutrient Metabolism
NTRN 365 Nutrition for the Prevention and Management of Disease: Pathophysiology
NTRN 366 Nutrition for the Prevention and Management of Disease: Clinical Applications
NTRN 367 Nutrition Strategies and Wellness Programming
NTRN 371 Special Problems *
NTRN 388 Seminar in Sports Nutrition
NTRN 390 Undergraduate Research *
NTRN 435 Nutrition during Pregnancy and Lactation
NTRN 436 Pediatric Nutrition
NTRN 437 Nutrition Communication, Counseling and Behavior Change Strategies
NTRN 438 Dietary Supplements

Additional Required Courses:

Chemistry:

CHEM 105 Principles of Chemistry I 3
CHEM 106 Principles of Chemistry II 3
CHEM 113 Principles of Chemistry Laboratory 2
CHEM 223 Introductory Organic Chemistry I (before NTRN 363) 3

Biology:

BIOL 214 Genes, Evolution and Ecology 3
BIOL 216 Development and Physiology 3
or BIOL 340 Human Physiology
& BIOL 346 and Human Anatomy
BIOL 216L Development and Physiology Lab 1
BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science 4

One of the following: 3

ANTH 319 Introduction to Statistical Analysis in the Social Sciences
PSCL 282 Quantitative Methods in Psychology

Bachelor of Arts degree requires:

Required Courses:

NTRN 201 Nutrition 3
NTRN 342 Food Science 3
NTRN 342L Food Science Lab 2
NTRN 343 Dietary Patterns 3
NTRN 363 Human Nutrition I: Energy, Protein, Minerals 3
NTRN 364 Human Nutrition II: Vitamins 3
NTRN 397 SAGES Capstone Proposal Seminar 3
NTRN 398 SAGES Senior Capstone Experience 3

Two nutrition electives chosen from the following: 6

NTRN 300 Healthy Lifestyles as Preventive Medicine
NTRN 328 Child Nutrition, Development and Health
NTRN 338 Dietary Supplements
NTRN 341 Food as Medicine: How what we eat influences how we feel, think, and our health status
NTRN 351 Food Service Systems Management
NTRN 360 Clinical Assessment and Diagnosis: Nutritional, Functional, Physical
NTRN 361 Metabolic Dysregulation of Energy from Obesity to Anorexia
NTRN 362 Exercise Physiology and Macronutrient Metabolism
NTRN 365 Nutrition for the Prevention and Management of Disease: Pathophysiology
NTRN 366 Nutrition for the Prevention and Management of Disease: Clinical Applications
NTRN 371 Special Problems *
NTRN 388 Seminar in Sports Nutrition
NTRN 390 Undergraduate Research *
NTRN 435 Nutrition during Pregnancy and Lactation
NTRN 436 Pediatric Nutrition
NTRN 437 Nutrition Communication, Counseling and Behavior Change Strategies
NTRN 438 Dietary Supplements

Additional Required Courses:

Chemistry:

CHEM 105 Principles of Chemistry I 3
CHEM 106 Principles of Chemistry II 3
CHEM 113 Principles of Chemistry Laboratory 2
CHEM 223 Introductory Organic Chemistry I (before NTRN 363) 3

Biology:

BIOL 214 Genes, Evolution and Ecology 3
BIOL 216 Development and Physiology 3
or BIOL 340 Human Physiology
& BIOL 346 and Human Anatomy
BIOL 216L Development and Physiology Lab 1
BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science 4

One of the following: 3

ANTH 319 Introduction to Statistical Analysis in the Social Sciences
PSCL 282 Quantitative Methods in Psychology

Total Units 60

* Only one of these courses is permitted.
400 level courses require instructor consent for undergraduates to enroll.
Bachelor of Science in Nutrition - Human Nutrition Major Example
Plan of Study

First Year

Units

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<tr>
<th>Course</th>
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<tr>
<td>Principles of Chemistry I (CHEM 105)</td>
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<td>Nutrition (NTRN 201)</td>
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<td>SAGES First Seminar</td>
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<td>Genes, Evolution and Ecology (BIOL 214)</td>
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<td>Principles of Chemistry II (CHEM 106)</td>
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<td>Principles of Chemistry Laboratory (CHEM 113)</td>
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Second Year

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<td>SAGES University Seminar</td>
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<td>Development and Physiology (BIOL 216)</td>
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<td>SAGES University Seminar</td>
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<td>Basic Statistics for Social and Life Sciences (STAT 201)</td>
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Third Year

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Fourth Year

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<td><strong>Year Total:</strong></td>
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**Total Units in Sequence:** 118

Nutritional Biochemistry and Metabolism

Bachelor of Arts degree requires:

<table>
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<th>Course</th>
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<tr>
<td>NTRN 201 Nutrition</td>
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<td>NTRN 343 Dietary Patterns</td>
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<tr>
<td>NTRN 363 Human Nutrition I: Energy, Protein, Minerals</td>
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<td>NTRN 364 Human Nutrition II: Vitamins</td>
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<tr>
<td>NTRN 397 SAGES Capstone Proposal Seminar</td>
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<td>NTRN 398 SAGES Senior Capstone Experience</td>
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<tr>
<td>NTRN 452 Nutritional Biochemistry and Metabolism</td>
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<tr>
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<tr>
<td>NTRN 300 Healthy Lifestyles as Preventive Medicine</td>
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<td>NTRN 328 Child Nutrition, Development and Health</td>
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<td>NTRN 351 Food Service Systems Management</td>
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<td>NTRN 360 Clinical Assessment and Diagnosis: Nutritional, Functional, Physical</td>
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<td>NTRN 361 Metabolic Dysregulation of Energy from Obesity to Anorexia</td>
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## Bachelor of Science degree requires:

### Required courses:

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<td>NTRN 398</td>
<td>SAGES Senior Capstone Experience</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 452</td>
<td>Nutritional Biochemistry and Metabolism</td>
<td>3</td>
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</tbody>
</table>

Three nutrition electives at 300-level (or above with instructor consent) chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRN 300</td>
<td>Healthy Lifestyles as Preventive Medicine</td>
<td></td>
</tr>
<tr>
<td>NTRN 328</td>
<td>Child Nutrition, Development and Health</td>
<td></td>
</tr>
<tr>
<td>NTRN 338</td>
<td>Dietary Supplements</td>
<td></td>
</tr>
<tr>
<td>NTRN 341</td>
<td>Food as Medicine: How we eat influences how we feel, think, and our health status</td>
<td></td>
</tr>
<tr>
<td>NTRN 351</td>
<td>Food Service Systems Management</td>
<td></td>
</tr>
<tr>
<td>NTRN 360</td>
<td>Clinical Assessment and Diagnosis: Nutritional, Functional, Physical</td>
<td></td>
</tr>
<tr>
<td>NTRN 361</td>
<td>Metabolic Dysregulation of Energy from Obesity to Anorexia</td>
<td></td>
</tr>
<tr>
<td>NTRN 365</td>
<td>Nutrition for the Prevention and Management of Disease: Pathophysiology</td>
<td></td>
</tr>
<tr>
<td>NTRN 366</td>
<td>Nutrition for the Prevention and Management of Disease: Clinical Applications</td>
<td></td>
</tr>
<tr>
<td>NTRN 367</td>
<td>Nutrition Strategies and Wellness Programming</td>
<td></td>
</tr>
<tr>
<td>NTRN 371</td>
<td>Special Problems</td>
<td></td>
</tr>
<tr>
<td>NTRN 388</td>
<td>Seminar in Sports Nutrition</td>
<td></td>
</tr>
<tr>
<td>NTRN 390</td>
<td>Undergraduate Research</td>
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</table>

### Additional required courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>MATH 121</td>
<td>Calculus for Science and Engineering I</td>
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<tr>
<td>MATH 122</td>
<td>Calculus for Science and Engineering II</td>
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<tr>
<td>MATH 124</td>
<td>Calculus II</td>
<td></td>
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<tr>
<td>MATH 223</td>
<td>Calculus for Science and Engineering III</td>
<td>3</td>
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<tr>
<td>MATH 227</td>
<td>Calculus III</td>
<td></td>
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<tr>
<td>MATH 224</td>
<td>Elementary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 228</td>
<td>Differential Equations</td>
<td></td>
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<tr>
<td>CHEM 105</td>
<td>Principles of Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 106</td>
<td>Principles of Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>CHEM 223</td>
<td>Introductory Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 224</td>
<td>Introductory Organic Chemistry II</td>
<td>3</td>
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<tr>
<td>CHEM 233</td>
<td>Introductory Organic Chemistry Laboratory I</td>
<td>2</td>
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<tr>
<td>CHEM 234</td>
<td>Introductory Organic Chemistry Laboratory II</td>
<td>2</td>
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<tr>
<td>BIOL 214</td>
<td>Genes, Evolution and Ecology</td>
<td>3</td>
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<tr>
<td>BIOL 215</td>
<td>Cells and Proteins</td>
<td>3</td>
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<tr>
<td>BIOL 216</td>
<td>Development and Physiology</td>
<td>3</td>
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<tr>
<td>BIOL 340 &amp; 346</td>
<td>Human Physiology and Human Anatomy</td>
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<tr>
<td>BIOL 216L</td>
<td>Development and Physiology Lab</td>
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<tr>
<td>PHYS 115</td>
<td>Introductory Physics I</td>
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<tr>
<td>PHYS 116</td>
<td>Introductory Physics II</td>
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<tr>
<td>PHYS 121</td>
<td>General Physics I - Mechanics</td>
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<td>PHYS 122</td>
<td>General Physics II - Electricity and Magnetism</td>
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<td>BIOC 307</td>
<td>Introduction to Biochemistry: From Molecules To Medical Science</td>
<td>4</td>
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<tr>
<td>BIOC 334 or 312</td>
<td>Structural Biology or Proteins and Enzymes</td>
<td>3</td>
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<tr>
<td>or NTRN 454</td>
<td>Advanced Nutrition and Metabolism: Investigative Methods</td>
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**Total Units:** 81
Bachelor of Arts in Nutrition - Nutritional Biochemistry and Metabolism Major Example Plan of Study

First Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Math and Calculus Applications for Life, Managerial, and Social Sci I (MATH 125)</td>
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<tr>
<td>Nutrition (NTRN 201)</td>
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<td>Genes, Evolution and Ecology (BIOL 214)</td>
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<tr>
<td>SAGES First Seminar</td>
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<tr>
<td>Principles of Chemistry I (CHEM 105)</td>
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<td></td>
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<tr>
<td>SAGES Breadth Requirements</td>
<td>3</td>
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<tr>
<td>Cells and Proteins (BIOL 215)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Principles of Chemistry Laboratory (CHEM 113)</td>
<td>2</td>
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<tr>
<td>Math and Calculus Applications for Life, Managerial, and Social Sci II (MATH 126)</td>
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<tr>
<td>Principles of Chemistry II (CHEM 106)</td>
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Second Year

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<th>Spring</th>
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<tr>
<td>Introductory Organic Chemistry Laboratory I (CHEM 233)</td>
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<tr>
<td>Introductory Organic Chemistry I (CHEM 223)</td>
<td>3</td>
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<tr>
<td>Development and Physiology (BIOL 216) &amp; Development and Physiology Lab (BIOL 216L)</td>
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<tr>
<td>SAGES University Seminar</td>
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<tr>
<td>Electives</td>
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<tr>
<td>Introductory Organic Chemistry II (CHEM 224)</td>
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Third Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 307)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Introductory Physics I (PHYS 115)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Food Science (NTRN 342)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Food Science Lab (NTRN 342L)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>SAGES Capstone Proposal Seminar (NTRN 397)</td>
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</tr>
<tr>
<td>Elective</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Introductory Physics II (PHYS 116)</td>
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<tr>
<td>SAGES Breadth Requirement</td>
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Fourth Year

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<tr>
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<th>Spring</th>
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<tbody>
<tr>
<td>SAGES Senior Capstone Experience (NTRN 398)</td>
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<tr>
<td>Nutritional Biochemistry and Metabolism (NTRN 452)</td>
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<tr>
<td>Human Nutrition I: Energy, Protein, Minerals (NTRN 363)</td>
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<tr>
<td>Elective</td>
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<td></td>
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<tr>
<td>Nutrition Elective (if not already taken)</td>
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<tr>
<td>Human Nutrition II: Vitamins (NTRN 364)</td>
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<tr>
<td>Structural Biology (BIOC 334)</td>
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<tr>
<td>Elective</td>
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Total Units in Sequence: 114

Minor in Nutrition

Nutrition majors are not eligible for this minor.

Non Nutrition majors may only take one minor: either Minor in Nutrition, Minor in Sports Nutrition, or Minor in Environmental Nutrition.

Required courses:

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRN 201</td>
<td>Nutrition</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 343</td>
<td>Dietary Patterns</td>
<td>3</td>
</tr>
<tr>
<td>Nine credits selected from:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NTRN 300</td>
<td>Healthy Lifestyles as Preventive Medicine</td>
<td></td>
</tr>
<tr>
<td>NTRN 328</td>
<td>Child Nutrition, Development and Health</td>
<td></td>
</tr>
<tr>
<td>NTRN 342</td>
<td>Food Science</td>
<td></td>
</tr>
<tr>
<td>NTRN 351</td>
<td>Food Service Systems Management</td>
<td></td>
</tr>
<tr>
<td>NTRN 361</td>
<td>Metabolic Dysregulation of Energy from Obesity to Anorexia</td>
<td></td>
</tr>
</tbody>
</table>
### Didactic Program in Dietetics (DPD)

The following courses must be included in the program.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRN 201</td>
<td>Nutrition</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 342</td>
<td>Food Science</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 342L</td>
<td>Food Science Lab</td>
<td>2</td>
</tr>
<tr>
<td>NTRN 343</td>
<td>Dietary Patterns</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 351</td>
<td>Food Service Systems Management</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 360</td>
<td>Clinical Assessment and Diagnosis: Nutritional, Physical</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 363</td>
<td>Human Nutrition I: Energy, Protein, Minerals</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 364</td>
<td>Human Nutrition II: Vitamins</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 365</td>
<td>Nutrition for the Prevention and Management of Disease: Pathophysiology</td>
<td>4</td>
</tr>
<tr>
<td>NTRN 366</td>
<td>Nutrition for the Prevention and Management of Disease: Clinical Applications</td>
<td>3</td>
</tr>
<tr>
<td>NTRN 550A</td>
<td>Advanced Community Nutrition (or NTRN 528)</td>
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</tr>
<tr>
<td>BIOC 307</td>
<td>Introduction to Biochemistry: From Molecules To Medical Science</td>
<td>4</td>
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<tr>
<td>BIOL 216</td>
<td>Development and Physiology (or BIOL 340 &amp; 346)</td>
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<tr>
<td>BIOL 343</td>
<td>Microbiology</td>
<td>3</td>
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<tr>
<td>CHEM 223</td>
<td>Introductory Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 150</td>
<td>Expository Writing (or SAGES Writing Portfolio)</td>
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<tr>
<td>SOCI 101</td>
<td>Introduction to Sociology</td>
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<tr>
<td>One of the following:</td>
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<tr>
<td>EDUC 304</td>
<td>Educational Psychology</td>
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<tr>
<td>PSCL 353</td>
<td>Psychology of Learning</td>
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<tr>
<td>PSCL 357</td>
<td>Cognitive Psychology</td>
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<tr>
<td>One of the following:</td>
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<tr>
<td>ANTH 215</td>
<td>Health, Culture, and Disease: An Introduction to Medical Anthropology</td>
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<tr>
<td>SOCI 311</td>
<td>Health, Illness, and Social Behavior</td>
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<td>One of the following:</td>
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<tr>
<td>ANTH 319</td>
<td>Introduction to Statistical Analysis in the Social Sciences</td>
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<tr>
<td>PSCL 282</td>
<td>Quantitative Methods in Psychology</td>
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<tr>
<td>PQHS 431</td>
<td>Statistical Methods I</td>
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<tr>
<td>STAT 201</td>
<td>Basic Statistics for Social and Life Sciences</td>
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<tr>
<td>STAT 243</td>
<td>Statistical Theory with Application I</td>
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<tr>
<td>STAT 312</td>
<td>Basic Statistics for Engineering and Science</td>
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<tr>
<td>STAT 313</td>
<td>Statistics for Experimenters</td>
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</tbody>
</table>

Total Units: 61
Masters Degrees

The Department of Nutrition offers six distinct programs leading to Masters Degrees: (1) MS in Nutrition (2) MS in Public Health Nutrition (3) MS in Public Health Nutrition Dietetic Internship (4) Combined Dietetic Internship/Master’s Degree Program (5) Master of Public Health/Master of Science in Nutrition Dual Degree Program and (6) MD/MS in Biomedical Investigation - Nutrition Track.

MS in Nutrition

This degree program offers two options. For those pursuing the thesis option, 30 semester hours of a planned program of study are required, including six to nine semester hours of research, as well as a final oral defense of the thesis. The non-thesis option requires 30 semester hours and a final written, comprehensive examination.

All candidates are required to take 21 semester hours of nutrition, including seven hours of advanced human nutrition. In addition, students are encouraged to pursue complementary studies in the biomedical, social and behavioral sciences. The plan of study may vary considerably depending on the education, goals and specific interests of each student. Students may elect to focus on nutritional biochemistry and metabolism or molecular nutrition. The individual program also may be planned to fulfill the academic requirements for dietetic registration (Didactic Program in Dietetics). Students must obtain advisor approval for elective courses selected that will be used to satisfy graduation requirements.

MS in Public Health Nutrition

The primary goal of this 16-month program is to prepare students for employment in public health or community agencies where you will work to promote health and reduce the risk of chronic disease and advance the nutritional health of our population. Coursework includes training in public health theory, program development and evaluation, nutritional epidemiology, human nutrition and life-cycle specific nutritional needs and concerns. A minimum of 31 semester hours of academic coursework is required to earn the degree. Note: students who have not previously earned an undergraduate degree in nutrition must complete NTRN 401 before beginning this program.

In addition to the general public health nutrition curriculum, students may elect to complete a certificate in Maternal and Child Nutrition. Specialty certificates may require completion of additional coursework.

Sample Program of Study-Fall Start

<table>
<thead>
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<th>Year Total:</th>
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<tbody>
<tr>
<td>Total Units in Sequence:</td>
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</table>

Sample Program of Study-Spring Start

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Public Health Nutrition (NTRN 528)</td>
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</tr>
<tr>
<td>Nutritional Epidemiology for Evidence Based Health Practice (NTRN 529)</td>
<td>3</td>
</tr>
<tr>
<td>Advanced Human Nutrition I (NTRN 433)</td>
<td>4</td>
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<tr>
<td>Nutrition for the Aging and Aged (NTRN 440)</td>
<td>3</td>
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<tr>
<td>Public Health Nutrition (NTRN 530)</td>
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<tr>
<td>Any two NTRN or related 400 or 500 level courses</td>
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<tr>
<td>Year Total:</td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric Nutrition (NTRN 436)</td>
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<tr>
<td>Any two NTRN or related 400 or 500 level courses</td>
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</table>

MS in Public Health Nutrition Dietetic Internship Program

The primary goal of this program is to prepare Registered Dietitian Nutritionists (RDNs) for employment in public health or community agencies. A minimum of 30 semester hours of combined academic work and supervised practice is required to earn the degree. Supervised practice is concurrent with coursework utilizing local agencies for translation of theory and science into practice. The program includes a ten-twelve week experience in an out of town public health agency that has a strong nutrition program.

In addition to the public health nutrition curriculum, students may elect to complete a certificate in Maternal and Child Nutrition. Specialty certificates may require completion of additional coursework. If a certificate program is selected, supervised practice will be geared toward the specific population group.

Upon completion of the program, students are eligible to take the Registered Dietitian Nutritionist (RDN) exam. The program is accredited by the Accreditation Council for Education in Nutrition and Dietetics (ACEND). This program is a non-thesis program of study.

General Track: Plan of Study

Note: Students must take either NTRN 436 or NTRN 440.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
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<tbody>
<tr>
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<tr>
<td>Nutritional Epidemiology for Evidence Based Health Practice (NTRN 529)</td>
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</tr>
<tr>
<td>Nutrition for the Aging and Aged (NTRN 440)</td>
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or Elective at the 400 level or higher
Seminar in Dietetics I (NTRN 516) 4
Public Health Nutrition (NTRN 530) 3
Elective: Any NTRN 400 or 500 level course, excluding NTRN 401
NTRN 531 Public Health Nutrition Field Experience 2
Advanced Public Health Nutrition Field Experience (NTRN 534) 3
Year Total: 13 8 3

Second Year

Fall
Pediatric Nutrition (NTRN 436) 3
NTRN 531 Public Health Nutrition Field Experience 3
Or Elective at 400 level or higher. 3
Year Total: 9

Total Units in Sequence: 33

**Combined Dietetic Internship/Master’s Degree Program**

The Combined Dietetic Internship/Master’s Degree Program combines academic work with clinical practice at a dietetic internship at University Hospitals Case Medical Center, the Louis Stokes Cleveland Department of Veterans Affairs Medical Center, or the Cleveland Clinic. A minimum of 30 semester hours is required. Admission is contingent on the student being selected and matched to one of the hospitals’ dietetic internship programs. Appointment to these internships follows the admission procedure outlined by the Accreditation Council for Education in Nutrition and Dietetics of the Academy of Nutrition and Dietetics.

Coursework is planned individually with the student’s academic advisor. This program is a non-thesis program of study.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Seminar in Dietetics I (NTRN 516)</td>
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<tr>
<td>NTRN 561 Investigative Methods in Nutrition</td>
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<td>Seminar in Dietetics II (NTRN 517)</td>
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<td>Research Practicum (NTRN 562)</td>
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<table>
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<th>Second Year</th>
<th>Units</th>
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<th>Spring</th>
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<tbody>
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Total Units in Sequence: 30

**Master of Public Health/Master of Science in Nutrition Dual Degree Program**

This is a dual degree program that is offered jointly by the Departments of Epidemiology and Biostatistics, and Nutrition. The core Master Degree courses include a mixture of those from nutrition, biochemistry and public health.

The trained graduate could be employed in a wide variety of settings, including (but not limited to) local, state, national, or global public policy, governmental public health, hospital outreach, community-based health non-profit organizations, health organizations, research projects; or the Food and Drug Administration. Additionally, these graduates could serve as health emissaries to foreign countries regarding nutrition, sufficient food supply, sanitary environment, food safety, oral rehydration, or the advisability of food supplements.

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<th>Units</th>
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<th>Spring</th>
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<tr>
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### Combined Dietetic Internship/Master’s Degree Program

The Combined Dietetic Internship/Master’s Degree Program combines academic work with clinical practice at a dietetic internship at University Hospitals Case Medical Center, the Louis Stokes Cleveland Department of Veterans Affairs Medical Center, or the Cleveland Clinic. A minimum of 30 semester hours is required. Admission is contingent on the student being selected and matched to one of the hospitals’ dietetic internship programs. Appointment to these internships follows the admission procedure outlined by the Accreditation Council for Education in Nutrition and Dietetics of the Academy of Nutrition and Dietetics.

Coursework is planned individually with the student’s academic advisor. This program is a non-thesis program of study.

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<td>NTRN 561 Investigative Methods in Nutrition</td>
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<td>Seminar in Dietetics II (NTRN 517)</td>
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Total Units in Sequence: 30

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### Master of Public Health/Master of Science in Nutrition Dual Degree Program

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### MD/MS Biomedical Investigation-Nutrition Track

For Admissions and MD requirements, see the MD Dual Degree Programs section (p. 27). This track is designed to provide medical students with more in-depth knowledge and research experience in nutrition. Students may elect to focus on nutrition biochemistry and metabolism or molecular nutrition or clinical nutrition. The student’s mentor or the Graduate Program Director will assist the student in selecting the appropriate courses for their interests.

**Students in Nutrition must complete:**

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<td>NTRN 434</td>
<td>Advanced Human Nutrition II</td>
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<tr>
<td>NTRN 551</td>
<td>Seminar in Advanced Nutrition ² semesters required; 1 unit each</td>
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<td>NTRN 601</td>
<td>Special Problems</td>
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<td>IBIS 600</td>
<td>Exam in Biomedical Investigation</td>
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<td>IBIS 401</td>
<td>Integrated Biological Sciences I</td>
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<td>IBMS 500</td>
<td>On Being a Professional Scientist: The Responsible Conduct of Research</td>
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And 2-3 credits or one course from those listed below:

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<td>NTRN 436</td>
<td>Pediatric Nutrition</td>
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<tr>
<td>NTRN 437</td>
<td>Nutrition Communication, Counseling and Behavior Change Strategies</td>
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<td>NTRN 438</td>
<td>Dietary Supplements</td>
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<tr>
<td>NTRN 439</td>
<td>Food Behavior: Physiological, Psychological and Environmental Determinants</td>
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<tr>
<td>NTRN 440</td>
<td>Nutrition for the Aging and Aged</td>
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<td>NTRN 452</td>
<td>Nutritional Biochemistry and Metabolism</td>
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<td>NTRN 448</td>
<td>Integrative and Functional Nutrition</td>
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<tr>
<td>NTRN 459</td>
<td>Diabetes Prevention and Management</td>
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<td>NTRN 454</td>
<td>Advanced Nutrition and Metabolism: Investigative Methods</td>
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<tr>
<td>NTRN 455</td>
<td>Molecular Nutrition</td>
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<tr>
<td>NTRN 456</td>
<td>Pediatric Obesity</td>
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<tr>
<td>NTRN 460</td>
<td>Sports Nutrition</td>
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<tr>
<td>NTRN 461</td>
<td>Metabolic Dysregulation of Energy from Obesity to Anorexia</td>
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<tr>
<td>NTRN 529</td>
<td>Nutritional Epidemiology for Evidence Based Health Practice (online)</td>
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<tr>
<td>NTRN 533</td>
<td>Nutritional Care of Neonate</td>
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### Graduate Certificates in Nutrition

#### Maternal and Child Nutrition

**Certificate Requirements:** Degree-seeking students who are enrolled in the MS in Nutrition, MS in Public Health Nutrition, MS in Public Health Nutrition Internship, the Coordinated Dietetic Internship/Master's Degree Program and the MD/MS program are eligible for this certificate. Credits for this coursework may be double counted toward the degree program and this certificate. Students must maintain a cumulative GPA of 3.0 to obtain this certificate. *Please note that only dietetic interns may apply NTRN 516 toward the requirements of this certificate.

**Required Courses**

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<td>Pediatric Nutrition</td>
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<td>NTRN 433</td>
<td>Advanced Human Nutrition I</td>
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<td>Seminar in Dietetics I</td>
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<td>NTRN 441</td>
<td>Human Lactation</td>
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<td>NTRN 446</td>
<td>Advanced Maternal Nutrition: Special Topics</td>
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<td>NTRN 456</td>
<td>Pediatric Obesity</td>
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<tr>
<td>NTRN 532C</td>
<td>Specialized Public Health Nutrition Field Experience (PHN students only.)</td>
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<td>NTRN 533</td>
<td>Nutritional Care of Neonate</td>
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<td>NTRN 602</td>
<td>Special Project in Nutrition</td>
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**Total Units** 15

#### Health Care Professionals

**Certificate Requirements:** A maximum of 6 credits may be double counted for this certificate and the certificate in Maternal and Child Nutrition. Students must maintain an average GPA of 3.0 to successfully complete this 15 credit certificate.

**Required Courses**

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<td>Advanced Human Nutrition I</td>
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<td>NTRN 434</td>
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<td>NTRN 457</td>
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<td>NTRN 459</td>
<td>Food Behavior: Physiological, Psychological and Environmental Determinants</td>
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**Total Units** 15
NTRN 440 Nutrition for the Aging and Aged
NTRN 446 Advanced Maternal Nutrition: Special Topics
NTRN 448 Integrative and Functional Nutrition
NTRN 452 Nutritional Biochemistry and Metabolism
NTRN 454 Advanced Nutrition and Metabolism: Investigative Methods
NTRN 455 Molecular Nutrition
NTRN 456 Pediatric Obesity
NTRN 459 Diabetes Prevention and Management
NTRN 460 Sports Nutrition
NTRN 461 Metabolic Dysregulation of Energy from Obesity to Anorexia
NTRN 462 Exercise Physiology and Macronutrient Metabolism
NTRN 528 Introduction to Public Health Nutrition
NTRN 529 Nutritional Epidemiology for Evidence Based Health Practice

Total Units 15-16

**PhD in Nutrition**

The PhD degree in Nutrition is awarded for study and research in nutrition. Areas of concentration are nutritional biochemistry and metabolism, and molecular nutrition. Admissions to the PhD in Nutrition program are obtained through the integrated Biomedical Scientist Training Program (BSTP), by direct admission to the department or via the Medical Scientist Training Program (MSTP).

In order to earn a PhD in Nutrition, a student must complete rotations in at least three laboratories followed by selection of a research advisor, completion of Core and Elective coursework, including responsible conduct of research, as described in the plan of study. Each graduate program follows the overall regulations established and described in CWRU Graduate Studies and documented to the Regents of the State of Ohio. Completion of the PhD degree will require 36 hours of coursework (24 hours of which are graded) and 18 hours of NTRN 701 Dissertation Ph.D.

In addition, each student must successfully complete a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. During the dissertation period, students are expected to meet twice a year with the thesis committee, present seminars in the department, and fulfill journal publication requirements. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program.

**Sample Plan of Study**

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicroquirements)

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<td>Molecular Biology I (IBMS 455)</td>
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After completion of required coursework, student enrolls in a minimum of one credit of NTRN 701 Dissertation Ph.D., Fall and Spring Semesters until graduation.

**Courses**

**NTRN 200. Case Cooks: Ethnic Eats. 1 Unit.**
In a world as connected as ours, it is important to learn about others’ cultures; and what better way to learn than through the medium of food! Something as simple as food can be interpreted thousands of ways and can serve as a link from our culture to ethnicities around the world. This half-semester class focuses on exploring cultural diversity in a way that everyone can relate to while also incorporating healthy, simple, budget friendly cooking skills. Course is geared towards the beginner skill level. Each week we will explore a different region of the world including Africa, South America, Europe, Asia, and the Middle East! Note: Please email instructor before registering if you have food allergies.

**NTRN 200H. Case Cooks: Healthy Lifestyles. 1 Unit.**
Studies say that those who frequently cook meals at home eat healthier, consume fewer calories and are happier than those who eat out. Isn’t it time you learn to cook? Join your classmates for a fun, edible education. This half-semester class focuses on healthy, simple, budget friendly cooking skills to increase your confidence in the kitchen. Course is geared towards the beginner skill level. Weekly cooking topics include, Treasures from the earth, Keep it simple & Make it quick, Protein power, Grocery game plans & Mastering Student Meals, Make it lighter. Note: Please email instructor before registering if you have food allergies.

**NTRN 201. Nutrition. 3 Units.**
The nutrients, their functions, food sources, and factors affecting human needs throughout life.

**NTRN 300. Healthy Lifestyles as Preventive Medicine. 3 Units.**
Decades of research have shown that a healthy lifestyle will significantly reduce the risk of chronic disease, improve health and quality of life. Because of this research, support has emerged that healthy lifestyles are in fact the "best preventive medicine". This course will focus on learning the key components of these healthy lifestyle principles and developing the skills necessary to practice and advocate a healthy lifestyle. It is designed for any student interested in learning how to practice and promote healthy lifestyles, but it is particularly helpful for all pre-health, public health, and nutrition majors. *A unique feature of this course is the opportunity for enrolled students, (who are interested), to pair with advanced nutrition students throughout the semester for ‘healthy eating’ guidance. Enrolled students will have healthy eating coaches!*

**NTRN 328. Child Nutrition, Development and Health. 3 Units.**
The relationship between nutrition and physical/cognitive growth and development of the child from the prenatal period through adolescence, including individuality, maturation and biological needs. Nutritional influences (nutrient requirements, food choices, and nutritional/feeding problems) and effects on health are emphasized. Prereq: NTRN 201.

**NTRN 337. Nutrition Communication, Counseling and Behavior Change Strategies. 3 Units.**
How do we help someone make a dietary behavior change, such as choosing a side salad instead of fries when eating a hamburger? Yes, it is a very challenging task and most often, providing just nutrition education is not sufficient. Therefore, the focus of this course is to prepare students for their future career by providing fundamental knowledge about human decision making and developing communication skills that can help improve others nutritional well-being. In addition, the course will critically evaluate and interpret nutrition information for the consumer. Changes in food marketing and sources of nutrition information for consumers over the past five decades will be analyzed and discussed. Furthermore, the impact of nutrition labeling, the food industry and food marketing on the dietary intake of Americans and various demographic groups in the U.S. will be studied. Offered as NTRN 337 and NTRN 437 Prereq: NTRN 201 or Requisites Not Met permission.

**NTRN 338. Dietary Supplements. 3 Units.**
An examination of dietary supplements specific to health promotion and disease prevention/treatment throughout the life cycle. Topics and concepts include regulation, controversies, safety, efficacy, and the surrounding scientific evidence for dietary supplement use. For NTRN 338, preference will be given to senior level Nutrition majors. Offered as NTRN 338 and NTRN 438. Prereq: Junior or Senior Standing.

**NTRN 340. Global Food Systems: Environmental Issues, Sustainability, and Health. 3 Units.**
Environmental changes impact humans worldwide, with an influence lasting many generations into the future. An in-depth understanding of the interplay between food systems - global food production, distribution, and selection - and environment and sustainability issues, as related to human nutrition, health, and well-being has never been more important. This course will provide an in-depth analysis regarding how food systems and the environment are interconnected in a multitude of ways. Additionally, the course will examine how issues of sustainability effect food production, distribution, and quality. Further, how environmental and sustainability issues directly affect the nutritive qualities of foods. Course topics initially include a review of environmental factors impacting food systems, types of sustainable food systems, historical perspectives, and aspects of human nutrition. Once students master the initial concepts, then into more detailed topics related to production approaches, biotechnology, soil/water quality, and food security on a local, national, and global level will be studied.

**NTRN 341. Food as Medicine: How what we eat influences how we feel, think, and our health status. 3 Units.**
This course will discuss key aspects of the interplay between food and health/wellness and in particular food synergy - interactions among dietary components and the effects on health. What are “whole foods” vs. basic nutrients? What are the most common nutrient deficiencies in men, women and children, including the elderly? Students will learn to interpret dietary recommendations/guidelines and which foods are used to improve digestion, optimize cardiovascular health and immune function, and help prevent cancer. Basic discussion of importance of gut micro-flora. Diet and body weight; also pros and cons of different dieting strategies. Increasing awareness of "culinary medicine" (i.e. how food acts as an integrated therapy). How what we eat influences how we feel, think and our general health status. There is an integrated culinary experience. Prereq: NTRN 201 or requisites not met permission.
NTRN 342. Food Science. 3 Units.
Chemical, physical and biological properties of food constituents and their interactions in food preparation and processing and practical application of processing methods and their effect on nutritional quality and acceptability; including global food biodiversity. Prereq: CHEM 105.

NTRN 342L. Food Science Lab. 2 Units.

NTRN 343. Dietary Patterns. 3 Units.
Examination of the food supply in the United States as it is affected by production, processing, marketing, government programs, regulation, and consumer selection. Nutritional evaluation of dietary patterns of different cultures. Counts for CAS Global & Cultural Diversity Requirement. Prereq: NTRN 201.

NTRN 351. Food Service Systems Management. 3 Units.
The application of organizational theory and skills in the preparation and service of quantity food. Laboratory experience in professional food services are included. Graduate students will analyze one aspect of food service management in depth. Offered as NTRN 351 and NTRN 451. Prereq: Nutrition major or consent of instructor.

NTRN 360. Clinical Assessment and Diagnosis: Nutritional, Functional, Physical. 3 Units.
Methods for the provision of nutrition services to individuals and groups. Principles of professional practice including ethics, standards, and regulatory issues. Prereq: NTRN 201 and NTRN 363 or MS in Nutrition or MS in Public Health Nutrition.

NTRN 361. Metabolic Dysregulation of Energy from Obesity to Anorexia. 3 Units.
Energy imbalance and the implications on health will be explored in this course. Key concepts covered in this class include: 1. Energy imbalance refers to positive and negative states of energy balance and occurs when energy intake does not match energy expended in metabolic processes, daily living activities, and physical activity; 2. Obesity is a result of chronic positive energy balance whereas anorexia nervosa is a condition of chronic negative energy balance; 3. Energy metabolism is controlled by a complex array of neural and hormonal signaling; 4. Energy imbalance disrupts the neural and hormonal signaling pathways of energy metabolism resulting in unfavorable health consequences such as pro-inflammatory state, oxidative stress, immune dysregulation, menstrual dysfunction, sarcopenia, and low bone mineral density; and 5. Exercise training can impact energy imbalance health-related outcomes. Learning Outcomes: Students will be able to 1. define energy balance and explain the components of energy expenditure; 2. define disordered eating, female athlete triad, and disordered eating; 3. explain the relationship among energy intake, energy expenditure, and body composition in energy imbalance; 4. describe alterations in skeletal muscle and adipose physiology in energy imbalance; 5. diagram neural control of feeding and energy homeostasis and hormonal control of energy metabolism; 6. explain the neural and hormonal changes that occur in chronic energy imbalance and describe current theories in how it results in menstrual dysfunction, inflammatory response, oxidative stress, immune dysregulation, sarcopenia, and low bone mineral density; and 7. explain how exercise training can influence inflammatory response, oxidative stress, immune function, and musculoskeletal health in energy imbalance. Offered as NTRN 361 and NTRN 461. Prereq: NTRN 201 or requisites not met permission.

NTRN 362. Exercise Physiology and Macronutrient Metabolism. 3 Units.
The purpose of this course is to provide students with the knowledge of theoretical and applied concepts of exercise physiology. Students will gain an understanding of the acute and chronic physiological responses and adaptations of the cardiovascular, metabolic, hormonal, and neuromuscular systems in response to exercise. Additional topics include factors effecting performance, assessing cardiorespiratory and muscular fitness, designing exercise programs for health and wellness, special populations, and athletes, environmental considerations and nutrition’s role in sport and exercise performance. Offered as NTRN 362 and NTRN 462. Prereq: NTRN 201 and BIOL 216.

NTRN 363. Human Nutrition I: Energy, Protein, Minerals. 3 Units.
Chemical and physiological properties of specific nutrients, including interrelationships and multiple factors, in meeting nutritional needs throughout the life cycle. Prereq: BIOL 216 and (Junior or Senior status).

NTRN 364. Human Nutrition II: Vitamins. 3 Units.
Chemical and physiological properties of vitamins, including interrelationships and multiple factors, in meeting nutritional needs throughout the life cycle. Prereq: NTRN 363.

NTRN 365. Nutrition for the Prevention and Management of Disease: Pathophysiology. 4 Units.
Interplay among etiology, metabolic perturbations, pathophysiology, clinical signs and symptoms, and nutrition principles for the prevention and management of disease. Prereq: NTRN 363 and BIOC 307 or equivalent or consent of instructor.

NTRN 366. Nutrition for the Prevention and Management of Disease: Clinical Applications. 3 Units.
Application of nutrition principles and knowledge for the prevention and management of disease. Case studies and other educational approaches and techniques will be used. Course includes evidence-based assessments and interpretation of key data (biochemical, dietary, physical) to develop nutritional interventions. Coreq: NTRN 365.

NTRN 367. Nutrition Strategies and Wellness Programming. 3 Units.
Wellness and its implication on nutritional choices will be explored in this class. Key concepts covered in this class include: 1. Overall well-being extends beyond smart dietary choices including social, emotional, spiritual, occupational, intellectual, and physical wellness. 2. The interrelationship among the wellness areas can alter adherence to a healthy diet. 3. Cultural differences in wellness exist and have an impact on nutritional choices. 4. Nutritional strategies must be individualized taking into account all aspects of wellness and cultural differences. 5. Interprofessional teams that include experts from each area of wellness are essential to provide optimal health care to individuals. Prereq: NTRN 201.
NTRN 368. THE BEST OF THE BEST: Nobel Prizes in Biomedical Research. 3 Units.
According to the will of Alfred Nobel, the prize that bears his name should be awarded "to the person(s) who shall have made the most important discovery within the domain of physiology or medicine (or chemistry)" that year. The Nobel awards are well known and highly publicized: they signify the "absolute best" - a concept close to the hearts of all, especially young students. Yet, the body of scientific work that has been carried out by the award recipient(s), and the criteria used to justify that particular choice are not trivial. Often, thorough understanding of complicated biological processes and experimental systems is required in order to fully appreciate why a particular discovery was chosen by the Nobel committee. In addition to covering in depth critical issues in biomedical research, the course will also address general questions: what is "best" or "most important"? How were the criteria developed and how applied? How do the criteria and findings endure the test of time? Offered as NTRN 368 and NTRN 468. Prereq: BIOC 307 and BIOC 308 and Senior standing.

NTRN 371. Special Problems. 1 - 3 Units.
Independent reading, research, or special projects supervised by a member of the nutrition faculty. Prereq: Junior or senior standing.

NTRN 388. Seminar in Sports Nutrition. 3 Units.
Study of energy and nutrient needs to support recreational exercise and competitive athletics, dietary supplements and specific foods and beverages that are marketed to athletes, and how nutrition can provide optimal muscle development, recovery and sports performance. Prereq: Junior or senior standing.

NTRN 390. Undergraduate Research. 3 - 9 Units.
Guided laboratory research in nutritional biochemistry or molecular nutrition under the sponsorship of a nutrition faculty member.

NTRN 397. SAGES Capstone Proposal Seminar. 3 Units.
In this departmental seminar course, students will conceptualize, develop and prepare a written plan, known as the "Capstone Proposal," for their senior Capstone project (NTRN 398: Senior Capstone Experience). Discussion will include, but not be limited to basic research principles, different types of research, ethics and IRB procedures. The Capstone Proposal shall include the project design, aims, methodology, budget, data analysis and presentation. Upon completion of this course, students will have confirmed student/Capstone advisor and, if applicable, mentor relationships, written a Capstone proposal and given an oral presentation of their proposal at a departmental colloquium. Counts as SAGES Departmental Seminar. Prereq: Declared Nutrition or Nutritional Biochemistry and Metabolism major and junior standing.

NTRN 397C. SAGES Capstone Proposal Seminar: Community. 3 Units.
This course fulfills the SAGES Department Seminar requirement. As such, it focuses on developing writing and discussion skills in your major area. This course will guide you through the process of selecting and planning your SAGES Capstone Experience (Community) to be completed in NTRN 398. Students will be matched to existing faculty projects in the Greater Cleveland community. Concurrent enrollment with any other SAGES requirement is not permitted. Counts as SAGES Departmental Seminar. Prereq: Nutrition major with Junior standing. Completed SAGES First Seminar and both SAGES University Seminars.

NTRN 397R. SAGES Capstone Proposal Seminar: Research. 3 Units.
This course fulfills the SAGES Department Seminar requirement. As such, it focuses on developing writing and discussion skills in your major area. This course will guide you through the process of selecting and planning your SAGES Capstone Experience to be completed in NTRN 398. Students will be matched to existing faculty research projects for their capstone experience. Concurrent enrollment with any other SAGES requirement is not permitted. Counts as SAGES Departmental Seminar. Prereq: Nutrition major with Junior standing. Completed SAGES First Seminar and both SAGES University Seminars.

NTRN 398. SAGES Senior Capstone Experience. 3 Units.
Students will implement their "Capstone Proposal" projects as designed in NTRN 397: Capstone Proposal Seminar. Pertinent research activities will depend on the nature of the student's "Capstone Proposal" project. The student will meet regularly with their Capstone advisor, at least twice monthly, to provide progress reports, discuss the project, and for critique and guidance. By the end of this course, the student will have completed their SAGES Senior Capstone research project and presented their project results/findings orally at the Senior Capstone Fair and at a departmental colloquium. Counts as SAGES Senior Capstone. Prereq: NTRN 397.

NTRN 399. Senior Project. 3 Units.

NTRN 401. Nutrition for Community and Health Care Professionals. 2 - 3 Units.
This course will focus on understanding how diet and nutrition impact health and wellness throughout the life cycle. There are core concepts in human nutrition that all health care providers should understand to optimize their care of individuals, themselves, and the community. These core concepts are the focus of this course. Students who complete all course modules and assignments with a passing grade will earn 2 credits. In order to earn 3 credits, students must complete all course modules and assignments with a passing grade and complete an additional 20 page paper on a nutrition topic approved by the instructor.

NTRN 402. Culinary and Lifestyle Medicine Coaching I. 1-3 Units.
This course will focus on learning the key components of healthy lifestyle principles* and develop the counseling and behavior change skills necessary to promote these competencies to advocate a healthy lifestyle. Participation in culinary medicine food labs, (which is the blending of the science of nutrition with skills in fundamental cooking and food education) is also a key component of this class. Culinary medicine is designed to foster a greater understanding of the core principles in medical nutrition therapy and foundational food and nutrition education, which is critical to overall well-being. Students will also have the elective opportunity to participate in the first core online tele-class module towards certification as a health coach by Wellcoaches®. Module 1 is the required first step towards a Wellcoaches® health coaching certification, with two additional online/hybrid modules required to participate in the certification exam, (modules 2 and 3 not provided by the University). These remaining modules and accompanying oral and written skill assessments must be completed within an 18 month period of time after completion of Module 1 to be fully eligible for the Wellcoach® Health Coach certificate. Certification as a Health and Wellness Coach is available for health care professionals. Certified Personal Coach is available for the non-health care professional. See wellcoaches website link for more program details, (found under student outcomes).
NTRN 410. Basic Oxygen & Physiological Function. 3 Units.
On-line lecture only course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as NTRN 410 and PHOL 410.

NTRN 433. Advanced Human Nutrition I. 4 Units.
Emphasis on reading original research literature in energy, protein and minerals with development of critical evaluation and thinking skills. Recommended preparation: NTRN 201 and CHEM 223 and BIOL 348 or equivalent.

NTRN 434. Advanced Human Nutrition II. 3 Units.
Emphasis on reading original research literature on vitamins with development of critical evaluation and thinking skills. Recommended preparation: NTRN 433 or consent.

NTRN 435. Nutrition during Pregnancy and Lactation. 3 Units.
Study of current research literature on nutrition for pregnancy and lactation including nutrient requirements, nutrition assessment, and nutrition intervention. Prereq: Graduate Student in Nutrition or Public Health Nutrition or (NTRN 363 and NTRN 364) or requisites not met permission.

NTRN 436. Pediatric Nutrition. 3 Units.
This course will focus on understanding the nutritional needs of infants, children and adolescents. Evidence based guidelines will be used as we discuss best clinical practice for the management of pediatric nutrition issues. Anthropometric measurements used in growth assessment will be reviewed. Nutrient requirements for each stage of development will be explored with a specific focus on micronutrients relevant to pediatrics such as fluoride, iron, calcium and vitamin D. Abnormal growth resulting in malnutrition and obesity will be examined with a focus on prevention, diagnosis and treatment. Skills necessary to complete a pediatric nutrition assessment will be reviewed with opportunities to practice and demonstrate competency. Prereq: NTRN 435.

NTRN 437. Nutrition Communication, Counseling and Behavior Change Strategies. 3 Units.
How do we help someone make a dietary behavior change, such as choosing a side salad instead of fries when eating a hamburger? Yes, it is a very challenging task and most often, providing just nutrition education is not sufficient. Therefore, the focus of this course is to prepare students for their future career by providing fundamental knowledge about human decision making and developing communication skills that can help improve others nutritional well-being. In addition, the course will critically evaluate and interpret nutrition information for the consumer. Changes in food marketing and sources of nutrition information for consumers over the past five decades will be analyzed and discussed. Furthermore, the impact of nutrition labeling, the food industry and food marketing on the dietary intake of Americans and various demographic groups in the U.S. will be studied. Offered as NTRN 337 and NTRN 437 Prereq: NTRN 201 or Requisites Not Met permission.

NTRN 438. Dietary Supplements. 3 Units.
An examination of dietary supplements specific to health promotion and disease prevention/treatment throughout the life cycle. Topics and concepts include regulation, controversies, safety, efficacy, and the surrounding scientific evidence for dietary supplement use. For NTRN 338, preference will be given to senior level Nutrition majors. Offered as NTRN 338 and NTRN 438. Prereq: NTRN 364 or requisites not met permission.

NTRN 439. Food Behavior: Physiological, Psychological and Environmental Determinants. 3 Units.
Good dietary habits are associated with improved population health. Despite this, a large proportion of individuals do not meet current dietary recommendations and there are significant disparities between groups based on sociodemographic characteristics. Why is this? Traditional views on this question focused solely on individual decision making without taking into account the complex influence of biology, social forces, and environment on dietary behavior. This course will introduce students to the major influences on dietary behavior and their interactions and modifying factors in the context of the socioecological model.

NTRN 440. Nutrition for the Aging and Aged. 3 Units.
Consideration of the processes of aging and needs which continue throughout life. The influences of food availability, intake, economics, culture, physical and social conditions and chronic disease as they affect the ability of the aged to cope with living situations. Recommended preparation: Nutrition major or consent of instructor.

NTRN 441. Human Lactation. 3 Units.
This course explores the complexities and importance of human milk and breastfeeding. Using lectures, group discussion, and experiential learning we will explore the following topics: nutrition and development in the breastfeeding infant/mother dyad; the physiology of breastfeeding; maternal and infant disease states and their effects on breastfeeding; common pathologies in breastfeeding; pharmacology and breastfeeding; psychological, social, and cultural issues and breastfeeding; clinical skills and techniques in advising the breastfeeding mother; public health, ethical, and legal issues in breastfeeding and breastfeeding advocacy; current research topics in breast milk and breastfeeding; and options for certification in lactation education. Prereq: NTRN 363 or NTRN 433 or NTRN 401 or Requisites Not Met permission.

NTRN 446. Advanced Maternal Nutrition: Special Topics. 3 Units.
Analysis of the problems commonly associated with high-risk pregnancies and fetal outcome. Discussion of causes, mechanisms, management and current research. Recommended preparation: NTRN 435 or consent.

NTRN 448. Integrative and Functional Nutrition. 3 Units.
An examination of the core concepts and principles surrounding integrative and functional medical nutrition therapy (IFMNT). The course will emphasize a whole systems approach to addressing clinical imbalances and creating personalized therapeutic interventions based upon an individual's genetics, environment and lifestyle. Topics include precision medicine, IFMNT nutrition care plan processes, IFMNT laboratory tests and interpretation, dietary supplementation, and discussion of the evidence for integrative therapeutic nutrition/diet plans related to the gut microbiome/gastrointestinal disorders, food sensitivity/intolerance, methylation, immune function, detoxification, cardiometabolic intervention, energy, hormones, and wellness.
NTRN 451. Food Service Systems Management. 3 Units.
The application of organizational theory and skills in the preparation and service of quantity food. Laboratory experience in professional food services are included. Graduate students will analyze one aspect of food service management in depth. Offered as NTRN 351 and NTRN 451. Prereq: Nutrition major.

NTRN 452. Nutritional Biochemistry and Metabolism. 3 Units.
Mechanisms of regulation of pathways of intermediary metabolism; amplification of biochemical signals; substrate cycling and use of radioactive and stable isotopes to measure metabolic rates. Recommended preparation: BIOC 307 or equivalent. Offered as BIOC 452 and NTRN 452.

NTRN 454. Advanced Nutrition and Metabolism: Investigative Methods. 3 Units.
Lecture/discussion course on the use of analytical techniques in metabolic research on whole body metabolism, energy balance, and disease (diabetes, obesity, and neuropathologies); discussions include the design of in-vitro and in-vivo investigative protocols in humans and animals using stable isotope tracer and mass spectrometric analysis; critical interpretation of data from the literature with emphasis on metabolic pathway identification, regulation and kinetics. Recommended preparation: BIOC 407.

NTRN 455. Molecular Nutrition. 3 Units.
Students will gain in-depth understanding of the basic science and translational aspects of 'hot topics' in current molecular nutrition. Class will be conducted by interactive discussion of assigned primary research articles. Prereq: BIOC 407 or Requisites Not Met permission.

NTRN 456. Pediatric Obesity. 3 Units.
This is an upper-level, discussion- and case-based course. This course will examine the epidemiology, potential causes, assessment, and treatment of pediatric obesity. Special topics from the current pediatric obesity literature will also be covered. This course has a large discussion component and incorporates weekly readings from the scientific literature. Class sessions take place via synchronous, web-based video conferencing with additional asynchronous video lectures and course work each week. Prereq: MS student in Nutrition or Requisites Not Met permission.

NTRN 459. Diabetes Prevention and Management. 3 Units.
In this course, we will explore the diabetes epidemic, its effects on the healthcare system, and strategies for prevention. The pathophysiology of the disease will be examined as well as environmental factors leading to the increase in diagnoses. Comorbid conditions and acute and chronic complications of diabetes and hyperglycemia will be addressed. Rationale for current therapeutic strategies will be explored, including the use of blood glucose monitoring, physical activity, nutrition counseling, oral medications, and insulin therapy. Patient education and health literacy will be studied in the context of patient centered goal setting. Requirements for developing a Diabetes Self-Management Education Program will be discussed. Community program development will be examined in the context of population-based prevention strategies. Prereq: Graduate Standing.

NTRN 460. Sports Nutrition. 3 Units.
Study of the relationships of nutrition and food intake to body composition and human performance. Laboratory sessions include demonstrations of body composition and fitness measurements and participation in a research project. Recommended preparation: NTRN 363 or NTRN 433 or consent.

NTRN 461. Metabolic Dysregulation of Energy from Obesity to Anorexia. 3 Units.
Energy imbalance and the implications on health will be explored in this course. Key concepts covered in this class include: 1. Energy imbalance refers to positive and negative states of energy balance and occurs when energy intake does not match energy expended in metabolic processes, daily living activities, and physical activity; 2. Obesity is a result of chronic positive energy balance whereas anorexia nervosa is a condition of chronic negative energy balance; 3. Energy metabolism is controlled by a complex array of neural and hormonal signaling; 4. Energy imbalance disrupts the neural and hormonal signaling pathways of energy metabolism resulting in unfavorable health consequences such as pro-inflammatory state, oxidative stress, immune dysregulation, menstrual dysfunction, sarcopenia, and low bone mineral density; and 5. Exercise training can impact energy imbalance health-related outcomes. Learning Outcomes: Students will be able to 1. define energy balance and explain the components of energy expenditure; 2. define disordered eating, female athlete triad, and disordered eating; 3. explain the relationship among energy intake, energy expenditure, and body composition in energy imbalance; 4. describe alterations in skeletal muscle and adipose physiology in energy imbalance; 5. diagram neural control of feeding and energy homeostasis and hormonal control of energy metabolism; 6. explain the neural and hormonal changes that occur in chronic energy imbalance and describe current theories in how it results in menstrual dysfunction, inflammatory response, oxidative stress, immune dysregulation, sarcopenia, and low bone mineral density; and 7. explain how exercise training can influence inflammatory response, oxidative stress, immune function, and musculoskeletal health in energy imbalance. Offered as NTRN 361 and NTRN 461. Prereq: NTRN 201 or requisites not met permission.

NTRN 462. Exercise Physiology and Macronutrient Metabolism. 3 Units.
The purpose of this course is to provide students with the knowledge of theoretical and applied concepts of exercise physiology. Students will gain an understanding of the acute and chronic physiological responses and adaptations of the cardiovascular, metabolic, hormonal, and neuromuscular systems in response to exercise. Additional topics include factors effecting performance, assessing cardiorespiratory and muscular fitness, designing exercise programs for health and wellness, special populations, and athletes, environmental considerations and nutrition's role in sport and exercise performance. Offered as NTRN 362 and NTRN 462. Prereq: Nutrition Major.

NTRN 468. THE BEST OF THE BEST: Nobel Prizes in Biomedical Research. 3 Units.
According to the will of Alfred Nobel, the prize that bears his name should be awarded "to the person(s) who shall have made the most important discovery within the domain of physiology or medicine (or chemistry)" that year. The Nobel awards are well known and highly publicized: they signify the "absolute best" - a concept close to the hearts of all, especially young students. Yet, the body of scientific work that has been carried out by the award recipient(s), and the criteria used to justify that particular choice are not trivial. Often, thorough understanding of complicated biological processes and experimental systems is required in order to fully appreciate why a particular discovery was chosen by the Nobel committee. In addition to covering in depth critical issues in biomedical research, the course will also address general questions: what is "best" or "most important"? How were the criteria developed and how applied? How do the criteria and findings endure the test of time? Offered as NTRN 368 and NTRN 468.
NTRN 470A. Nutrient Drug Interactions: Introduction. 1 Unit.
We rely on the gastrointestinal system for processing not only food and beverages but also drugs. The mass of ingested food (100's of grams) exceeds that of most drugs (a few mg) by 10,000-fold or more. Nutrients and drugs follow similar processes through absorption, distribution, metabolism and excretion. Nutritional state is also a powerful determinant of drug action. Drugs have potent effects on nutritional status. Conversely, nutrition modifies the action of drugs. Herbal supplements and functional foods have properties of both foods and drugs, but are regulated by the FDA as foods. Flavonoids from foods have mild medicinal properties and interact with multiple drug metabolizing pathways. Current teaching around nutrient-drug interactions consists almost entirely of listings of potential interactions, or interactions that have been reported in humans as seldom as a single instance. Fortunately, most nutrient drug interactions are not dangerous and have a low potential for seriousness. Clinical impact is great only for those drugs with a low therapeutic index, meaning that the threshold concentration for toxicity is close to the concentration needed for therapeutic efficacy. To identify these potentially life-threatening interactions, health care professionals should learn more about the principles of pharmacology. Electrolyte imbalances such as high or low plasma levels of potassium, magnesium and calcium are a common side effect of frequently prescribed medications. The role of nutrition in drug interactions and preferences in the incidence and severity of these side effects is not known. NTRN 452 is recommended but not required. Prereq: Graduate standing.

NTRN 470B. Nutrient Drug Interactions: Pharmacology. 1 Unit.
Foods affect every stage of drug kinetics from dissolution of tablets and capsules, through absorption, distribution, metabolism and excretion. Nutritional state is also a powerful determinant of drug action. Herbal supplements and functional foods have properties of both foods and drugs, but are regulated by the FDA as foods. Flavonoids from foods have mild medicinal properties and interact with multiple drug metabolizing pathways. Current teaching around nutrient-drug interactions consists almost entirely of listings of potential interactions, or interactions that have been reported in humans as seldom as a single instance. Fortunately, most nutrient drug interactions are not dangerous and have a low potential for seriousness. Clinical impact is great only for those drugs with a low therapeutic index, meaning that the threshold concentration for toxicity is close to the concentration needed for therapeutic efficacy. To identify these potentially life-threatening interactions, health care professionals should learn more about the principles of pharmacology. Electrolyte imbalances such as high or low plasma levels of potassium, magnesium and calcium are a common side effect of frequently prescribed medications. The role of nutrition in drug interactions and preferences in the incidence and severity of these side effects is not known. NTRN 452 is recommended but not required. Prereq: Graduate standing.

NTRN 470C. Nutrient Drug Interactions: Clinical Applications. 1 Unit.
The clinical management of patients and clients must integrate pharmaconterapeutics with nutrition based care plans. Drugs can affect nutritional needs and conversely nutrition can modify the efficacy of drugs. Disease states modify the actions of both nutrients and drugs as well as their interactions. Distinct nutrient-drug interactions are prominent in different patient populations. NTRN 452 is recommended but not required. Prereq: Graduate standing and NTRN 470A.

NTRN 516. Seminar in Dietetics I. 4 Units.
Study of evidence-based guidelines for dietetic practice in medical nutrition therapy. Emphasis on life cycle stages and common disease states that require specialized nutrition care. Enrollment restricted to those accepted into Case Coordinated Dietetic Internship/Master Degree Program.

NTRN 517. Seminar in Dietetics II. 4 Units.
Study of scientific basis for clinical and community nutrition practice and developments in food service systems management. Recommended preparation: Dietetic internship.

NTRN 528. Introduction to Public Health Nutrition. 3 Units.
An introduction to the field of public health/community nutrition with a focus on three key themes: (1) The role of nutrition in population based health, (2) the multilevel nature of key influences on dietary behavior, and (3) skills needed to be a successful public health practitioner. Prereq: Graduate Student in Nutrition or Public Health Nutrition or Requisites Not Met permission.

NTRN 529. Nutritional Epidemiology for Evidence Based Health Practice. 3 Units.
This course is designed to establish the foundation in evidence based practice (EBP), which requires you to understand clinical and epidemiological study design and statistical interpretation. It also establishes basic scientific writing skills to ensure students are well prepared for future graduate courses and a career in the medical sciences. The course is based on the core competencies in evidence-based practice for health professionals (Albarqouni et al, JAMA Network Open 2018). In this consensus statement, the authors divide EBP into five steps: (1) Ask, (2) Acquire, (3) Appraise and Interpret, (4) Apply and (5) Evaluate, all of the skills which are developed in this course. Students will work together online to understand how to apply these 5 steps to understand the current research literature to answer questions that might arise in health sciences practice and to identify gaps in the literature that require developing their own research questions.

NTRN 530. Public Health Nutrition. 3 Units.
Exploration of the professional role of the Public Health Dietitian/Nutritionist with a focus on three key themes: (1) The conduct of research and interpretation of research findings related to public health nutrition; (2) development of skills in the domains of public health management, program design and implementation, and communications and marketing; and (3) approaches to thinking about public health more broadly through the use of entrepreneurship and community building. Prereq: Graduate Student in Nutrition or Public Health Nutrition or Requisites Not Met permission.

NTRN 531. Public Health Nutrition Field Experience. 1 - 6 Units.
Individually planned public health experience. May be concurrent with course work in local agencies or in blocks of full-time work with a city, county, or state health agency. Prereq: Open to public health nutrition students only. Consent of instructor.

NTRN 532C. Specialized Public Health Nutrition Field Experience. 1 - 3 Units.
Individually arranged clinical experience. Prereq: Public Health Nutrition students only. Consent of instructor.

NTRN 533. Nutritional Care of Neonate. 3 Units.
Nutritional assessment and management of high-risk newborns with emphasis on prematurity and low birth weight. Review of current literature coordinated with clinical experience in the neonatal intensive care unit. Issues on follow-up included. Recommended preparation: NTRN 435 or consent.

NTRN 534. Advanced Public Health Nutrition Field Experience. 1 - 6 Units.
Individually planned advanced public health experience. Prereq: Open to public health nutrition students only.
NTRN 550A. Advanced Community Nutrition. 3 Units.
An introduction to the field of public health/community nutrition with a focus on three key themes: (1) The role of nutrition in population based health, (2) the multilevel nature of key influences on dietary behavior, and (3) skills needed to be a successful public health practitioner. Prereq: Senior Nutrition major or Requisites Not Met permission.

NTRN 551. Seminar in Advanced Nutrition. 1 Unit.
Ph.D. students meet weekly to discuss topical journal articles. Students gain experience in critical evaluation of research and develop presentation/communication skills. Discussion of research integrity and ethics. Students participate in departmental seminars with invited speakers.

NTRN 561. Investigative Methods in Nutrition. 1 - 4 Units.
Research methods appropriate for nutrition. Methods for conducting research in nutrition and food sciences, food service management and dietetics. Designing research proposals. Prereq: Nutrition major.

NTRN 562. Research Practicum. 1 - 4 Units.
Students will participate in nutrition-related research activities that employ a variety of research methodologies (clinical research, bench science, surveys, systematic reviews, etc.). Students will be engaged in the acquisition of scientific data, and data entry, analysis and interpretation.

NTRN 601. Special Problems. 1 - 18 Units.
Under the supervision of the instructor, the student will develop and/or implement an individual or group special project in global nutrition, community nutrition, wellness, or other area of food and nutrition practice. Prereq: Graduate Standing.

NTRN 610. Oxygen and Physiological Function. 1 Unit.
Lecture/discussion course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include oxygen transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as ANAT 610, NTRN 610, and PHOL 610.

NTRN 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

NTRN 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Department of Pathology

Wolstein Research Building 5537
http://www.case.edu/med/pathology/
Phone: 216.368.1993; Fax: 216.368.0494
Clifford V. Harding, MD, PhD, Chair
clifford.harding@case.edu
Christine Kehoe (christine.kehoe@case.edu), Student Affairs

The clinical, research and educational activities of the CWRU Department of Pathology (https://case.edu/medicine/pathology) are centered at CWRU School of Medicine and University Hospitals Cleveland Medical Center (UHMC). There are five Divisions within the Department, including two basic science units housed in the School of Medicine (the Division of Experimental Pathology and the Center for Global Health and Diseases) and three clinical divisions housed at University Hospitals (the Division of Anatomic Pathology, the Division of Clinical Pathology, and the Division of Community Hospitals Pathology). In addition, our affiliates include the Cuyahoga County Medical Examiner’s Office and the Pathology Department at the Louis Stokes Cleveland VA Medical Center.

The CWRU Department of Pathology NIH funding level is ranked in the top 10 nationally. World-class research is conducted in the department in many areas with the largest research focus areas being, immunology, cancer biology and neurodegenerative diseases. The department’s research activities are characterized by highly cooperative and collaborative interactions within the department, and with many other departments at Case and its affiliated institutions. Research laboratories of the department are located primarily in the Wolstein Research Building and Institute of Pathology.

Educational programs include graduate programs, clinical residency and fellowships and contributions to medical student and undergraduate teaching. The Pathology Graduate Program includes a PhD program with three constituent training programs (Immunology Training Program, Cancer Biology Training Program, Molecular and Cellular Basis of Disease Training Program) and two MS programs (Plan A and Plan B). For information about graduate programs, please see here (https://case.edu/medicine/pathology). The Pathology Residency includes 24 residency training positions, and the Department provides three clinical fellowship programs (Cytopathology, Hematopathology and Transfusion Medicine). For information about the Pathology Residency, please see here (https://case.edu/medicine/pathology/training/residency-and-clinical-fellowships).

Master’s Degrees

MS in Pathology (Plan B)

The Molecular and Cellular Basis of Disease (MCBD) Program is intended for students with a background in the biological sciences who are interested in pursuing advanced coursework in the basis of disease. The core curriculum and electives include many topics of medical relevance, including cell and molecular biology, disease pathogenesis, cancer biology, immunology, histology, and gross anatomy. This coursework may be useful for those interested in pursuing a professional doctoral degree (e.g., MD, DO, PhD, DDS, or DMD) or opportunities in basic or clinical research, teaching, biotechnology, pharmaceuticals, healthcare, or government. Our standard program is now 16 months. The time of matriculation in the MCBD Program is flexible; a typical time to degree for the full-time program is 3 semesters, but extended (21 month) and accelerated 12-month programs are also available. The course of study will be determined by the student, their Academic advisor, and the Graduate Program Committee and will consist of 30 credit hours of coursework plus a final project. Flexible electives allow students to focus on an area of interest. While the Master’s may be a terminal degree, it may also lead to admission to doctoral programs.

For information on the Pathology MS Program, please contact Pamela Wearsch, PhD, paw28@case.edu/216.368.5059, or Christy Kehoe, cxk15@case.edu/216.368.1993.

Description of Program

Students will earn a Plan B Masters from Case Western Reserve University. The degree program is comprised of core courses in cell biology and disease pathogenesis (PATH 475 Cell and Molecular Foundations of Pathology or IBMS 455 Molecular Biology I/IBMS 453 Cell Biology I; PATH 510 Basic Pathologic Mechanisms), 2 concentration electives coursework from related disciplines, and a comprehensive
final project in the form of a review paper that will ideally be suitable for publication. The topic of the review paper will be determined by the student and their academic advisor. In the final two semesters, student will register for 1-3 credits of PATH 650 Independent Study while writing their paper. An advisor for the paper should be identified by mutual interest during the first year.

Typical Curriculum

First Year

<table>
<thead>
<tr>
<th>FALL REQUIREMENTS (choose one):</th>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
<th>Summer</th>
</tr>
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<tbody>
<tr>
<td>Cell and Molecular Foundations of Pathology (PATH 475)</td>
<td>3-6</td>
<td></td>
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<tr>
<td>Cell Biology I (IBMS 453) or Molecular Biology I (IBMS 455)</td>
<td></td>
<td>3-7</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>FALL ELECTIVES (choose one or two):</th>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)</td>
<td>3-7</td>
<td></td>
<td></td>
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<tr>
<td>Introduction to Clinical Inquiry (IQ) (MGRD 410)</td>
<td>4</td>
<td></td>
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</tbody>
</table>

Histology and Ultrastructure (ANAT 412)

SPRING REQUIREMENTS:

| Basic Pathologic Mechanisms (PATH 510) | 4     |
| Independent Study (PATH 650) | 1     |

SPRING ELECTIVES (choose one or two):

| Fundamental Immunology (PATH 416) | 3-7   |
| Neurodegenerative Diseases: Pathological, Cell. & Molecular Perspectives (PATH 444) |       |
| Basic Cancer Biology and the Interface with Clinical Oncology (PATH 406) |       |
| Experimental Pathology Seminar II (PATH 512) |       |
| Immunology Journal Club (PATH 513) |       |

SUMMER TERM: Optional coursework and activities

| Cadaver dissection-based human anatomy with histology and physiologic correlations (ANAT 410) | 0-6   |
| Students may apply to laboratories to do research projects in related fields (e.g. cancer, immunology, neuropathology) |       |
| Pre-professional students may wish to spend time on school applications |       |

Year Total: 10-17 8-12

Second Year

<table>
<thead>
<tr>
<th>FALL REQUIREMENTS:</th>
<th>Fall</th>
<th>Units</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Study (PATH 650)</td>
<td>3-7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FALL ELECTIVES (choose two or three for 16 month standard program):

Current Topics in Cancer (PATH 422)
Advanced Immunobiology (PATH 465)
Immunology of Infectious Diseases (PATH 481)
Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection (PATH 525)
Aging and the Nervous System (PATH 410)
Experimental Pathology Seminar I (PATH 511) ( )

Immunology Journal Club (PATH 513)

Other electives upon approval

Year Total: 4-10

Total Units in Sequence: 22-45

Admission Criteria

Applicants will be screened by the Pathology Department Admissions Committee. Students will be required to supply a GRE, MCAT, DAT, or USMLE score, a transcript, three letters of recommendation and an application essay that details the student’s interest in the Program. Students will be interviewed on campus or via electronic media (i.e. FaceTime or Skype). Although there are no set requirements, successful applicants would be expected to have an MCAT >500, GRE verbal and quantitative >150, and an undergraduate GPA around 3.0. Applications are accepted on a rolling basis for matriculation during any academic term.

Tuition

Financial aid will not be provided by the Department. Students may apply for financial aid through the federal government at http://www.fafsa.ed.gov/.

MS in Pathology (Plan A)

A part-time program leading to the Master of Science degree in Pathology is available to laboratory staff who are employed by Case Western Reserve University. Students in this program must be full-time university employees and must have the agreement of their supervisor to begin studies as a part-time student. Courses are available as an employee fringe benefit (up to 6 credits per semester for Fall and Spring, and 3 credits for Summer) and can only be taken as limited by the fringe benefit regulations.

A formal application for this program must be submitted to the graduate school. Prior to submission of this application, the employee, the supervisor, and the Director of the Pathology Graduate Program must meet to review and facilitate the student’s application for admission.

This program can lead to a MS degree through Plan A. Required core courses include IBMS 453 Cell Biology I (3 credits), IBMS 455 Molecular Biology I (3 credits), PATH 510 Basic Pathologic Mechanisms (4 credits), and participation in a seminar course (PATH 511 Experimental Pathology Seminar I and/or PATH 512 Experimental Pathology Seminar II) for at
least one semester. IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I and must be taken as graded courses (not P/F).

Plan A requires a minimum of 30 total coursework credits. In addition to the required core courses, the student must take a minimum of 6 credits of PATH 651 Thesis M.S. Thesis, which involves research in the laboratory of the supervisor (who serves as the MS Thesis Mentor) and thesis preparation. The student must register for at least one credit of PATH 651 Thesis M.S. every semester until graduation. A GPA of 2.75 or better must be maintained for a terminal MS degree. (Students considering using the MS in Pathology as a "stepping stone" to the PhD degree must maintain a GPA of 3.0 or better.) An MS thesis must be prepared based on the research, and the student must pass an MS Degree Examination in which the thesis is defended.

**MD/MS Biomedical Investigation—Pathology Track**

For Program Admissions and MD requirements, see MD Dual Degree Programs (p. 27). This track is designed to provide students with an in-depth understanding of the cellular basis of disease or immunity. During the first year of medical school, the student should identify a mentor and begin planning coursework and a research project leading to the MS degree. Because the background and interest of applicants vary widely, members of the Program Oversight Committee will assist each student in designing an individualized schedule of graduate courses for any track.

Students are expected to complete at least two graduate courses (3 credits each or total 6 credits) before beginning the laboratory research period (year 3), and students should take three graduate courses before the research period if this is possible. For students to receive graduate credit for any medical coursework (as IBIS credit, e.g. IBIS 403 Integrated Biological Sciences III), they must register at the beginning of the semester. Students in the MD/MS joint degree program must attain a cumulative GPA of 3.0 in the graduate courses. Students in this program may participate in any of the three tracks of the Department of Pathology Graduate Program.

For information about the Pathology Track in the MD/MS program, contact Pamela Wearsch, PhD, paw28@case.edu/216.368.5059, or Christy Kehoe, cxk15@case.edu/216.368.1993.

**Students in the Pathology track must complete:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PATH 601</td>
<td>Special Problems</td>
<td>18</td>
</tr>
<tr>
<td>PATH 511</td>
<td>Experimental Pathology Seminar I</td>
<td>1</td>
</tr>
<tr>
<td>or PATH 512</td>
<td>Experimental Pathology Seminar II</td>
<td>1</td>
</tr>
<tr>
<td>IBIS 600</td>
<td>Exam in Biomedical Investigation</td>
<td>0</td>
</tr>
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</table>

**And 9 credits from the Pathology courses listed below or other Approved courses.** Other department’s graduate level course may be accepted provided it is appropriate to the student’s project and is approved by his/her Thesis Committee or the Graduate Program Director in Pathology.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>PATH 410</td>
<td>Aging and the Nervous System</td>
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<td>PATH 416</td>
<td>Fundamental Immunology</td>
<td>4</td>
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<tr>
<td>PATH 430</td>
<td>Oxidative Stress and Disease Pathogenesis</td>
<td>1</td>
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<tr>
<td>PATH 444</td>
<td>Neurodegenerative Diseases: Pathological, Cell. &amp; Molecular Perspectives</td>
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</tr>
<tr>
<td>PATH 510</td>
<td>Basic Pathologic Mechanisms</td>
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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>PATH 525</td>
<td>Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection</td>
<td>3</td>
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</table>

**Example Plan of Study of Minimum Coursework:**

**First Year**

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<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td>MD Curriculum Graduate course*</td>
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<tr>
<td>MD Curriculum</td>
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<tr>
<td>Special Problems (PATH 601) (optional)</td>
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**Second Year**

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<tr>
<td>Integrated Biological Sciences III (IBIS 403)</td>
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<tr>
<td>Graduate Course*</td>
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<tr>
<td>Graduate Course*</td>
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**Third Year**

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<tr>
<td>Special Problems (PATH 601)</td>
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<tr>
<td>Special Problems (PATH 601)</td>
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<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
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<tr>
<td>or Experimental Pathology Seminar II (PATH 512)</td>
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<tr>
<td>Exam in Biomedical Investigation (IBIS 600)</td>
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**Fourth Year**

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**Fifth Year**

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<tr>
<td>Year Total:</td>
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Total Units in Sequence: 32-34

* 15 graded credits of graduate school courses should be taken in the first 2 years, including IBIS 403 Integrated Biological Sciences III (6 credits) and three PATH graduate courses (3 credits each). Students may defer a maximum of one 3-credit hour course to Year 3.
PhD in Pathology

PhD Training in the Pathology Graduate Program occurs in three tracks that share a common core curriculum but provide additional track-specific curricular offerings. This provides a cohesive program that addresses the specific needs of different Pathology-related areas of research training. Section II of the handbook “Pathology PhD Program” describes core features of the program that are shared and provides detailed descriptions of the three training tracks:

- Molecular and Cellular Basis of Disease Training Program (MCBTP)
- Immunology Training Program (ITP)
- Cancer Biology Training Program (CBTP)

To earn a PhD in Pathology, a student must complete rotations in at least three laboratories followed by selection of a research advisor, and complete Core and Elective coursework including responsible conduct of research as described in the Course of Study, below. Students who previously completed relevant coursework, (for example, with a MS) may petition to complete alternative courses. Each training track follows the overall regulations established and described in CWRU Graduate Studies and documented to the Regents of the State of Ohio. Completion of the PhD degree will require 36 hours of coursework (24 hours of which are graded) and 18 hours of PATH 701 Dissertation Ph.D.

In addition, each PhD student must successfully complete a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. The qualifier is generally completed in the summer after year two. During the dissertation period, students are expected to meet twice a year with the thesis committee, present seminars in the department, and fulfill journal publication requirements. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program.

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

### Molecular and Cellular Basis of Disease Training Program (MCBTP)

#### First Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td>Cell Biology I (IBMS 453)</td>
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<tr>
<td>Molecular Biology I (IBMS 455)</td>
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<td></td>
<td></td>
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<tr>
<td>Research Rotation in Biomedical Sciences Training Program (BSTP 400)</td>
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<tr>
<td>Mentor and track chosen</td>
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<tr>
<td>Basic Pathologic Mechanisms (PATH 510)</td>
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<td>Fundamental Immunology (PATH 416)</td>
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<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
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<td></td>
<td></td>
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<tr>
<td>Thesis committee chosen; preproposal meeting scheduled</td>
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<td></td>
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<tr>
<td>Special Problems (PATH 601)</td>
<td>1-9</td>
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<tr>
<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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#### Second Year

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<th>Summer</th>
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<tbody>
<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
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<tr>
<td>MCBDTP Track Elective</td>
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<tr>
<td>MCBDTP Track or other Elective</td>
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<tr>
<td>Special Problems (PATH 601)</td>
<td>1-9</td>
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<tr>
<td>Thesis proposal defense and advancement to candidacy within next 9 months*</td>
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<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
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<tr>
<td>Electives (Core, MCBDTP track or other)</td>
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<td></td>
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<tr>
<td>Special Problems (PATH 601) or Dissertation Ph.D. (PATH 701)</td>
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<td></td>
<td></td>
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<tr>
<td>Thesis proposal defense and advancement to candidacy must be completed**</td>
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<tr>
<td>Year Total:</td>
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<td>6-16</td>
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#### Third Year

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<tbody>
<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
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</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
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<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
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<td>1</td>
</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
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<td>1-9</td>
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<td>2-10</td>
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#### Fourth Year

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<tbody>
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#### Fifth Year

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**Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)**

Total Units in Sequence: 43-126
Alternate courses for MSTP students: IBIS 401-404. MSTP students in the MCBDTP do not need to take IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I, PATH 510 Basic Pathologic Mechanisms or PATH 416 Fundamental Immunology although PATH 416 Fundamental Immunology may still be taken as a Track Elective

Alternate course is MSTP 400 Research Rotation in Medical Scientist Training Program for MSTP students and PATH 601 Special Problems for direct admit students

**Immunology Training Program (ITP)**

***First Year***

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**Third Year**

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**Fourth Year**

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**Fifth Year**

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**Total Units in Sequence:**

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Alternate course is MSTP 400 (http://bulletin.case.edu/search/?P=MSTP%20400) Research Rotation in Medical Scientist Training Program for MSTP students and PATH 601 (http://bulletin.case.edu/search/?P=PATH%20601) Special Problems for direct admit students

** PATH 520 (http://bulletin.case.edu/search/?P=PATH%20520) Basic Cancer Biology and the Interface with Clinical Oncology + PATH 521 (http://bulletin.case.edu/search/?P=PATH%20521) Special Topics in Cancer Biology and Clinical Oncology is included as a Track Elective for ITP students.

### Cancer Biology Training Program (CBTP)

#### First Year

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<td>Basic Pathologic Mechanisms (PATH 510)</td>
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<tr>
<td>Basic Cancer Biology and the Interface with Clinical Oncology (PATH 520)</td>
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<td>Special Topics in Cancer Biology and Clinical Oncology (PATH 521)</td>
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#### Fourth Year

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**Total Units in Sequence: 43-126**

* Alternative courses for MSTP students: IBIS 401-404. MSTP students in the CBTP do not need to take IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I, PATH 510 Basic Pathologic Mechanisms, or PATH 416 Fundamental Immunology, although PATH 416 Fundamental Immunology may still be taken as a Track Elective.

** Alternate course is MSTP 400 (http://bulletin.case.edu/search/?P=MSTP%20400) Research Rotation in Medical Scientist Training Program for MSTP students with PATH 601 (http://bulletin.case.edu/search/?P=PATH%20601) Special Problems for direct admit students.

Petition to convert 601 credits to 701 credits for semester in which advancement occurs

Once 36 credits including 24 graded credits have been completed, register for up to 6 credits of PATH 701 Dissertation Ph.D.

# Exception: Take 1-3 credits of PATH 701 Dissertation Ph.D.
Important: Students should take the following steps to reduce charges to their mentor and department: AFTER ADVANCE TO CANDIDACY, IT IS NO LONGER NECESSARY TO REGISTER FOR 9 CREDITS PER SEMESTER TO MAINTAIN FULL-TIME STUDENT STATUS. In the first semester after advancement to candidacy, students should register only for the number of credits of PATH 701 Dissertation Ph.D. needed to bring their total number of accumulated credits of PATH 701 to 9 by the end of the semester (and should register for no other courses).

In subsequent semesters, students should register for only 1 credit of PATH 701 (and no other courses), except that in the final semester registration should be for the number of credits of PATH 701 needed to complete a total of 18 credits by the end of the semester. EXCEPTION: IT IS IMPORTANT TO MAXIMIZE THE NUMBER OF PATH 701 CREDITS THAT CAN BE COMPLETED DURING PERIODS WHERE TRAINING GRANT SUPPORT IS AVAILABLE. If the student is on the NIH T32 training grant of NRSww award or other funding mechanism that supports this level of tuition, registration should be for the full 9 credits during semesters when grant support for tuition will be available, until a total of 18 credits of PATH 701 is accumulated, after which registration should be for only 1 credit of PATH 701 each semester until graduation. Even prior to advancing to candidacy, if a student has completed 36 "foundation" credits of graduate courses (at least 24 of which must be graded courses), the student should enroll in as many credits of PATH 701 as possible up to a maximum of 6 credits with the remaining credits to be graded courses or PATH 601. In the semester in which the student advances to candidacy, any PATH 601 credits for that semester that are beyond the 36 "foundation" credits should be converted to PATH 701 by petition to Graduate Studies. Students registering for PATH 601, PATH 651 or PATH 701 must indicate their thesis advisor as the Instructor. If a Class Section does not exist with your Thesis Advisor as Instructor, please see the Student Affairs Coordinator to add the Section in order for you to register.

NOTE: Schedule beyond year 5 will generally be the same as year 5.

Courses

PATH 316. Fundamental Immunology. 4 Units.
Introductory immunology providing an overview of the immune system, including activation, effector mechanisms, and regulation. Topics include antigen-antibody reactions, immunologically important cell surface receptors, cell-cell interactions, cell-mediated immunity, innate versus adaptive immunity, cytokines, and basic molecular biology and signal transduction in B and T lymphocytes, and immunopathology. Three weekly lectures emphasize experimental findings leading to the concepts of modern immunology. An additional recitation hour is required to integrate the core material with experimental data and known immune mediated diseases. Five mandatory 90 minute group problem sets per semester will be administered outside of lecture and recitation meeting times. Graduate students will be graded separately from undergraduates, and 22 percent of the grade will be based on a critical analysis of a recently published, landmark scientific article. Offered as BIOL 316, BIOL 416, CLBY 416, PATH 316 and PATH 416. Prereq: BIOL 215 and BIOL 218L.

PATH 390. Undergraduate Research in Cancer Biology, Immunology, or Pathology. 1 - 3 Units.
Students undertake a research project directly related to ongoing research in the investigator's/instructor's laboratory. Written proposal outlining research topic, a schedule of meetings and format and length of final written report to be prepared prior to registration for credit. Recommended preparation: One year of college chemistry and consent of instructor.

PATH 405. Discussions in Molecular Immunology (Health and Disease). 2 Units.
Targeted student population would be undergraduate (Biology major), PhD, MD, or MD/PhD students interested in emerging research on the mechanisms of molecular immunology and effects on health and defects in disease. Readings will be assigned, and students will come to class prepared for discussions. P/NP grades will be based on these discussions. 5 or fewer students will be selected for this class. Prereq: Undergraduate Biology majors, PhD, MD, or MD/PhD students.

PATH 406. Basic Cancer Biology and the Interface with Clinical Oncology. 3 Units.
This is a graduate-level introductory course in cancer biology taught through the Departments of Pharmacology and Pathology. This course will give students a broad overview of current basic cancer biology, highlight recent advances in cancer therapeutics, and provide a clinical perspective of the pathogenesis and treatment of common cancers. Classes will be of lecture and discussion format, and will also include student discussion of journal research articles to develop critical thinking in cancer research and experimental design as well as presentation/communication skills. About 1 to 3 students per class will be scheduled to lead the presentation and discussion of the selected journal articles. However, all students will be required to read the material in advance and be ready for discussion. Topics will cover growth factor action and signal transduction, oncogenes, tumor suppressor genes, DNA damage, apoptosis, cancer immunology, cancer stem cells, metastasis, angiogenesis, chemotherapy, radiation therapy, targeted therapeutics, photodynamic therapy, targeting cancer stem cells, chemoprevention, and clinical aspects of cancers of the breast, prostate, lymphatic tissue, and colon. Course grades for PHRM/PATH 520 (Ph.D. track): will be determined by class participation/presentation (40%), an original research grant proposal (35%) and written and oral critiques of two research proposals (25%). Course grades for PHRM/PATH 406 (M.S. and non-degree track): will be determined by class participation/presentation (40%), a literature review term paper (35%) and oral defense of term paper with course directors (25%). Presentations/Participation: Instructors will complete a standardized evaluation form to provide you uniform feedback in a timely manner. Required Reading: Assigned reviews, original articles (in blackboard) Recommended Reading: The Biology of Cancer (2nd Edition), by Robert A. Weinberg Garland Science, copyright 2014 Recommended Preparation: A course in Cell Biology. A course in Molecular Biology. Offered as PATH 406, PATH 520, PHRM 406 and PHRM 520.

PATH 410. Aging and the Nervous System. 1 Unit.
Lectures and discussion on aspects of neurobiology of aging in model systems; current research on Alzheimer's, Parkinson's, and Huntington's diseases.
PATH 416. Fundamental Immunology. 4 Units.
Introductory immunology providing an overview of the immune system, including activation, effector mechanisms, and regulation. Topics include antigen-antibody reactions, immunologically important cell surface receptors, cell-cell interactions, cell-mediated immunity, innate versus adaptive immunity, cytokines, and basic molecular biology and signal transduction in B and T lymphocytes, and immunopathology. Three weekly lectures emphasize experimental findings leading to the concepts of modern immunology. An additional recitation hour is required to integrate the core material with experimental data and known immune mediated diseases. Five mandatory 90 minute problem set per semester will be administered outside of lecture and recitation meeting times. Graduate students will be graded separately from undergraduates, and 22 percent of the grade will be based on a critical analysis of a recently published, landmark scientific article. Offered as BIOL 416, BIOL 416, CLBY 416, PATH 316 and PATH 416. Prereq: Graduate standing and consent of instructor.

PATH 417. Cytokines: Function, Structure, and Signaling. 3 Units.
Regulation of immune responses and differentiation of leukocytes is modulated by proteins (cytokines) secreted and/or expressed by both immune and non-immune cells. Course examines the function, expression, gene organization, structure, receptors, and intracellular signaling of cytokines. Topic include regulatory and inflammatory cytokines, colony stimulating factors, chemokines, cytokine and cytokine receptor gene families, intracellular signaling through STAT proteins and tyrosine phosphorylation, clinical potential, and genetic defects. Lecture format using texts, scientific reviews and research articles. Recommended preparation: PATH 416 or equivalent. Offered as BIOL 417, CLBY 417, and PATH 417.

PATH 418. Tumor Immunology. 3 Units.
Interactions between the immune system and tumor cells. Topics include the historical definition of tumor specific transplantation antigens, immune responses against tumor cells, the effects of tumor cell products on host immune responses, molecular identification of tumor specific transplantation antigens and recent advances in the immunotherapy of human cancers. Prereq: PATH 416.

PATH 420. Topics in Evolution and Medicine. 3 Units.
The course will be based primarily on the textbook, as well as additional readings to supplement this lucide but relatively brief introduction to the field. Topics to be covered include the overview of the relevance of evolution to medicine; human demography, history and disease; basic and evolutionary genetics; cystic fibrosis; life history trade-offs and the evolutionary biology of aging; cancer; host-pathogen interactions and co-evolution; somatic cell mutation, selection, and evolution in health and disease (not in textbook); sexually transmitted diseases; malaria; gene culture co-evolution; and man-made diseases. Recommended Preparation: Undergraduate knowledge of genetics, biochemistry, cell biology, microbiology, and immunology is advisable. Prior consultation and permission from the Course Director is strongly advised.

PATH 422. Current Topics in Cancer. 3 Units.
The concept of cancer hallmarks has provided a useful guiding principle in our understanding of the complexity of cancer. The hallmarks include sustaining proliferative signaling, evading growth suppressors, enabling replicative immortality, activating invasion and metastasis, inducing angiogenesis, resisting cell death, deregulating cellular energetics, avoiding immune destruction, tumor-promoting inflammation, and genome instability and mutation. The objectives of this course are to (1) examine the principles of some of these hallmarks, and (2) explore potential therapies developed based on these hallmarks of cancer. This is a student-driven and discussion-based graduate course. Students should have some background on the related subjects and have read scientific papers in their prior coursework. Students will be called on to present and discuss experimental design, data and conclusions from assigned publications. There will be no exams or comprehensive papers but students will submit a one-page critique (strengths and weaknesses) of one of the assigned papers prior to each class meeting. The course will end with a full-day student-run symposium on topics to be decided jointly by students and the course director. Grades will be based on class participation, written critiques, and symposium presentations. Offered as BIOL 420, MBIOL 420, PATH 422, and PHRM 420. Prereq: CBIO 453 and CBIO 455.

PATH 432. Current Topics in Vision Research. 3 Units.
Vision research is an exciting and multidisciplinary area that draws on the disciplines of biochemistry, genetics, molecular biology, structural biology, neuroscience, and pathology. This graduate level course will provide the student with broad exposure to the most recent and relevant research currently being conducted in the field. Topics will cover a variety of diseases and fundamental biological processes occurring in the eye. Regions of the eye that will be discussed include the cornea, lens, and retina. Vision disorders discussed include age-related macular degeneration, retinal ciliopathies, and diabetic retinopathy. Instructors in the course are experts in their field and are members of the multidisciplinary visual sciences research community here at Case Western Reserve University. Students will be exposed to the experimental approaches and instrumentation currently being used in the laboratory and in clinical settings. Topics will be covered by traditional lectures, demonstrations in the laboratory and the clinic, and journal club presentations. Students will be graded on their performance in journal club presentations (40%), research proposal (40%), and class participation (20%). Offered as NEUR 432, PATH 432, PHRM 432 and BIOL 432.

PATH 444. Neurodegenerative Diseases: Pathological, Cellular & Molecular Perspectives. 3 Units.
This course, taught by several faculty members, encompasses the full range of factors that contribute to the development of neurodegeneration. Subjects include pathological aspects, neurodegeneration, genetic aspects, protein conformation and cell biology in conditions such as Alzheimer’s disease, Parkinson’s disease, amyotrophic lateral sclerosis and prion diseases. Students read assigned primary literature and present and discuss these in class.
PATH 450. Interdisciplinary Musculoskeletal Research: Selected Topics and Grant Writing Workshop. 3 Units.
This is an introductory graduate course in MSK research topics, grant writing, and reviewing skills. During this course, each student will be introduced to diverse multidisciplinary topics in MSK research and will write a research grant on a MSK topic of his/her choice that is not regurgitation of their mentor’s grant. Students will also participate in editing and reviewing the proposals of their classmates. Proposals can form the basis of fellowship applications (F30/F31). For predocs, your department/program may allow the proposal to form the basis for the written component of your preliminary examination. Recommended Preparation: Current engagement in musculoskeletal research.

PATH 465. Advanced Immunobiology. 4 Units.
This course will cover fundamental (innate and adaptive responses, antigen recognition, cell activation, etc.) and applied (immune evasion, autoimmunity, allergy, transplantation, vaccines, etc.) immunology topics, highlighting the most important and recent advancements found in the primary literature. Lectures will be derived largely from the primary literature, but will also include modern techniques and fundamental background knowledge to enhance the learning environment for the immunology concepts presented. Course organization consists of two lectures per week by the immunology faculty, midterm and final examinations, and an oral presentation. Enrolled students have the option of concurrent enrollment in PATH 466 Writing for Immunologists. Prereq: PATH 416

PATH 466. Proposal Writing for Immunologists. 1 Unit.
This course is an introduction to research proposal writing and evaluation for immunology graduate students. One of the most important aspects of being an active investigator in academia, biotechnology, or pharmaceutical industries is being a skilled communicator of one’s ideas. This course is designed to teach these practical writing skills and will include lectures and discussions of key writing strategies. Throughout the semester, students will write a research proposal on a topic outside of their thesis research focus (but it can be related), present their ideas in front of the class, and take part in an end-of-semester review panel of the proposals of their classmates. Enrollment requires concurrent enrollment in PATH 465 Advanced Immunobiology and instructor permission. Prereq: PATH 416. Coreq: PATH 465

PATH 475. Cell and Molecular Foundations of Pathology. 3 Units.
This course is designed for M.S. students in the Pathology Graduate Program, and is an introductory course covering normal cell and molecular biology as well as cell physiology. Additional topics to be discussed in the course will include cell structure and function, as well as correlates to cellular and molecular pathology. Recommended Preparation: Should have undergrad-level cell biology and biochemistry.

PATH 480. Logical Dissection of Biomedical Investigations. 3 Units.
PATH 480 is an upper level graduate course encompassing discussion and critical appraisal of both published and pre-published research papers, book chapters, commentaries and review articles. Emphasis will be placed on evaluating the logical relationships connecting hypotheses to experimental design and experimental data to conclusions drawn. Thus, the course will aim to develop students’ capacities for independent thinking and critical analysis. Half of the course will be devoted to an analysis of fundamental conceptual issues pertaining to immunology, but this material will be applicable to a wide variety of fields. The other half of the course will be devoted to the analysis of papers that have been submitted for publication (with the students acting as primary reviewers of these papers). Our expectation is that this course will have practical relevance for students by providing them with methods to review their own prepublication manuscripts and eliminate common errors. It should also give students the tools to question widely held beliefs in diverse biomedical fields. Recommended preparation is completion of the C3MB curriculum and 2nd year or higher graduate school training. Previous exposure to immunology and molecular biology will be helpful but not required.

PATH 481. Immunology of Infectious Diseases. 3 Units.
This course centers on mechanisms of immune defense, immune escape and disease pathogenesis caused by important human pathogens. Some of the infectious diseases covered in this course include AIDS, TB and Malaria. Most topics focus on immunology of viral, bacterial, protozoan and fungal infections. Topics will also include aspects of epidemiology and global health. Classes will consist of literature review of current scientific articles, faculty lectures and student presentations. Grades will be determined by exams, class presentations, participation, and short reports. Graduate students will also be asked to write a brief research proposal. PATH 481 involves faculty from: Division of Infectious Diseases and HIV Medicine, Center for Global Health & Diseases, Department of Pathology. Prereq: PATH 416.

PATH 488. Yeast Genetics and Cell Biology. 3 Units.
This seminar course provides an introduction to the genetics and molecular biology of the yeasts S. cerevisiae and S. pombe by a discussion of current literature focusing primarily on topics in yeast cell biology. Students are first introduced to the tools of molecular genetics and special features of yeasts that make them important model eukaryotic organisms. Some selected topics include cell polarity, cell cycle, secretory pathways, vesicular and nuclear/cytoplasmic transport, mitochondrial import and biogenesis, chromosome segregation, cytoskeleton, mating response and signal transduction. Offered as CLBY 488, GENE 488, MBIO 488, and PATH 488.

PATH 510. Basic Pathologic Mechanisms. 4 Units.
An interdisciplinary introduction to the fundamental principles of molecular and cellular biology as they relate to the pathologic basis of disease. Lectures, laboratories, conferences.

PATH 511. Experimental Pathology Seminar I. 1 Unit.
Weekly discussions of current topics and research by students, staff and distinguished visitors.

PATH 512. Experimental Pathology Seminar II. 1 Unit.
Weekly discussions of current topics and research by students, staff and distinguished visitors.
PATH 513. Immunology Journal Club. 1 Unit.
The Immunology Journal Club is a weekly seminar course in which enrolled students present recently published articles from the primary immunology literature for discussion by the group. Registered students are required to present one article and participate in discussions. Articles are selected by the students, must not be directly related to their own research project, and are approved by the course director. The purpose of the course is to provide the opportunity to practice presentation skills and to foster discussion of recent and high profile advances in immunology. Prereq: Enrolled in M.S. Pathology program.

PATH 520. Basic Cancer Biology and the Interface with Clinical Oncology. 3 Units.
This is a graduate-level introductory course in cancer biology taught through the Departments of Pharmacology and Pathology. This course will give students a broad overview of current basic cancer biology, highlight recent advances in cancer therapeutics, and provide a clinical perspective of the pathogenesis and treatment of common cancers. Classes will be of lecture and discussion format, and will also include student discussion of journal research articles to develop critical thinking in cancer research and experimental design as well as presentation/communication skills. About 1 to 3 students per class will be scheduled to lead the presentation and discussion of the selected journal articles. However, all students will be required to read the material in advance and be ready for discussion. Topics will cover growth factor action and signal transduction, oncogenes, tumor suppressor genes, DNA damage, apoptosis, cancer immunology, cancer stem cells, metastasis, angiogenesis, chemotherapy, radiation therapy, targeted therapeutics, photodynamic therapy, targeting cancer stem cells, chemoprevention, and clinical aspects of cancers of the breast, prostate, lymphatic tissue, and colon. Course grades for PHRM/PATH 520 (Ph.D. track): will be determined by class participation/presentation (40%), an original research grant proposal (35%) and written and oral critiques of two research proposals (25%). Course grades for PHRM/PATH 406 (M.S. and non-degree track): will be determined by class participation/presentation (40%), a literature review term paper (35%) and oral defense of term paper with course directors (25%). Presentations/Participation: Instructors will complete a standardized evaluation form to provide you uniform feedback in a timely manner. Required Reading: Assigned reviews, original articles (in blackboard) Recommended Reading: The Biology of Cancer (2nd Edition), by Robert A. Weinberg Garland Science, copyright 2014 Recommended Preparation: A course in Cell Biology. A course in Molecular Biology. Offered as PATH 406, PATH 520, PHRM 406 and PHRM 520.

PATH 521. Special Topics in Cancer Biology and Clinical Oncology. 1 Unit.
This one credit hour course in Cancer Biology is intended to give students an opportunity to do independent literature research while enrolled in PHRM 520/PATH 520. Students must attend weekly Hematology/Oncology seminar series and write a brief summary of each of the lectures attended. In addition, students must select one of the seminar topics to write a term paper which fully reviews the background related to the topic and scientific and clinical advances in that field. This term paper must also focus on Clinical Oncology, have a translational research component, and integrate with concepts learned in PHRM 520/PATH 520. Pharmacology students must provide a strong discussion on Therapeutics, while Pathology students must provide a strong component on Pathophysiology of the disease. Recommended preparation: CBIO 453 and CBIO 455, or concurrent enrollment in PHRM 520 or PATH 520. Offered as PATH 521 and PHRM 521.

PATH 523. Histopathology of Organ Systems. 3 Units.
Comprehensive course covering the underlying basic mechanisms of injury and cell death, inflammation, immunity, infection, and neoplasia followed by pathology of specific organ systems. Material will include histological (‘structure’) and physiological (‘function’) aspects related to pathology (human emphasis). Recommended preparation: ANAT 412 or permission of instructor. Offered as ANAT 523 and PATH 523.

PATH 524. Cell Biology of Neurodegenerative Disorders. 3 Units.
PATH 524 is a 3 credit hour introductory course on neurodegenerative disorders intended for Master’s and first and second-year medical students. This course attempts to bridge the gap between molecular mechanisms at the cellular level with disease presentation and therapeutic options for neurodegenerative disorders of protein misfolding and metal mis-metabolism. The course will cover topics related to Alzheimer’s disease, Parkinson’s disease, Huntington’s disease, Amyotrophic lateral sclerosis, Multiple sclerosis, Prion diseases, disorders of iron and copper metabolism, and other disorders of interest to the students. The class will meet once every week, and following an introductory lecture, the students will discuss relevant scientific reports from recent literature. Students are expected to participate actively in class discussion, and write a 5-6 page research proposal following NIH guidelines for the final exam. The students are expected to present and defend their proposal in class. Grading criteria: Class participation (70%), final paper and presentation (30%).

PATH 525. Neurodegenerative Diseases of the Brain and the Eye: Molecular Basis of the Brain-Eye Connection. 3 Units.
This is a graduate-level seminar course that familiarizes students with common neurodegenerative conditions of the brain and the eye. The molecular basis of each disorder and associated ophthalmic pathology will be emphasized. Contribution of heavy metals in brain and ocular pathology will be discussed where appropriate. Specific examples include Alzheimer’s Disease, Parkinson’s Disease, prion disorders, Huntington’s Disease, age-related macular degeneration, glaucoma, and others based on popular demand. The students will be expected to discuss relevant research publications in class in an interactive format. Grading will be based on class participation and completion of an R21 grant proposal. Concurrent enrollment in PATH 526 on grant writing skills is strongly recommended but not required. Offered as PATH 525 and CLBY 525.

PATH 526. Introduction to Scientific Grant Writing. 1 Unit.
PATH 526 is a graduate-level course that will familiarize students with grant writing and reviewing skills. The students will be exposed to material pertaining to different grant opportunities, the grant review process, and strategies for maximizing chances of success. Grading will be based on class participation and the preparation and presentation of an R21 grant proposal in class. Coreq: PATH 525.

PATH 601. Special Problems. 1 - 18 Units.
Research on the nature and causation of disease and on host factors which tend to protect against disease. Special courses and tutorials in subspecialty areas of general and/or systemic anatomic and/or clinical pathology.

PATH 650. Independent Study. 1 - 9 Units.
Laboratory rotation experience in a selected faculty research laboratory designed to introduce the M.S. student to all aspects of modern laboratory research including the design, execution and analysis of original experimental work.

PATH 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.)
Department of Pharmacology

Room W-321, School of Medicine
http://pharmacology.case.edu/
Phone: 216.368.4617
John J. Mieyal, PhD, Interim Chair
john.mieyal@case.edu

The Department of Pharmacology offers training leading to MS, PhD, or MD/PhD degrees for highly qualified post-undergraduate candidates committed to research careers in the biomedical sciences. Adequate preparation in the biological sciences, mathematics, organic chemistry, and physics or physical chemistry is a prerequisite for admission.

Multidisciplinary training, carried out by faculty in pharmacology and other basic science departments, emphasizes molecular, cellular, physiological, and translational aspects of the pharmacological sciences. Areas of faculty expertise include drug/xenobiotic metabolism; receptor-ligand interactions, and biochemical reaction mechanisms; cell biology of signaling pathways; structure-function of membrane components; endocrine and metabolic regulation; cell surface and nuclear receptors, hormonal regulation of gene expression; cancer biology and therapeutics, bacterial and viral pathogenesis, neuroscience/neuropharmacology, and drug resistance.

Students who desire the combined MD/PhD degrees are admitted to the Medical Scientist Training Program (http://bulletin.case.edu/schoolofmedicine/dualdegreeprograms/#medicalscientisttrainingshowtext) (MSTP). These students participate in the two-year integrated preclinical curriculum of the School of Medicine (University Program), which features clinical correlation of basic biologic concepts. Combined degree students who select the PhD in pharmacology undertake a series of advanced courses, research rotations, preliminary examinations and dissertation research in the same manner as that described for the PhD program.

Facilities

The Department of Pharmacology occupies about 25,000 net square feet distributed among several locations, namely the School of Medicine Harland Goff Wood Building and the adjacent Wood Research Tower, as well as facilities in the West Quad Bldg. Facilities include extensive chromatographic and tissue culture facilities, a transgenic mouse laboratory, imaging and confocal microscopy equipment, and ready access to specialized research techniques, including various aspects of recombinant DNA and hybridoma technology, in situ hybridization histochemistry, fluorescence cell sorting, NMR spectroscopy and mass spectrometry, X-ray crystallography, and cryo electron microscopy.

Masters Degrees

Although training efforts by the Department of Pharmacology are primarily directed toward the award of the PhD degree, training for the MS degree is offered also in a variety of contexts. For example, research assistants in the Department who seek educational advancement may pursue the MS degree via Plan A (thesis) or Plan B (coursework only). Medical students who seek to specialize in Pharmacology during the scholarly research component of their preclinical program may pursue the MS degree. Employees in the Biotechnology Industry may seek advanced training in Pharmacology by pursuing the MS degree at Case.

Finally, a PhD candidate who is unable to complete the PhD requirements for extraordinary reasons may petition to have earned credits transferred to fulfill MS degree requirements.

Masters Plan B (Coursework, MS direct admit)

This program is aimed at students who seek a Master’s Degree but do not intend to specialize in research following their Master’s work. To satisfy the requirement for a Comprehensive Exam for the MS Degree, students register for 1 credit of EXAM 600 Master’s Comprehensive Exam during their final semester and sit for an integrative essay question-style examination on the content of the required coursework. A total of 30 credit hours are required (see below).

The advancement of understanding and practice of therapeutics is based on research. Therefore all students in degree programs in Pharmacology are expected to become involved in independent research and scholarship. Registration for PHRM 601 Independent Study and Research requires a pre-arrangement with a faculty mentor who will oversee the combination of study and bench research and proscribe the basis for satisfactory performance, including oral and written reports. With pre-approval of the Departmental Director of Graduate Studies, a student’s study plan may substitute additional specific advanced courses to replace PHRM 601 Independent Study and Research credits.

Sample Plan of Study for Plan B

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Cell Biology I (IBMS 453)</td>
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<td>Molecular Biology I (IBMS 455)</td>
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<td>Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A (IBMS 456A)</td>
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<td>Fundamental Biostatistics to Enhance Research Rigor &amp; Reproducibility (IBMS 450)</td>
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<td>Principles of Pharmacology I: The Molecular Basis of Therapeutics (PHRM 401)</td>
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<tr>
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<td>Independent Study and Research (PHRM 601)</td>
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<tr>
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<tr>
<td>Master’s Comprehensive Exam (EXAM 600)</td>
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Total Units in Sequence: 30

Masters Plan A (Research, direct admit)

In addition to the course requirements below, candidates for this degree are required to submit an acceptable written thesis based on their original research, and register for at least 9 credit hours of PHRM 651
Thesis M.S. (master's dissertation research). The acceptability of the thesis will be determined by an oral examination administered by the student's Thesis Advisory Committee. This committee must be chaired by a member of the primary Faculty of Pharmacology, and it should include the research mentor and two other faculty members (total of four faculty members, two from the Department of Pharmacology). As above, a minimum of 27 credit hours are required. For these students, passing the final exams in PHRM 401 Principles of Pharmacology I: The Molecular Basis of Therapeutics and PHRM 402 Principles of Pharmacology II: The Physiological Basis of Therapeutics satisfies the requirement for a Comprehensive Exam for the MS Degree.

**Required courses for Plan A**

**First Year**

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<th>Course Description</th>
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<td>Molecular Biology I (IBMS 455)</td>
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Year Total: 9

**Second Year**

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**Third Year**

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Year Total: 5-13

**Fourth Year**

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Year Total: 10-13

**Fifth Year**

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Year Total: 10-13

**Total Units in Sequence:** 36

**MD/MS Biomedical Sciences - Pharmacology**

For Program Admissions information and MD requirements, see MD Dual Degree Programs (p. 27). A sample plan of study for the Pharmacology track is below.

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<td>Fundamental Biostatistics to Enhance Research Rigor &amp; Reproducibility (IBMS 450)</td>
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**Second Year**

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<td>Advanced Elective Course complementary to research focus</td>
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<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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Year Total: 5-13

**Third Year**

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Year Total: 10-13

**Fourth Year**

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Year Total: 10-13

**Fifth Year**

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Year Total: 10-13

**Total Units in Sequence:** 38-62

**PhD in Pharmacology**

Students seeking the PhD degree in Pharmacology are admitted into the Department of Pharmacology through the administrative structure...
of Biomedical Sciences Training Program (http://casemed.case.edu/bsstp) which provides an introduction to many related training areas within the biomedical field during the first year. PhD applicants may indicate Pharmacology as their "primary program of interest" (PPI) during the application process. Alternatively, admission may be through the Medical Scientist Training Program (MSTP) (https://case.edu/medicine/admissions-programs/md-phd-program/prospective-students/mstp-admissions).

The PhD program is divided into three phases. The first phase allows students to follow an integrated first-year sequence of course work that involves a core curriculum in cell and molecular biology. In addition, the first year includes three research rotations that allow the students to sample areas of research and become familiar with their laboratories. Selection of a specific training program and thesis advisor is made before the end of the first year. The second phase involves a two part core course in the fundamentals of pharmacology, oral presentations, and laboratory experience, which is concluded with a comprehensive written exam designed to challenge students to apply key concepts in new contexts. Successful completion of this phase leads to admission to PhD candidacy.

After advancing to PhD candidacy, students enter one of four Research Interest Groups according to the interest of the student, the mentor and the anticipated nature of the thesis project. The four interest Groups are: Cancer Therapeutics, Membrane & Structural Biology and Pharmacology, Molecular Pharmacology and Cellular Regulation, and Translational Therapeutics.

Upon completion of coursework requirements (54 total credits, see below), the PhD degree is awarded to students who also complete and defend a research project leading to two original and meritorious scientific contributions that are submitted for publication to leading journals in the field of study; at least one manuscript must be accepted for publication before scheduling the PhD thesis defense.

Core course requirements for the PhD in Pharmacology

The first year consists of the Core curriculum in Cell Biology and Molecular Biology (IBMS 453 Cell Biology I, IBMS 455 Molecular Biology I), research rotations, scientific ethics, part one of the Pharmacology core course, and an advanced course (18 credit hours total). During Year two, part two of the Pharmacology core course, a second advanced course, two seminar presentation courses, and independent study complete the course requirements. In all, 24 credits of graded coursework and 12 credits of P/N coursework are completed. Then 18 credits of dissertation research fulfill the program of study.

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>IBMS 453</td>
<td>Cell Biology I</td>
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<td>Molecular Biology I</td>
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<td>PHRM 401</td>
<td>Principles of Pharmacology I: The Molecular Basis of Therapeutics</td>
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<tr>
<td>PHRM 402</td>
<td>Principles of Pharmacology II: The Physiological Basis of Therapeutics</td>
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<tr>
<td>PHRM 511</td>
<td>Pharmacology Seminar Series</td>
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<td></td>
<td>Two advanced electives (from the Advanced Track offerings)</td>
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<td></td>
<td>Prelim I Comprehensive Examination</td>
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<td>IBMS 450</td>
<td>Fundamental Biostatistics to Enhance Research Rigor &amp; Reproducibility</td>
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<tr>
<td>IBMS 456A</td>
<td>Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A</td>
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<td>IBMS 500</td>
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<td>PHRM 601</td>
<td>Independent Study and Research</td>
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<td>PHRM 526</td>
<td>Grant Writing Tutorial</td>
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<tr>
<td>PHRM 701</td>
<td>Dissertation Ph.D.</td>
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Plan of Study

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

<table>
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<th>Year</th>
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<tr>
<td><strong>First Year</strong></td>
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<td>Research Rotation 2,3</td>
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<td>Since You Were Born: Nobel Prize Biomedical Research in the Last 21 Years- Section A (IBMS 456A)</td>
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<tr>
<td>Selection of Thesis Advisor</td>
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<td>Principles of Pharmacology I: The Molecular Basis of Therapeutics (PHRM 401)</td>
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<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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<td>Independent Study and Research (PHRM 601)</td>
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<td>3</td>
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<td>Total Units</td>
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**PHRM 309. Principles of Pharmacology. 3 Units.**
Principles of Pharmacology introduces the basic principles that underlie all of Pharmacology. The first half of the course introduces, both conceptually and quantitatively, drug absorption, distribution, elimination and metabolism (pharmacokinetics) and general drug receptor theory and mechanism of action (pharmacodynamics). Genetic variation in response to drugs (pharmacogenetics) is integrated into these basic principles. The second half of the course covers selected drug classes chosen to illustrate these principles. Small group/recitation sessions use case histories to reinforce presentation of principles and to discuss public perceptions of therapeutic drug use. Graduate students will be expected to critically evaluate articles from the literature and participate in a separate weekly discussion session. Recommended preparation for PHRM 409: Undergraduate degree in science or permission of instructor. Offered as PHRM 309 and PHRM 409. (CHEM 223 and CHEM 224), or (CHEM 323 and CHEM 324), or (EBME 201 and EBME 202), or (BIOL 116 and BIOL 117).

**PHRM 315. Nuclear Receptors in Health and Disease. 3 Units.**
This course focuses on hormone-gene interactions mediated by the ligand-inducible transcription factors termed nuclear hormone receptors. The class will address the mechanisms of action, regulatory features, and biological activities of several nuclear receptors. The usage of nuclear receptors as therapeutic targets in disease states such as cancer, inflammation, and diabetes will also be discussed. The course aims to teach students to critically evaluate primary literature relevant to nuclear hormone receptors biology, and to reinforce presentation/discussion skills. Grades for undergraduates will be based on midterm, final exam; grades for graduates will be based on midterm, final exam, and presentation of a recently published research article related to the role of nuclear receptors in health and disease. Offered as PHRM 315, BIOC 315, PHRM 415 and BIOC 415.

**PHRM 340. Science and Society Through Literature. 3 Units.**
This course will examine the interaction of scientific investigation and discovery with the society it occurred in. What is the effect of science on society and, as importantly, what is the effect of society on science? An introduction will consider the heliocentric controversy with focus on Galileo. Two broad areas, tuberculosis and the Frankenstein myth, will then be discussed covering the period 1800-present. With tuberculosis, fiction, art and music will be examined to understand the changing views of society towards the disease, how society’s perception of tuberculosis victims changed, and how this influenced their treatments and research. With Frankenstein, the original novel in its historical context will be examined. Using fiction and film, the transformation of the original story into myth with different connotations and implications will be discussed. Most classes will be extensive discussions coupled with student presentations of assigned materials. Offered as PHRM 340, BETH 440, PHRM 440, and HSTY 440.

**PHRM 400. Research Experience in Pharmacology. 0 - 1 Units.**
Research rotation in pharmacology.

**PHRM 401. Principles of Pharmacology I: The Molecular Basis of Therapeutics. 3 Units.**
This core course focuses on the chemical and biochemical properties of therapeutic agents and molecular mechanisms of therapeutic action, including kinetic and thermodynamic principles of enzyme catalysis and drug-receptor interactions. Moreover, emphasis is placed on fundamental principles of pharmacokinetics, including the absorption, distribution, metabolism, and excretion of drugs. Mathematical concepts needed to understand appropriate administration of drugs and maintaining therapeutic concentrations of drugs in the body are discussed. A second broad area of emphasis is on fundamental principles of pharmacodynamics, including drug-receptor theory, log dose-response relationships, therapeutic index, receptor turnover, and signal transduction mechanisms. The primary learning objective is to develop a self-directed, critical approach to the evaluation and design of experimental research in the broad context of receptor interactions with endogenous ligands and therapeutic agents in the context of disease models. This is a team-coordinated course involving session organized by faculty to facilitate student-directed learning experiences including discussion of study questions, problem solving applications, and primary literature presentations. A two-part laboratory exercise introduces experimental methodologies widely applied during the study of molecular interactions between therapeutic agents and receptor targets to reinforce fundamental principles of drug action. This 3-credit hour course meets 3 hr per week during the spring semester of year 1.
PHRM 402. Principles of Pharmacology II: The Physiological Basis of Therapeutics. 3 Units.
This course focuses on human physiology of organ systems including the central nervous system, cardiovascular system, and those systems (gastrointestinal, hepatic, and renal) that are involved in determining the pharmacokinetics or time course of drug action in vivo. A second major emphasis is placed on disease-based sessions where normal physiology, pathophysiology, and key drug classes to treat pathophysiologies are discussed. The students learn key concepts in endocrine pathologies, inflammatory disorders, pulmonary diseases, infectious diseases, and cancer. The main learning objectives are for the student to gain an understanding of basic principles of modern pharmacology and physiology and to build self-directed learning skills. This is a highly interactive course in which faculty lectures are minimized. A heavy emphasis is placed on student-directed learning experiences including presentation and discussion of primary literature, problem solving applications, small group discussion and team-based learning. This 3-credit hour course meets 3 hr per week during the fall semester of year 2.

PHRM 403. Public and Professional Views of Modern Therapeutics. 3 Units.
This course will present the students with headline news stories from the popular press along with pertinent published articles from the scientific literature. The object is to engage the students in critical evaluation of the scientific literature and news reports to discern the scientific basis for decisions such as removal of drugs from the market. The course will focus on topics such as Cox-2 Inhibitors and Heart Disease, Antidepressant Use for Adolescents, and Parkinson’s Disease and Stem Cell Therapy, among others. Evaluation will be based on participation in student-led discussion sessions, weekly topical quizzes, and on written critiques of the primary literature.

PHRM 406. Basic Cancer Biology and the Interface with Clinical Oncology. 3 Units.
This is a graduate-level introductory course in cancer biology taught through the Departments of Pharmacology and Pathology. This course will give students a broad overview of current basic cancer biology, highlight recent advances in cancer therapeutics, and provide a clinical perspective of the pathogenesis and treatment of common cancers. Classes will be of lecture and discussion format, and will also include student discussion of journal research articles to develop critical thinking in cancer research and experimental design as well as presentation/communication skills. About 1 to 3 students per class will be scheduled to lead the presentation and discussion of the selected journal articles. However, all students will be required to read the material in advance and be ready for discussion. Topics will cover growth factor action and signal transduction, oncopathways, tumor suppressor genes, DNA damage, apoptosis, cancer immunology, cancer stem cells, metastasis, angiogenesis, chemotherapy, radiation therapy, targeted therapeutics, photodynamic therapy, targeting cancer stem cells, chemoprevention, and clinical aspects of cancers of the breast, prostate, lymphatic tissue, and colon. Course grades for PHRM/PATH 520 (Ph.D. track): will be determined by class participation/presentation (40%), an original research grant proposal (35%) and written and oral critiques of two research proposals (25%). Course grades for PHRM/PATH 406 (M.S. and non-degree track) will be determined by class participation/presentation (40%), a literature review term paper (35%) and oral defense of term paper with course directors (25%). Presentations/Participation: Instructors will complete a standardized evaluation form to provide you uniform feedback in a timely manner. Required Reading: Assigned reviews, original articles (in blackboard) Recommended Reading: The Biology of Cancer (2nd Edition), by Robert A. Weinberg Garland Science, copyright 2014 Recommended Preparation: A course in Cell Biology. A course in Molecular Biology. Offered as PATH 406, PATH 520, PHRM 406 and PHRM 520.

PHRM 409: Undergraduate degree in science or permission of instructor.
Principles of Pharmacology introduces the basic principles that underlie all of Pharmacology. The first half of the course introduces, both conceptually and quantitatively, drug absorption, distribution, elimination and metabolism (pharmacokinetics) and general drug receptor theory and mechanism of action (pharmacodynamics). Genetic variation in response to drugs (pharmacogenetics) is integrated into these basic principles. The second half of the course covers selected drug classes chosen to illustrate these principles. Small group/recitation sessions use case histories to reinforce presentation of principles and to discuss public perceptions of therapeutic drug use. Graduate students will be expected to critically evaluate articles from the literature and participate in a separate weekly discussion session. Recommended preparation for PHRM 409: Undergraduate degree in science or permission of instructor. Offered as PHRM 309 and PHRM 409.

PHRM 412. Membrane Transport Processes. 3 Units.
Membranes and membrane transporters are absolutely required for all cells to take up nutrient, maintain membrane potential and efflux toxins. This course will consider the classification and structure of membrane transport proteins and channels, examine the common mechanistic features of all systems and the specific features of different classes of transporter. Understanding the physiological integration of transport processes into cell homeostasis and consideration of transporters and channels as drug targets will be a goal. Course format is minimal lecture, primarily student presentations of primary literature papers. Offered as PHOL 412 and PHRM 412. Prereq: CBIO 453 and CBIO 455.
PHRM 415. Nuclear Receptors in Health and Disease. 3 Units.
This course focuses on hormone-gene interactions mediated by the ligand-inducible transcription factors termed nuclear hormone receptors. The class will address the mechanisms of action, regulatory features, and biological activities of several nuclear receptors. The usage of nuclear receptors as therapeutic targets in disease states such as cancer, inflammation, and diabetes will also be discussed. The course aims to teach students to critically evaluate primary literature relevant to nuclear hormone receptors biology, and to reinforce presentation/discussion skills. Grades for undergraduates will be based on midterm, final exam; grades for graduates will be based on midterm, final exam, and presentation of a recently published research article related to the role of nuclear receptors in health and disease. Offered as PHRM 315, BIOC 315, PHRM 415 and BIOC 415.

PHRM 420. Current Topics in Cancer. 3 Units.
The concept of cancer hallmarks has provided a useful guiding principle in our understanding of the complexity of cancer. The hallmarks include sustaining proliferative signaling, evading growth suppressors, enabling replicative immortality, activating invasion and metastasis, inducing angiogenesis, resisting cell death, deregulating cellular energetics, avoiding immune destruction, tumor-promoting inflammation, and genome instability and mutation. The objectives of this course are to (1) examine the principles of some of these hallmarks, and (2) explore potential therapies developed based on these hallmarks of cancer. This is a student-driven and discussion-based graduate course. Students should have had some background on the related subjects and have read scientific papers in their prior coursework. Students will be called on to present and discuss experimental design, data and conclusions from assigned publications. There will be no exams or comprehensive papers but students will submit a one-page critique (strengths and weaknesses) of one of the assigned papers prior to each class meeting. The course will end with a full-day student-run symposium on topics to be decided jointly by students and the course director. Grades will be based on class participation, written critiques, and symposium presentations. Offered as BIOC 420, Mbio 420, PATH 422, and PHRM 420. Prereq: CBIO 453 and CBIO 455.

PHRM 432. Current Topics in Vision Research. 3 Units.
Vision research is an exciting and multidisciplinary area that draws on the disciplines of biochemistry, genetics, molecular biology, structural biology, neuroscience, and pathology. This graduate level course will provide the student with broad exposure to the most recent and relevant research currently being conducted in the field. Topics will cover a variety of diseases and fundamental biological processes occurring in the eye. Regions of the eye that will be discussed include the cornea, lens, and retina. Vision disorders discussed include age-related macular degeneration, retinal ciliopathies, and diabetic retinopathy. Instructors in the course are experts in their field and are members of the multidisciplinary visual sciences research community here at Case Western Reserve University. Students will be exposed to the experimental approaches and instrumentation currently being used in the laboratory and in clinical settings. Topics will be covered by traditional lectures, demonstrations in the laboratory and the clinic, and journal club presentations. Students will be graded on their performance in journal club presentations (40%), research proposal (40%), and class participation (20%). Offered as NEUR 432, PATH 432, PHRM 432 and BIOC 432.

PHRM 440. Science and Society Through Literature. 3 Units.
This course will examine the interaction of scientific investigation and discovery with the society it occurred in. What is the effect of science on society and, as importantly, what is the effect of society on science? An introduction will consider the heliocentric controversy with focus on Galileo. Two broad areas, tuberculosis and the Frankenstein myth, will then be discussed covering the period 1800-present. With tuberculosis, fiction, art and music will be examined to understand the changing views of society towards the disease, how society’s perception of tuberculosis victims changed, and how this influenced their treatments and research. With Frankenstein, the original novel in its historical context will be examined. Using fiction and film, the transformation of the original story into myth with different connotations and implications will be discussed. Most classes will be extensive discussions coupled with student presentations of assigned materials. Offered as PHRM 340, BETH 440, PHRM 440, and HSTY 440.

PHRM 466. Cell Signaling. 3 Units.
This is an advanced lecture/journal/discussion format course that covers cell signaling mechanisms. Included are discussions of neurotransmitter-gated ion channels, growth factor receptor kinases, cytokine receptors, G protein-coupled receptors, steroid receptors, heterotrimeric G proteins, ras family GTPases, second messenger cascades, protein kinase cascades, second messenger regulation of transcription factors, microtubule-based motility, actin/myosin-based motility, signals for regulation of cell cycle, signals for regulation of apoptosis. Offered as CLBY 466, PHOL 466 and PHRM 466.

PHRM 475. Protein Biophysics. 3 Units.
This course focuses on in-depth understanding of the molecular biophysics of proteins. Structural, thermodynamic and kinetic aspects of protein function and structure-function relationships will be considered at the advanced conceptual level. The application of these theoretical frameworks will be illustrated with examples from the literature and integration of biophysical knowledge with description at the cellular and systems level. The format consists of lectures, problem sets, and student presentations. A special emphasis will be placed on discussion of original publications. Offered as BIOC 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.

PHRM 511. Pharmacology Seminar Series. 0 - 1 Units.
Current topics of interest in the pharmacologist sciences.

PHRM 513. Structural Journal Club. 1 Unit.
Current topics of interest in structural biology, and protein biophysics. Offered as PHOL 513 and PHRM 513.
PHRM 520. Basic Cancer Biology and the Interface with Clinical Oncology. 3 Units.
This is a graduate-level introductory course in cancer biology taught through the Departments of Pharmacology and Pathology. This course will give students a broad overview of current basic cancer biology, highlight recent advances in cancer therapeutics, and provide a clinical perspective of the pathogenesis and treatment of common cancers. Classes will be of lecture and discussion format, and will also include student discussion of journal research articles to develop critical thinking in cancer research and experimental design as well as presentation/communication skills. About 1 to 3 students per class will be scheduled to lead the presentation and discussion of the selected journal articles. However, all students will be required to read the material in advance and be ready for discussion. Topics will cover growth factor action and signal transduction, oncogenes, tumor suppressor genes, DNA damage, apoptosis, cancer immunology, cancer stem cells, metastasis, angiogenesis, chemotherapeutic, radiation therapy, targeted therapeutics, photodynamic therapy, targeting cancer stem cells, chemoprevention, and clinical aspects of cancers of the breast, prostate, lymphatic tissue, and colon. Course grades for PHRM/PATH 520 (Ph.D. track): will be determined by class participation/presentation (40%), an original research grant proposal (35%) and written and oral critiques of two research proposals (25%). Course grades for PHRM/PATH 406 (M.S. and non-degree track): will be determined by class participation/presentation (40%), a literature review term paper (35%) and oral defense of term paper with course directors (25%). Presentations/Participation: Instructors will complete a standardized evaluation form to provide you uniform feedback in a timely manner. Required Reading: Assigned reviews, original articles (in blackboard) Recommended Reading: The Biology of Cancer (2nd Edition), by Robert A. Weinberg Garland Science, copyright 2014 Recommended Preparation: A course in Cell Biology. A course in Molecular Biology. Offered as PATH 406, PATH 520, PHRM 406 and PHRM 520.

PHRM 521. Special Topics in Cancer Biology and Clinical Oncology. 1 Unit.
This one credit hour course in Cancer Biology is intended to give students an opportunity to do independent literature research while enrolled in PHRM 520/PATH 520. Students must attend weekly Hematology/Oncology seminar series and write a brief summary of each of the lectures attended. In addition, students must select one of the seminar topics to write a term paper which fully reviews the background related to the topic and scientific and clinical advances in that field. This term paper must also focus of Clinical Oncology, have a translational research component, and integrate with concepts learned in PHRM 520/PATH 520. Pharmacology students must provide a strong discussion on Therapeutics, while Pathology students must provide a strong component on Pathophysiology of the disease. Recommended preparation: CBIO 453 and CBIO 455, or concurrent enrollment in PHRM 520 or PATH 520. Offered as PATH 521 and PHRM 521.

PHRM 525. Topics in Cell and Molecular Pharmacology. 0 - 18 Units.
Individual library research project under the guidance of a pharmacology sponsor. Projects will reflect the research interest of the faculty sponsor, including molecular endocrinology, neuropharmacology, receptor activation and signal transduction, molecular mechanisms of enzyme action and metabolic regulation.

PHRM 526. Grant Writing Tutorial. 1 - 3 Units.
Students will be expected to provide critiques of a grant proposal to bring to a workshop. At the workshop, a faculty review panel will discuss the grant proposal and provide critiques to illustrate the key components that are necessary for any grant proposal, and the specific items that enhance the quality of the proposal or detract from it. The students will be able to compare what they emphasized in their critiques to what the expert panel focused on. After completing the workshop, each student will prepare a proposal based on their thesis topic; this document will be scored, and the student will also be evaluated for an oral defense of the proposal.

PHRM 527. Pathways to Personalized Medicine. 3 Units.
This is a course of independent study designed to take the student from the bedside to the bench and back again. Students will select a problem from a list of important therapeutic issues related to variability in drug responsiveness and design a research program to elucidate its molecular, biochemical, genetic and pathophysiological basis. The resulting research proposal is expected to be multidimensional and include molecular, cellular, whole animal and clinical investigations. To guide the process students will assemble a mentoring group including at least one member of the Translational Therapeutics Track Faculty, a clinician working in the clinical realm in which the problem originates and a basic scientist with relevant experience. The written proposal will be defended orally. Recommended preparation: 1st year Pharm Graduate required courses.

PHRM 528. Contemporary Approaches to Drug Discovery. 3 Units.
This course is designed to teach the students how lead compounds are discovered, optimized, and processed through clinical trials for FDA approval. Topics will include: medicinal chemistry, parallel synthesis, drug delivery and devices, drug administration and pharmacokinetics, and clinical trials. A special emphasis will be placed on describing how structural biology is used for in silico screening and lead optimization. This component will include hands-on experience in using sophisticated drug discovery software to conduct in silico screening and the development of drug libraries. Each student will conduct a course project involving in silico screening and lead optimization against known drug targets, followed by the drafting of an inventory disclosure. Another important aspect of this course will be inclusion of guest lectures by industrial leaders who describe examples of success stories of drug development. Offered as BIOL 528, PHOL 528, PHRM 528, and SYBB 528.

PHRM 555. Current Proteomics and Bioinformatics. 3 Units.
This course is designed for graduate students across the university who wish to acquire a better understanding of fundamental concepts of proteomics and related bioinformatics as well as hands-on experience with techniques used in current proteomics. Lectures will cover protein/peptide separation techniques, protein mass spectrometry, and biological applications which include quantitative proteomics, protein modification proteomics, interaction proteomics, structural genomics and structural proteomics. Also, it will cover experimental design, basic statistical concept and issues related to high-dimensional data from high-throughput technologies. Laboratory portion will involve practice on the separation of proteins by two-dimensional gel electrophoresis, molecular weight measurement of proteins by mass spectrometry, peptide structural characterization by tandem mass spectrometry. It will also include bioinformatics tools for protein identification and protein-protein interaction networks. The instructors’ research topics will also be discussed. Recommended preparation: CBIO 453, CBIO 455, and PQHS 431. Offered as PHRM 555 and SYBB 555.
PHRM 600. Preparation for Qualifying Exam. 1 Unit.
Students pursuing the M.S. or Ph.D. degrees in Pharmacology are required to prepare systematically for the comprehensive qualifying exam by reviewing the concepts of cellular and molecular biology and pharmacology. The qualifier is comprised of a two-part written exam administered simultaneously to all eligible students. It is designed to evaluate their understanding of concepts presented in the various core courses. It also assesses their skills in critical reading of research articles and design of experiments. The division into two parts allows each student to receive feedback on deficient areas and work toward improvement on the second segment. Eligibility: Students may register for the exam when they have fulfilled two criteria: (a) Successful completion (grade B or better) in all of the Core Courses, and an overall GPA of 3.0 or better. (b) Satisfactory performance in all research rotations and consistent research effort in the thesis laboratory as documented formally by the Ph.D. mentor. No student on probation may sit for the Qualifying Exam (Prelim I). Prereq: CBIO 453, CBIO 455, PHRM 401 and PHRM 402.

PHRM 601. Independent Study and Research. 1 - 18 Units.
(Credit as arranged.)

PHRM 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.)

PHRM 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

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Room E-524, School of Medicine
http://physiology.case.edu/
Phone: 216.368.2084
Walter F. Boron, MD, PhD, Chair
walter.boron@case.edu

Bart Jarmusch (bbj2@case.edu), Manager of Graduate Education

The Department of Physiology and Biophysics at Case is a multidisciplinary department that takes great pride in its history of conducting research and training graduate students. The department includes 20 Primary and 33 Secondary faculty members, more than 25 post-doctoral associates, and over 300 full-time PhD, MD/PhD, and Master of Science degree students. The training programs are designed to provide a mentored training environment that maximizes faculty-student interaction.

As outlined below, the department offers PhD, MD/PhD, and Master of Science degrees. These programs are tailored to prepare students for successful careers in biomedical, pharmaceutical and industrial research. The department offers multiple graduate-level programs, each of which uses state-of-the-art molecular, cell biology, and biophysical approaches to study physiological questions at a variety of different organizational levels. The goal is to provide an outstanding training opportunity. The major goals of the PhD and Tech Masters programs are to provide students with a broad knowledge base in organ systems and integrated physiology and in-depth expertise and outstanding research potential in the fields of cellular and molecular physiology and molecular and cellular biophysics. These goals are accomplished using a series of foundation and advanced topic courses, skill development courses, laboratory rotations and thesis research. The MS in Medical Physiology program is a post-baccalaureate program designed to help students prepare for admission to medical, dental, pharmacy, or veterinary school or for opportunities to work in the biotechnology industry.

Master's Degrees
The Master's Program in Medical Physiology is designed for students with at least a bachelor's degree in a chemical, physical, or biological science who are seeking advanced training in the physiological sciences, typically in preparation for admission to a professional medical program (e.g. Medical School, Dental School). The program is flexible in duration. It can take as little as 1 year (2 semesters, 9 months) to complete the required 30 credit hours of course work. However, students who wish to decompress the program can take 14 months or more to complete the requirements. Core courses and flexible electives allow students to focus their work in key areas of medical physiology, including Anatomy, Biochemistry, or Pharmacology. Graduates of the Medical Physiology Master’s Program also can pursue careers in basic and clinical research, research administration, teaching or management in academia, the pharmaceutical and biotechnology industries, private research institutions, government science or regulatory agencies, or medicine and health care.

**MS Medical Physiology - Type B Non-Thesis Option**

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<tr>
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<tr>
<td>Medical Physiology I (PHOL 481)</td>
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<tr>
<td>Translational Physiology I (PHOL 483)</td>
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<tr>
<td>Elective</td>
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<td>Medical Physiology II (PHOL 482)</td>
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<td>Translational Physiology II (PHOL 484)</td>
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<tr>
<td>(PHOL 498D)</td>
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<td>Year Total:</td>
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</table>

**MS Medical Physiology - Type A Thesis Option**

The Department of Physiology and Biophysics encourages research staff members to expand their critical research knowledge and skills by enrolling in our Master's of Science in Physiology and Biophysics program. This Tech Master's Program is specifically designed for staff working full time. Each employer has their own policy on allowing staff to take classes and enroll in graduate programs. CWRU's policy is to allow staff, with their supervisor's permission, to take up to 6 credit hours per term, with tuition being covered by CWRU as part of the employee benefits package. Staff are expected to make up the time they spend in class during the day, after hours.

<table>
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<tr>
<th>First Year</th>
<th>Units</th>
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<tr>
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<td>Fall</td>
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<tr>
<td>Conversations on Protein Structure and Function (PHOL 456)</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory Research Rotation (PHOL 505)</td>
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</table>
Physiology and Biophysics Departmental Seminar (PHOL 498A) 1
Cell Signaling (PHOL 466) 3
Physiology of Organ Systems (PHOL 480) 4
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500) 1
Laboratory Research Rotation (PHOL 505) 1
Elective 3
Physiology Seminar B (Spring Semester) (PHOL 498B) 1

Year Total: 4 13

Total Units in Sequence: 17

MD/MS Biomedical Investigation - Physiology Track

This track offers training in physiology and biomedical laboratory technology, including emphasis on mentored independent research training which includes both laboratory experience and formal coursework in modern laboratory methodology and instrumentation.

Students in Physiology and Biotechnology track must complete:

- PHOL 498A Physiology and Biophysics Departmental Seminar 1
- PHOL 498B Physiology Seminar B (Spring Semester) 1
- PHOL 601 Research 1-18
- IBIS 600 Exam in Biomedical Investigation 0

And 9 credits from the following course list:

- PHOL 456 Conversations on Protein Structure and Function 2
- PHOL 466 Cell Signaling 3
- PHOL 480 Physiology of Organ Systems 4
- PHOL 530 Technology in Physiological Sciences 3

PhD in Physiology and Biophysics

The Physiology and Biophysics Graduate Program provides comprehensive training leading to the PhD degree and MD/PhD degrees. This program has three tracks of study with emphasis on Cell and Molecular Physiology, Structural Biology and Biophysics, and Organ Systems Physiology. Admissions to the Physiology and Biophysics program may be obtained in the integrated Biomedical Sciences Training Program (http://casemed.case.edu/bstp), by direct admission to the department or via the Medical Scientist Training Program (http://mstp.case.edu/default.asp).

To earn a PhD in Physiology and Biophysics, a student must complete rotations in at least three laboratories followed by selection of a research advisor, and complete Core and Elective coursework including responsible conduct of research as described in the course of study, below. Students who previously completed relevant coursework, for example with a MS, may petition to complete alternative courses. Each graduate program follows the overall regulations established and described in CWRU Graduate Studies and documented to the Regents of the State of Ohio. Completion of the PhD degree will require 36 hours of coursework (24 hours of which are graded) and 18 hours of PHOL 701 Dissertation Ph.D..

In addition, each student must successfully complete a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. The qualifier is generally completed in the summer after year two. During the dissertation period, students are expected to meet twice a year with the thesis committee, present seminars in the department, and fulfill journal publication requirements. At the completion of the program, successful defense of a doctoral dissertation is required. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program.

Plan of Study for PhD in Cell and Molecular Physiology *

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

**First Year**

<table>
<thead>
<tr>
<th>Course Description</th>
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<td>Laboratory Research Rotation (PHOL 505)</td>
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**Second Year**

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**Third Year**

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<td>Dissertation Ph.D. (PHOL 701)</td>
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Year Total: 2-10 2-10

Total Units in Sequence: 28-60

* After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total

**Plan of Study for PhD in Structural Biology and Biophysics**

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<th>Fall</th>
<th>Spring</th>
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<tr>
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| **Second Year**                                              |       |      |        |
| Research (PHOL 601)                                          | 1-9   |      |        |
| Physiology Seminar B (Spring Semester) (PHOL 498B)           | 1     |      |        |
| Year Total:                                                  | 2-10  | 2-10 |        |

| **Third Year**                                               |       |      |        |
| Research (PHOL 601)                                          | 1-9   |      |        |
| Physiology Seminar B (Spring Semester) (PHOL 498B)           | 1     |      |        |
| Year Total:                                                  | 2-10  | 2-10 |        |

| **Total Units in Sequence:**                                 | 26-58 |      |
| * After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total |

| **Program of Study for PhD in Organ Systems and Integrated Physiology**
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<th>Spring</th>
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<td>Cell Biology I (IBMS 453)</td>
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<td>Research (PHOL 601)</td>
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<td>Physiology of Organ Systems (PHOL 480)</td>
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<tr>
<td>Cardiovascular Physiology (PHOL 514)</td>
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<tr>
<td>Cardio-Respiratory Physiology (PHOL 519)</td>
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<td>Year Total:</td>
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| **Second Year**                                              |       |      |
| Research (PHOL 601)                                          | 1-9   |      |
| Physiology Seminar B (Spring Semester) (PHOL 498B)           | 1     |      |
| Year Total:                                                  | 2-10  | 2-10 |

| **Third Year**                                               |       |      |
| Research (PHOL 601)                                          | 1-9   |      |
| Physiology Seminar B (Spring Semester) (PHOL 498B)           | 1     |      |
| Year Total:                                                  | 2-10  | 2-10 |

| **Total Units in Sequence:**                                 | 30-62 |
| * After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total |

| **Courses**
| PHOL 351. Independent Study. 1 - 6 Units. |
| This course is a guided program of study in physiology textbooks, reviews, and original articles. Guided laboratory projects to reproduce and extend classical physiological experiments are offered to the undergraduate science major. This course is being offered in conjunction with the Graduate level course PHOL 451. Students are required to consult with the faculty member whose work they have interest in and plan their individual experience. |
PHOL 401A. Physiology and Biophysics of Molecules and Cells. 2 Units.
Physiology and Biophysics of Molecules and Cells is a graduate-level introductory course designed to provide the fundamental principles of modern physiology, protein science and structural biology, and to prepare students for advanced courses in the biomedical sciences. The course is divided into 2 blocks that can be taken independently as PHOL 401A or PHOL 401B (2 credit hrs each) during the Spring semester of each year. The first block will cover the structure and function of proteins and lipids, and the organization of cellular membranes. Topics will include primary, secondary, tertiary and quaternary protein structure and analysis, enzyme kinetics, allostery and cooperativity, lipid membrane organization and domain structure, and protein-protein and protein-lipid interactions. The second block will cover molecular pathways and processes critical for cellular homeostasis, function, and signaling. Topics will include molecular mechanisms of transport across biological membranes and cellular compartments, ionic basis of the resting membrane potential, action potential generation and propagation, osmosis and Gibb-Donnan equilibria, regulation of voltage-gated channels and electrogenic transporters, cellular pH regulation, and the biophysics of epithelial transport. Format will be a combination of lecture, discussion-based problem sets, journal paper presentations, and computer lab exercises and demonstrations. Grading will be based on performance on two essay-type exams administered in the middle and at the end of each block (80%), and on class participation (20%).

PHOL 401B. Physiology and Biophysics of Molecules and Cells. 2 Units.
Physiology and Biophysics of Molecules and Cells is a graduate-level introductory course designed to provide the fundamental principles of modern physiology, protein science and structural biology, and to prepare students for advanced courses in the biomedical sciences. The course is divided into 2 blocks that can be taken independently as PHOL 401A or PHOL 401B (2 credit hrs each) during the Spring semester of each year. The first block will cover the structure and function of proteins and lipids, and the organization of cellular membranes. Topics will include primary, secondary, tertiary and quaternary protein structure and analysis, enzyme kinetics, allostery and cooperativity, lipid membrane organization and domain structure, and protein-protein and protein-lipid interactions. The second block will cover molecular pathways and processes critical for cellular homeostasis, function, and signaling. Topics will include molecular mechanisms of transport across biological membranes and cellular compartments, ionic basis of the resting membrane potential, action potential generation and propagation, osmosis and Gibb-Donnan equilibria, regulation of voltage-gated channels and electrogenic transporters, cellular pH regulation, and the biophysics of epithelial transport. Format will be a combination of lecture, discussion-based problem sets, journal paper presentations, and computer lab exercises and demonstrations. Grading will be based on performance on two essay-type exams administered in the middle and at the end of each block (80%), and on class participation (20%).

PHOL 402A. Physiological Basis for Disease. 3 Units.
Physiological Basis for Disease is a graduate-level course designed to provide the fundamental physiology of a select group of organ systems and examples of how the molecular basis of disease affects physiological function of these systems. As such, PHOL402 will prepare students for future study in advanced biomedical sciences. The course is 3 credit hours and will be offered in the both the Fall (402A) and Spring (402B) semesters of each academic year. Course content of PHOL402 builds on knowledge learned in Medical Physiology-- PHOL481 and PHOL482, and is designed to be taken concurrently or in series with Medical Physiology courses. Topics to be covered during the Fall (402A) semester include pathophysiology of cancer, and select diseases of the central nervous system, cardiovascular system, and urinary/renal system. Topics to be covered in the Spring (402B) semester include select diseases of the respiratory, gastrointestinal, and endocrine systems. The format will be a combination of lectures, in class discussions, and take-home problem sets to facilitate student-directed learning. Grading will be based on problem sets (30%) and weekly quizzes (70%). Due to the course format and large class size, this course is intended primarily for master’s students. PhD students that desire to take this course must first seek approval from their graduate program directors.

PHOL 402B. Physiological Basis for Disease. 3 Units.
Physiological Basis for Disease is a graduate-level course designed to provide the fundamental physiology of a select group of organ systems and examples of how the molecular basis of disease affects physiological function of these systems. As such, PHOL402 will prepare students for future study in advanced biomedical sciences. The course is 3 credit hours and will be offered in the both the Fall (402A) and Spring (402B) semesters of each academic year. Course content of PHOL402 builds on knowledge learned in Medical Physiology-- PHOL481 and PHOL482, and is designed to be taken concurrently or in series with Medical Physiology courses. Topics to be covered during the Fall (402A) semester include pathophysiology of cancer, and select diseases of the central nervous system, cardiovascular system, and urinary/renal system. Topics to be covered in the Spring (402B) semester include select diseases of the respiratory, gastrointestinal, and endocrine systems. The format will be a combination of lectures, in class discussions, and take-home problem sets to facilitate student-directed learning. Grading will be based on problem sets (30%) and weekly quizzes (70%). Due to the course format and large class size, this course is intended primarily for master’s students. PhD students that desire to take this course must first seek approval from their graduate program directors.

PHOL 410. Basic Oxygen & Physiological Function. 3 Units.
On-line lecture only course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as NTRN 410 and PHOL 410.
PHOL 412. Membrane Transport Processes. 3 Units.
Membranes and membrane transporters are absolutely required for all cells to take up nutrient, maintain membrane potential and efflux toxins. This course will consider the classification and structure of membrane transport proteins and channels, examine the common mechanistic features of all systems and the specific features of different classes of transporter. Understanding the physiological integration of transport processes into cell homeostasis and consideration of transporters and channels as drug targets will be a goal. Course format is minimal lecture, primarily student presentations of primary literature papers. Offered as PHOL 412 and PHRM 412. Prereq: CBIO 453 and CBIO 455.

PHOL 419. Applied Probability and Stochastic Processes for Biology. 3 Units.
Applications of probability and stochastic processes to biological systems. Mathematical topics will include: introduction to discrete and continuous probability spaces (including numerical generation of pseudo random samples from specified probability distributions), Markov processes in discrete and continuous time with discrete and continuous sample spaces, point processes including homogeneous and inhomogeneous Poisson processes and Markov chains on graphs, and diffusion processes including Brownian motion and the Ornstein-Uhlenbeck process. Biological topics will be determined by the interests of the students and the instructor. Likely topics include: stochastic ion channels, molecular motors and stochastic ratchets, actin and tubulin polymerization, random walk models for neural spike trains, bacterial chemotaxis, signaling and genetic regulatory networks, and stochastic predator-prey dynamics. The emphasis will be on practical simulation and analysis of stochastic phenomena in biological systems. Numerical methods will be developed using a combination of MATLAB, the R statistical package, MCell, and/or URDME, at the discretion of the instructor. Student projects will comprise a major part of the course. Offered as BIOL 319, EECS 319, MATH 319, SYBB 319, BIOL 419, EBME 419, MATH 419, PHOL 419, and SYBB 419.

PHOL 430. Advanced Methods in Structural Biology. 1 - 6 Units.
The course is designed for graduate students who will be focusing on one or more methods of structural biology in their thesis project. This course is divided into 3-6 sections (depending on demand). The topics offered will include X-ray crystallography, nuclear magnetic resonance spectroscopy, optical spectroscopy, mass spectrometry, cryo-electron microscopy, and computational and design methods. Students can select one or more modules. Modules will be scheduled so that students can take all the offered modules in one semester. Each section is given in 5 weeks and is worth 1 credit. Each section covers one area of structural biology at an advanced level such that the student is prepared for graduate level research in that topic.

PHOL 451. Independent Study. 1 - 18 Units.
Guided program of study using physiology textbooks, research reviews, and original research articles. An independent laboratory research project may also be included.

PHOL 456. Conversations on Protein Structure and Function. 2 Units.
The goal of this course is to supplement the short and basic presentation of Proteins in C3MB by lectures and discussions for students with backgrounds in physical-chemical sciences or students who already have a good basic background in protein science. The course presents an overview of Protein structure/function. Following an introduction to the principles of protein structure, the physical basis of protein folding and stability, and a brief overview of structural and bioinformatics approaches to protein analysis is presented. Typically two lecture/discussion style presentations are followed by a student lead journal club on recent high profile papers. The way the Journal club is done is that one student presents a paper (background and figures in powerpoint slides) while presentation of the main figures is shared between the class. Papers and Figures will be assigned by instructor. Typically two papers will be presented per session. Offered as PHOL 456 and BIOL 457.

PHOL 466. Cell Signaling. 3 Units.
This is an advanced lecture/journal/discussion format course that covers cell signaling mechanisms. Included are discussions of neurotransmitter-gated ion channels, growth factor receptor kinases, cytokine receptors, G protein-coupled receptors, steroid receptors, heterotrimeric G proteins, ras family GTPases, second messenger cascades, protein kinase cascades, second messenger regulation of transcription factors, microtubule-based motility, actin/myosin-based motility, signals for regulation of cell cycle, signals for regulation of apoptosis. Offered as CLBY 466, PHOL 466 and PHRM 466.

PHOL 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course is on a special topic of interest in evolutionary biology. Topics will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHIL/PHOL/BIOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467.

PHOL 475. Protein Biophysics. 3 Units.
This course focuses on in-depth understanding of the molecular biophysics of proteins. Structural, thermodynamic and kinetic aspects of protein function and structure-function relationships will be considered at the advanced conceptual level. The application of these theoretical frameworks will be illustrated with examples from the literature and integration of biophysical knowledge with description at the cellular and systems level. The format consists of lectures, problem sets, and student presentations. A special emphasis will be placed on discussion of original publications. Offered as BIOL 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.

PHOL 477. Human Physiology. 4 Units.
This lecture/seminar experience is meant to enhance the student's fundamental knowledge in human physiology with an emphasis on physiologic concepts in relationship to health, disease and illnesses. The course will provide students with an understanding of the function, regulation and integration of the major organ systems. Offered as PAST 477 and PHOL 477.
PHOL 478. Lifestyle Medicine. 3 Units.
While the current acute care model of medicine focuses on disease and treatment of individual organ systems by specialists, 50-60% of the public use complementary and alternative medicine (CAM), which focuses on prevention rather than disease. In CAM, damage caused by Western diets is avoided with low fat, vegetarian, or vegan diets, and with herbs and supplements. Damage mediated by emotional responses to stress is counteracted with relaxation practices such as yoga, meditation or hypnosis. In support of CAM, NIH-funded research performed over the past decade has shown that 70-90% of chronic diseases such as obesity, atherosclerosis, and cancer result from lifestyle. Moreover, mechanisms of lifestyle-induced disease as well as mechanisms by which these can be prevented or reversed by CAM practices have been described. This course examines interrelationships between lifestyle, health and disease and influences of CAM practices in terms of physiological health. Topics include evidence that Western diets, chronic emotional stress resulting from pervasive environmental, societal, workplace, financial, or relationship issues, and changes in circadian rhythms resulting from behaviors such as not getting enough sleep or working night-shifts facilitate disease by inducing cellular events that include epigenetic modification, changes in gene expression, and decreased telomere length. Mechanisms by which CAM practices prevent or reverse these lifestyle-mediated changes are also covered. In addition, the course considers the broader issue of how economic and political pressures are forcing rapid changes in healthcare and the influence that lifestyle-based approaches is likely to have on evolving delivery models, healthcare costs, and public health policies. The course is presented over a period of 8 weeks during the summer session. It is heavily discussion-based delivered in the form of slide presentations, discussions of the literature, video segments, and experiential relaxation instructions. Grading is based on class discussion and a written discussion paper. 

PHOL 479. Clinical Reasoning: Applied Medical Physiology. 3 Units.
Physicians, detectives, scientists and mechanics all use deductive reasoning with multiple hypotheses to solve problems. The primary objective of this course is to help students apply their knowledge of medical physiology to solving clinical problems. The second objective is to develop an overall view of the clinical reasoning process as a problem-solving method. This will be done primarily through problem-based case studies of patients with cardiovascular, pulmonary and renal disease. Case studies will be supplemented by video presentations of patient history and physical exam, and student-led presentations. Prereq: PHOL 482 and PHOL 484.

PHOL 480. Physiology of Organ Systems. 4 Units.
Our intent is to expand the course from the current 3 hours per week (1.5 hour on Monday and Wednesday) to 4 hours per week (1.5 hours on Monday and Wednesday plus 1 hour on Friday). Muscle structure and function, Myasthenia gravis and Sarcopenia; Central Nervous System, (Synaptic Transmission, Sensory System, Autonomic Nervous System, CNS circuits, Motor System, Neurodegenerative Diseases, Paraplegia and Nerve Compression); Cardiovascular Physiology (Regulation of Pressure and flow, Circulation, Cardiac Cycle, Electrophysiology, Cardiac Function, Control of Cardiovascular function, Hypertension); Hemorraghy, Cardiac Hypertrophy and Fibrillation; Respiration Physiology (Gas Transport and Exchange, Control of Breathing, Acid/base regulation, Cor Pulmonaryar and Cystic Fibrosis, Sleeping apnea and Emphysema); Renal Physiology (Gomelular Filtration, Tubular Function/transport, Gomeluronephritis, Tubulopaties); Gastro-Intestinal Physiology (Gastric motility, gastric function, pancreas and bile function, digestion and absorption, Liver Physiology, Pancreatitis, Liver Disease and cirrhosis); Endocrine Physiology (Thyroid, Adrenal glands, endocrine pancreas, Parathyroid, calcium sensing receptor, Cushing and diabetes, Reproductive hormones, eclampsia); Integrative Physiology (Response to exercise, fasting and feeding, aging). For all the classes, the students will receive a series of learning objectives by the instructor to help the students address and focus their attention to the key aspects of the organ physiology (and physiopathology). The evaluation of the students will continue to be based upon the students’ participation in class (60% of the grade) complemented by a mid-term and a final exam (each one accounting for 20% of the final grade). Offered as BIOL 480 and PHOL 480.

PHOL 481. Medical Physiology I. 6 Units.
Physiology is the dynamic study of life. It describes the vital functions of living organisms and their organs, cells, and molecules. For some, physiology is the function of the whole person. For many practicing clinicians, physiology is the function of an individual organ system. For others, physiology may focus on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on how the component cells function, which in turn depends on the interactions among subcellular organelles and countless molecules. Thus, it requires an integrated understanding of events at the level of molecules, cells, and organs. Medical Physiology I is a lecture course (3, 2 hr. lectures/week). It is the first of a two-part, comprehensive survey of physiology that is divided into four blocks: Block 1 covers the physiology of cells and molecules, signal transduction, basic electrophysiology, and muscle physiology; Block 2 covers the nervous system; Block 3 covers the cardiovascular system, and; Block 4 covers the respiratory system. Grading in the course will be based on performance on multiple choice/short essay examinations administered at the end of each block with each examination weighted according to the number of lectures contained in that block.
PHOL 482. Medical Physiology II. 6 Units.
Physiology is the dynamic study of life. It describes the vital functions of living organisms and their organs, cells, and molecules. For some clinicians, physiology is the function of an individual organ system. For others, physiology may focus on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on how the component cells function, which in turn depends on the interactions among subcellular organelles and countless molecules. Thus, it requires an integrated understanding of events at the level of molecules, cells, and organs. Medical Physiology II is a lecture course (3, 2hr. lectures/week). It is the second of a two-part, comprehensive survey of physiology that is divided into five blocks: Block 5 covers the physiology of the urinary system; Block 6 covers the gastrointestinal system; Block 7 covers the endocrine system; Block 8 covers reproduction; and Block 9 covers the physiology of everyday life. Grading in the course will be based on performance on multiple choice/short essay examinations administered at the end of each block with each examination weighted according to the number of lectures contained in that block.

PHOL 483. Translational Physiology I. 3 Units.
Physiology is the dynamic study of life, describing the vital functions of living organisms and their organs, cells, and molecules. For some clinicians, physiology is the function of an individual organ system. For others, it focuses on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on cellular function, which in turn depends on molecular interactions. Translational Physiology I will explore examples of how the latest basic research in physiology and biophysics is being applied to the treatment of human disease. For example, while the students are studying the basic principles of cardiovascular physiology, they will also be investigating how these principles are being applied to treat/cure human cardiovascular disorders such as congestive heart failure, coronary artery disease, etc. Translational Physiology I is a lecture course (1, 2hr lecture/week, and 1, 1hr lecture/week) taught by clinical and basic science faculty. The 2 hour lecture will be given primarily by clinical faculty and is focused on applying physiological principles to clinical cases of pathophysiology. The 1 hour lecture will be given primarily by basic science faculty and will expose students to the process of translating fundamental basic science research to the clinic, that is bench-to-bedside. It is the second of a two-part course that follows topics being simultaneously covered in the Medical Physiology II course. It is divided into 4 blocks: Block 5 covers the physiology of the urinary system; Block 6 covers the gastrointestinal system and metabolism; Block 7 covers the endocrine system and reproduction, and, Block 8 covers the physiology of everyday life. Grading in the course will be based on performance on multiple choice examinations administered at the end of each block with each examination weighted according to the number of lectures contained in the block. Coreq: PHOL 482.

PHOL 484. Translational Physiology II. 3 Units.
Physiology is the dynamic study of life, describing the vital functions of living organisms and their organs, cells, and molecules. For some clinicians, physiology is the function of an individual organ system. For others, it focuses on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on how the component cells function, which in turn depends on the interactions among subcellular organelles and countless molecules. Translational Physiology II will explore examples of how the latest basic research in physiology and biophysics is being applied to the treatment of human disease. For example, while the students are studying the basic physiology of the urinary system, they will also be investigating how these principles are being applied to treat/cure human kidney disorders such as renal failure, high blood pressure, glomerular disease, etc. Translational Physiology II is a lecture course (1, 2hr lecture/week, and 1, 1hr lecture/week) taught by clinical and basic science faculty. The 2 hour lecture will be given primarily by clinical faculty and is focused on applying physiological principles to clinical cases of pathophysiology. The 1 hour lecture will be given primarily by basic science faculty and will expose students to the process of translating fundamental basic science research to the clinic, that is bench-to-bedside. It is the second of a two-part course that follows topics being simultaneously covered in the Medical Physiology II course. It is divided into 4 blocks: Block 5 covers the physiology of the urinary system; Block 6 covers the gastrointestinal system and metabolism; Block 7 covers the endocrine system and reproduction, and, Block 8 covers the physiology of everyday life. Grading in the course will be based on performance on multiple choice examinations administered at the end of each block with each examination weighted according to the number of lectures contained in the block. Coreq: PHOL 482.

PHOL 485. Comparative & Evolutionary Physiology. 4 Units.
This course presents physiological concepts from the comparative and evolutionary perspective. Aspects of vertebrate and mammalian evolution will be considered with respect to the generation of adaptive advantages for organisms to changing environmental challenges since the Cambrian. Comparative physiological concepts include scaling, variations in nutrition, energy metabolism and work efficiency. The important influences of time, temperature, water and energy on mammalian biology will be presented. The course is a lecture based course that can be taken in person or on-line. Evaluations will be by regular quizzes, a mid-term and a final exam, all MCQ. Offered as PHOL 485 and ORIG 485.

PHOL 492. Clinical Reasoning II. 3 Units.
The objective of this course is to help students use principles of medical physiology to solve clinical problems. The second objective is to develop an overall view of clinical reasoning and improve critical thinking skills. The topics in Clinical Reasoning II are neurology, gastroenterology and endocrine/metabolic diseases. PHOL 479 Clinical Reasoning I, which covers cardiovascular, pulmonary and renal diseases, is not required. I anticipate that you will learn to: - Recognize physiologic mechanisms underlying abnormal physical findings, laboratory tests and imaging. - Use signs, symptoms, physical findings, laboratory tests and imaging to generate patient problem lists. - Develop and refine diagnostic hypotheses, i.e., differential diagnosis. - Understand the physiological basis of appropriate treatment plans. Prereq: PHOL 481.
PHOL 497. Journal Club in Structural Biology and Biophysics. 1 Unit. Biweekly Journal club to engage faculty and students in discussion of recent high profile papers in structural biology and protein biophysics. Registered students have to present one entire seminar on an assigned paper and attend all seminars, as well as participate in discussion. Recommended Preparation: undergraduate biochemistry or equivalent.

PHOL 497A. Neurology Grand Rounds. 1 Unit. This course is a weekly seminar series offered summer, fall, and spring semesters by the Department of Neurology at University Hospitals Case Medical Center. To earn a Passing grade in this course, students must attend at least 75% of the grand rounds offered by the Department of Neurology during the semester (signing in at the session) and submit to the course director within the week following the Grand Rounds, a one page report containing: 1) the name of the presenter and their professional affiliation; 2) the title of the presentation; 3) time and place of the Grand Rounds; 4) a one paragraph synopsis of the content of the presentation. Recommended Preparation: Pass the NBME Subject Exam in Physiology and Neurophysiology. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

PHOL 497B. Neurology Grand Rounds. 1 Unit. This course is a weekly seminar series offered summer, fall, and spring semesters by the Department of Neurology at University Hospitals Case Medical Center. To earn a Passing grade in this course, students must attend at least 75% of the grand rounds offered by the Department of Neurology during the semester (signing in at the session) and submit to the course director within the week following the Grand Rounds, a one page report containing: 1) the name of the presenter and their professional affiliation; 2) the title of the presentation; 3) time and place of the Grand Rounds; 4) a one paragraph synopsis of the content of the presentation. Recommended Preparation: Pass the NBME Subject Exam in Physiology and Neurophysiology. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

PHOL 497C. Clinical Nephrology Conference. 1 Unit. Clinical Nephrology Conference (CNC) at MetroHealth Medical Center, Dept. Medicine, Division of Nephrology. This course must be taken at least once and can be taken up to 2 times for a total of 2 credit hours. For the 15-week semester, students are responsible for attending and reporting on 12 of the scheduled CNC. For each CNC, the student must submit to the course director (Dr. Liedtke) within the week following the CNC, a one page report stating: a. The name of the presenter and their professional affiliation b. The title of the presentation c. Time and place of the CNC. A one paragraph synopsis of the presentation The course director is responsible for assigning the grades for this course. Prior or concurrent CITI training must be completed. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

PHOL 497D. Clinical Nephrology Conference. 1 Unit. Clinical Nephrology Conference (CNC) at MetroHealth Medical Center, Dept. Medicine, Division of Nephrology. This course must be taken at least once and can be taken up to 2 times for a total of 2 credit hours. For the 15-week semester, students are responsible for attending and reporting on 12 of the scheduled CNC. For each CNC, the student must submit to the course director (Dr. Liedtke) within the week following the CNC, a one page report stating: a. The name of the presenter and their professional affiliation b. The title of the presentation c. Time and place of the CNC. A one paragraph synopsis of the presentation The course director is responsible for assigning the grades for this course. Prior or concurrent CITI training must be completed. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

PHOL 497E. Pulmonary Grand Rounds. 1 Unit. Students are responsible for attending 10 of 15 sessions for that semester. Pulmonary Science Grand Rounds (adult pulmonology) and Pediatric Basic Science Seminar Series are convened Friday mornings at UH Case Medical Center at 8:00 am and 9:00 am, respectively. For each session attended, the student must submit to the course director (Dr. Liedtke) within the week following the session, a one page report stating: a. name of the presenter and their professional affiliation, b. title of the presentation, c. time and place of the session, and d. one paragraph synopsis of the presentation. The course director is responsible for assigning the grades for this course. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B.

PHOL 497F. Pulmonary Grand Rounds. 1 Unit. This course must be taken once and can be taken up to 2 times for a total of 2 credit hours. Students are responsible for attending 10 of 15 sessions for that semester. Pulmonary Science Grand Rounds (adult pulmonology) and Pediatric Basic Science Seminar Series are convened Friday mornings at UH Case Medical Center at 8:00 am and 9:00 am, respectively. For each session attended, the student must submit to the course director (Dr. Liedtke) within the week following the session, a one page report stating: a. name of the presenter and their professional affiliation, b. title of the presentation, c. time and place of the session, and d. one paragraph synopsis of the presentation. The course director is responsible for assigning the grades for this course. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B.

PHOL 498A. Physiology and Biophysics Departmental Seminar. 1 Unit. Weekly one-hour reviews by invited speakers of their research. Students present literature reviews or summaries of their research.

PHOL 498B. Physiology Seminar B (Spring Semester). 1 Unit. Weekly one-hour reviews by invited speakers of their research. Offered spring semester.

PHOL 498C. Physiology and Biophysics Department Seminar for Medical Physiology Students. 1 Unit. Weekly one-hour research reviews offered by various speakers, upon invitation. Students will present literature reviews or summaries of their own research throughout the course. Grades will be determined by quizzes based on the research presented.

PHOL 498D. Physiology MSMP Seminar B (Spring Semester). 1 Unit. Weekly one-hour research reviews offered by various speakers, upon invitation. Students will present literature reviews or summaries of their own research throughout the course. Grades will be determined by quizzes based on the research presented. Offered spring semester.

PHOL 505. Laboratory Research Rotation. 1 Unit. Six week experience in a selected faculty research laboratory designed to introduce the student to all aspects of modern laboratory research including the design, execution and analysis of original experimental work. Recommended preparation: Consent of instructor and scheduled laboratory.

PHOL 514. Cardiovascular Physiology. 3 Units.
The goal of this course is to provide the student with a solid foundation in cardiovascular physiology and pathophysiology. The course will begin by providing a solid foundation in the structure, phenotype and function of cardiac and vascular muscle. In addition, electrophysiology and metabolism will be addressed. Both basic physiology and more advanced topics, such as pathophysiology, will be covered using a journal club format. (Twice weekly, 1.5 hrs/class.) Student participation is required.

PHOL 519. Cardio-Respiratory Physiology. 3 Units.
This course is designed to integrate systemic, cellular and molecular aspects of cardio-respiratory systems in physiological and pathophysiological states. The course requires prior knowledge of basic physiology of the cardiovascular systems. Extensive student participation is required. Instructors provide a brief overview of the topic followed by presentation and critical appraisal of recent scientific literature by students.

PHOL 528. Contemporary Approaches to Drug Discovery. 3 Units.
This course is designed to teach the students how lead compounds are discovered, optimized, and processed through clinical trials for FDA approval. Topics will include: medicinal chemistry, parallel synthesis, drug delivery and devices, drug administration and pharmacokinetics, and clinical trials. A special emphasis will be placed on describing how structural biology is used for in silico screening and lead optimization. This component will include hands-on experience in using sophisticated drug discovery software to conduct in silico screening and the development of drug libraries. Each student will conduct a course project involving in silico screening and lead optimization against known drug targets, followed by the drafting of an inventory disclosure. Another important aspect of this course will be inclusion of guest lectures by industrial leaders who describe examples of success stories of drug development. Offered as BIOL 528, PHOL 528, PHRM 528, and SYBB 528.

PHOL 530. Technology in Physiological Sciences. 3 Units.
This lecture/discussion/journal course focuses on techniques in the physiological sciences. Topics include spectroscopy, microscopy, and electrophysiology. The theory and practice are covered with an emphasis on examples taken from the scientific literature.

PHOL 537. Microscopy-Principles and Applications. 3 Units.
This course provides an introduction to various types of light microscopy, digital and video imaging techniques, and their applications to biological and biomedical sciences via lectures and hands-on experience. Topics covered include geometrical and physical optics; brightfield, darkfield, phase contrast, DIC, fluorescence and confocal microscopes; and digital image processing. Offered as GENE 537, MBIO 537, and PHOL 537.

PHOL 601. Research. 1 - 18 Units.
Cellular physiology laboratory research activities that are based on faculty and student interests.

PHOL 610. Oxygen and Physiological Function. 1 Unit.
Lecture/discussion course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include oxygen transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as ANAT 610, NTRN 610, and PHOL 610.

PHOL 614. Sleep Physiology - Neurobiology of Sleep/Wake. 3 Units.
Participants in this course will gain an understanding of the neural mechanisms contributing to the states of sleep and wakefulness. Contemporary theories regarding why humans need to sleep will be reviewed. We will also review how perturbations within specific neurotransmitter systems become manifest as sleep related disorders and the pharmacological interventions used to normalize activity within those neural pathways. Prereq: PHOL 481 and PHOL 482 or requisites not met permission.

PHOL 620A. Clinical Observer: Neurology Service. 2 Units.
This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care; he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

PHOL 620B. Clinical Observer: Stroke Service. 2 Units.
This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care; he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.
PHOL 620C. Clinical Observer: Epilepsy Service. 2 Units.
This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care - he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

PHOL 620D. Clinical Observer: Neurology (Neuromuscular). 2 Units.
This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care - he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B.

PHOL 621. Clinical Nephrology Observer. 4 Units.
This course is a total of 4 week intensive experience offered on the School of Medicine elective schedule. Students will round with fellow and Medicine residents rotating during the elective on a daily basis starting with morning work rounds. Attending rounds generally begin in the afternoon. The student is restricted to a total of 15 hrs/ week on clinical rounds. The student is expected to read appropriate or assigned text, journal and internet resources for necessary background reading; the time spent on these resources do not count toward the 15 hrs/week for rounds. The fellow or attending physician on the service will recommend to the course director (Dr. Liedtke) whether the student earned a Pass or Fail in the course based upon attendance, professional demeanor, active participation, and knowledge of the area. The course director is responsible for assigning the grades for this course. CITI training must be completed prior to enrollment. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, PHOL 498B.

PHOL 622. Pediatric Pulmonology Observation. 2 Units.
Pediatric Pulmonology Observation (must be approved). 2 credit hours. Location: University Hospital, Rainbow Babies & Children Hospital. This course is an intensive experience with 2 weeks offered on the elective schedule detailed in Appendix A and 1 week with attending physician reading PFTs. For 2 weeks, students will round with attending staff and medical students according to their daily schedule at Rainbow Babies & Children Hospital, Pulmonary Division, starting with morning work rounds. Attending rounds generally begin in the afternoon. The student will not have direct patient contact. The student is expected to read appropriate or assigned text, journal and internet resources for necessary background reading. Students will journal their daily experience. Students will write a paper relating basic physiology to a case identified during rounds; the Director (Dr. Liedtke) will grade the paper. The attending physician on the service will recommend to the course director (Dr. Liedtke) based upon attendance, professional demeanor, active participation, and knowledge of the area. The course director is responsible for assigning the grades for this course. Dr. Ross Meyers will serve as the student's mentor and assign students to services. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL498B.

PHOL 623. Adult Pulmonology Observation. 2 Units.
Adult Pulmonology AOC (must be approved). 2 credit hours. Location: University Hospital and VA Hospital. This course is an intensive experience with 2 weeks offered on the elective schedule detailed in Appendix A and 1 week with attending physician reading PFTs to evaluate 25 adult PFT, 6 exercise tests, and 6 methacholine challenges. For 2 weeks, students will round with attending staff and medical students according to their daily schedule at University Hospital starting with morning work rounds. Attending rounds generally begin in the afternoon. The student will not have direct patient contact. The student is expected to read appropriate or assigned text, journal and internet resources for necessary background reading. Students will journal their daily experience. Students will write a paper relating basic physiology to a case identified during rounds; the Director (Dr. Liedtke) will grade the paper. The attending physician on the service will recommend to the course director (Dr. Liedtke) based upon attendance, professional demeanor, active participation, and knowledge of the area. The course director is responsible for assigning the grades for this course. Dr. Ross Meyers will serve as the student's mentor and assign students to services. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL498B.

PHOL 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.)
Population and Quantitative Health Sciences

Room W-G57, School of Medicine
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Jonathan Haines, PhD, Chair
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The Department of Population and Quantitative Health Sciences (http://epbiwww.case.edu) (formerly the Department of Epidemiology and Biostatistics) is a multidisciplinary department offering a range of educational programs rooted in Epidemiology, Biostatistics, Biomedical and Health Informatics, Clinical Research and Public Health. These programs include an undergraduate minor, graduate certificate, 4 Master’s degrees and 3 PhD degrees. Our graduates develop the knowledge, skills, and competencies needed to assume positions of leadership with the ultimate goal of advancing the public’s health. Through challenging coursework, independent and collaborative research opportunities, and internships students will develop a thorough understanding of the multiple determinants of population health outcomes and the research and analytic skills to answer today’s complex health problems.

The Department of Population and Quantitative Health Sciences offers the following degrees:

- **Doctor of Philosophy (PhD)**
  - Epidemiology & Biostatistics (p. 160)
  - Biomedical & Health Informatics (p. 159)
  - Clinical and Translational Science (http://bulletin.case.edu/schoolofmedicine/epidemiologyandbiostatistics/
  %20/schoolofmedicine/generalmedicalsciences/#clinicalresearchmtext)

- **Master of Science (MS)**
  - Biostatistics (p. 152)
  - Biomedical & Health Informatics (p. 158)
  - Clinical Research (http://bulletin.case.edu/schoolofmedicine/crsp/#clinicalresearchmtext)

- **Master of Public Health (MPH)** (p. 155)

- **Graduate Certificate**
  - Health Informatics (p. 161)
  - Clinical Research (http://bulletin.case.edu/schoolofmedicine/generalmedicalsciences/#globalhealthcertificatetext)

- **Undergraduate Minor**
  - Public Health (p. 154)

**Faculty and Research**

Department faculty are nationally recognized and have more than $12 million in grants that support projects including HIV/TB research in Uganda, the search for genes that cause disease, cancer prevention and control, studies of interventions to change human behaviors that promote good health, design of clinical trials, studies to change high-risk behaviors related to AIDS, studies of public policies concerning the health of the elderly, and cost/benefit studies of medical interventions. Many research projects are performed in collaboration with the four affiliated hospitals; the University Hospitals, Metro Health, the Cleveland Clinic and the Louis Stokes Cleveland VA Medical Center. Faculty members work closely with our local health departments and serve on many community task forces. The department has offices in multiple locations at the university, (Wood Building and Wolstein Research Building) and in the Prevention Research Center for Healthy Neighborhoods (PRHCN). The department maintains two scientific computer centers comprised of 14 lab computers and over a dozen servers. Several very large national health care and demographic databases are stored on these servers and are used for faculty and student research and educational projects.

**Master of Science in Biostatistics**

Questions and Information:

Nickalaus Kozura, EdM

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ms-biostatistics@case.edu

The Department of Population and Quantitative Health Sciences offers a revolutionary new, Master of Science (MS) Program in Biostatistics (and a BS/MS paired with any BS major), a discipline in high and exploding demand. The program can be done intensively in 11 months, or at a slower pace to finish in 1.5 or 2 years. The program was designed after extensive interviews were conducted with a wide array of potential employers to make sure our graduates will have the edge in a marketplace that has been rapidly changing, while also prepared to continue in a PhD program. More and more, biostatisticians are expected to have familiarity with the area of application. The CWRU MS Biostatistics program reflects these new needs. Students may elect to take the program part-time and complete it at their own pace.

Picture yourself saving and improving lives:

- Analyzing data from health studies to determine the best treatment
- Working with data from millions of patients
- Identifying genes linked to specific diseases
- Using data to develop instruments to measure latent constructs like psychosocial well-being

There are four tracks our students can choose from Biostatistics, Genomics & Bioinformatics, Health Care Analytics, and Social & Behavioral Science.

Students do internships at leading academic medical centers and research centers, at the National Institutes of Health and in industry. Graduates are going on to jobs at leading health institutions and getting funded PhD slots at top Universities.

**Core Courses for this Program:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQHS 414</td>
<td>Data Management and Statistical Programming</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 431</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 432</td>
<td>Statistical Methods II</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 453</td>
<td>Categorical Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 602</td>
<td>Practicum (Internship/Practicum)</td>
<td>3</td>
</tr>
</tbody>
</table>
PQHS 602                   Practicum (Introduction to Biostatistical Consulting)  1

Total Units  19

**Biostatistics Track:**

The biostatistics-track students will receive a carefully designed balanced training in biostatistical theories, methods, and biomedical applications. This track student will gain mastery of basic probability theory and statistical inference, learn the methods of survival and longitudinal data analysis, and still have the flexibility to choose an elective from advanced courses. The didactic methods and theory, and hands on analytical training would lead to either the pursuit of an advanced relevant degree and/or work as a master’s level biostatistician in various settings, e.g. academia, industry, hospitals, Pharmaceutical companies or government agencies.

**Track Leader:**

Dr. Abdus Sattar, PhD
Email: sattar@case.edu
Phone Number: 216.368.1501
Website: sattar.case.edu

**Required Courses (9 Credits)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQHS 435</td>
<td>Survival Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 480</td>
<td>Introduction to Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 459</td>
<td>Longitudinal Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Select 1 of the following Track Electives (3 Credits)</td>
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</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQHS 471</td>
<td>Machine Learning &amp; Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>STAT 426</td>
<td>Multivariate Analysis and Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 450</td>
<td>Clinical Trials and Intervention Studies</td>
<td>3</td>
</tr>
</tbody>
</table>

**Genomics and Bioinformatics Track:**

Students will be trained to work in genomics and bioinformatics areas. In addition to the basics in biostatistics, they will learn the designs, methods, techniques, and tools that are commonly used in genetic epidemiology, statistical genomics, and bioinformatics research. Big Data methods of data mining and machine learning are also required in this track. Target job positions are analyst, statistician and bioinformaticians in a genomics or genetic epidemiology research team in a research institute/university, pharmaceutical or biotech company.

**Track Leader:**

Chun Li, PhD
Email: cxl791@case.edu
Phone Number: 216.368.5633

**Required Track Courses (12 Credits)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQHS 471</td>
<td>Machine Learning &amp; Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 451</td>
<td>A Data-Driven Introduction to Genomics and Human Health</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 452</td>
<td>Statistical Methods for Genetic Epidemiology</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PQHS 457</td>
<td>Current Issues in Genetic Epidemiology: Design and Analysis of Sequencing Studies</td>
<td>3</td>
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</table>

**Health Care Analytics Track:**

Biostatistics is a vital part of clinical research, which includes both observational studies and randomized clinical trials. Modern clinical, or patient, research takes advantage of innovative methodologies for the design and analysis of such studies to increase the likelihood of success and minimize patient burden and the use of scarce resources. Clinical research biostatisticians work as part of multi-disciplinary teams with clinical and statistical investigators to develop and execute study designs and analysis plans with scientific rigor, and in support of regulatory requirements by sanctioning bodies and funding agencies. Principal roles include the design, analysis, coordination and reporting of observational and trial-based clinical research studies. Most of a clinical research biostatistician’s work is dedicated to evaluating, executing and reporting on well-designed studies to help investigators meet their scientific objectives. Related job titles include biostatistician, lead, senior or principal biostatistician, consulting statistician, statistical researcher, statistical programmer, clinical informaticist, data scientist and clinical research manager. Such positions require strong written and verbal communication skills, and the ability to work as part of a team with subject matter experts on protocol development and statistical reporting. Biostatisticians completing the Health Care Analytics track will be well-positioned to apply for positions in industry, academia (including teaching hospitals), pharmaceutical companies and government.

**Track Leader:**

Thomas Love, PhD
Email: tel3@case.edu
Phone Number: 216.778.1265

**Required Track Courses (6 Credits)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PQHS 435</td>
<td>Survival Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 515</td>
<td>Secondary Analysis of Large Health Care Databases</td>
<td>3</td>
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</table>

**Select 2 of the following Track Electives (6 Credits)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PQHS 459</td>
<td>Longitudinal Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 500</td>
<td>Design and Analysis of Observational Studies</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 450</td>
<td>Clinical Trials and Intervention Studies</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 471</td>
<td>Machine Learning &amp; Data Mining</td>
<td>3</td>
</tr>
</tbody>
</table>

**Social and Behavioral Sciences Track:**

Students will be trained to work as analysts and research assistants in the social and behavioral sciences, including anthropology, sociology, psychology, psychiatry, and social work. Students will be trained in the most common study designs and analytic methods in these application areas. Such work often involves collaboration with multidisciplinary teams in community-practice / biomedical settings, with a focus on developmental, social/behavioral, cognitive, and/or mental health outcomes. This track is intended for students whose undergraduate work involved a major or minor in one of the social and behavioral sciences. It was created to serve the needs of social and behavioral science researchers who need research analysts trained in statistics, but with an understanding of their field and familiarity with qualitative and mixed
methods as well. Target job positions are in academia, government, and research institutes.

Track Leader:
Arin Connell, PhD
Email: arin.connel@case.edu
Phone Number: 216.368.1550

Required Track Courses (12 Credits)
PQHS 459 Longitudinal Data Analysis 3
MPHP 482 Qualitative and Mixed Methods in Public Health 3
NURS 632 Advanced Statistics: Structural Equation Modeling 3
PSCL 412 Measurement of Behavior 3

Graduates from accredited universities and colleges will be considered for admission to the department. All applicants must satisfy both CWRU and department requirements for graduate admission. The MS program in Biostatistics consists of a 16-credit core curriculum, plus a 12 credit major and a 3 credit internship or practicum.

General Requirements
Students must satisfy the requirements of the School of Graduate Studies as stated here, as well as those outlined by the Biostatistics program. The MS program in Biostatistics offers “Plan B”, as defined by the CWRU School of Graduate Studies. For Plan B, the student must successfully submit and pass their written internship/practicum project.

Minor in Public Health
Questions and Information:
Nickalaus Koziura, EdM
Undergraduate Minor in Public Health
Case Western Reserve University
10900 Euclid Avenue, W-G74
Cleveland, Ohio 44106-4945
216.368.5957 - phone
ph-minor@case.edu

The impact of public health and the need for the general public to know more is periodically highlighted by the impact of opioid addiction being the leading cause of death of Ohioans under age 55, obesity being the leading cause of death, and during crises such as epidemics and pandemics like Zika, Ebola, and Avian Flu. Education in public health is not only necessary for those entering the public health workforce, but is a critical complementary subject for all those considering a career in a health related field.

The Undergraduate Minor in Public Health is a 15 credit program that exposes students to the field of public health. This minor is designed to equip students with the core concepts of Public Health and is highly collaborative with many departments to provide a robust option for students who are pre-health or pursuing medical anthropology, medical sociology, mental health, global health, or nutrition and health promotion.

Courses for the Minor may be double-counted from Majors.

Required Courses (9 Credits):
A Master of Public Health degree is designed to prepare students to address the broad mission of public health, defined as “enhancing health in human populations, through organized community effort,” utilizing education, research and community service. Public health practitioners are prepared to identify and assess the health needs of different populations, and then to plan, implement and evaluate programs to meet those needs. It is the task of the public health practitioner to protect and promote the wellness of humankind. The master of public health program prepares students to enhance health in human populations through organized community effort. Graduates are qualified to work in local and state health departments, universities and colleges, hospitals, ambulatory medical centers, non-profit organizations, and the insurance and pharmaceutical industries. The program seeks to attract a rich mix of students, including those pursuing degrees in medicine, nursing, dentistry, law, social work, anthropology, bioethics, management and other fields, as well as students holding undergraduate degrees.

Students in the MPH program can complete the program using one of two plans of study. Common Core and Intensive Research Pathway. The Common Core is the standard plan of study for MPH Students and the Intensive Research Pathway (IRP) is an alternative plan of study that allows students to gain exposure to more quantitative coursework. Students can complete any concentration regardless of their plan of study. Previous experience or education pertaining to public health may increase the student’s flexibility in course selection. Students may also enroll part-time and take courses over a three to five-year period.

Both the Common Core and the IRP address and meet all Foundational Knowledge and Core Competencies. Regardless of plan of study, all MPH students will complete the same Applied Practical Experience and Integrated Learning Experience requirements. Below is a direct plan of study comparison between the Common Core and the IRP.

### Common Core Course Requirements:
- **Core required courses (18 credits)**
  - MPH 405 Statistical Methods in Public Health 3
  - MPH 406 History and Philosophy of Public Health 3
  - MPH 411 Introduction to Health Behavior 3
  - MPH 429 Introduction to Environmental Health 3
  - MPH 439 Public Health Management and Policy 3

### Intensive Research Pathway Course Requirements:
- **Core required courses (27 credits)**
  - MPH 406 History and Philosophy of Public Health 3
  - MPH 411 Introduction to Health Behavior 3
  - MPH 429 Introduction to Environmental Health 3
  - MPH 439 Public Health Management and Policy 3
  - MPH 483 Introduction to Epidemiology for Public Health Practice 3
  - PQHS 431 Statistical Methods I 3
  - PQHS 432 Statistical Methods II 3
  - PQHS 490 Epidemiology: Introduction to Theory and Methods 3
  - PQHS 414 Data Management and Statistical Programming 3

### Culminating Experience
- MPH 650 Public Health Practicum 3
- Complete 9 credits within chosen Concentration 9

### Electives 6

**Total Units: 42**

### Concentrations
Currently, five different concentrations (a.k.a. tracks) are offered by the CWRU MPH Program: Population Health Research, Global Health, Health Policy & Management, Health Promotion & Disease Prevention, and Health Informatics. Each concentration has a required course or courses (in addition to the core required courses), plus selective offerings to be combined for a total of 9 credit hours in major coursework. Students develop a Capstone project relevant to the concentration area, and apply the knowledge of the subject. Individual emphasis will differ from student to student within each concentration.

MPH students can also choose to expand the emphasis and depth of their program of study by electing to do a double concentration plan of study. For the double concentration, the student chooses two areas (two concentrations) of equal emphasis and takes 3 courses in each area (this requires the student to take a minimum of 48 credit hours). The student’s Capstone project must embrace and integrate both emphases, and no double-counting of credits can take place. Students choosing to do the double concentration plan of study should also work closely with an advisor to ensure optimal course selection and foster the evolution of a successful Capstone project.
Concentration Competencies:

- Construct a conceptual model and choose an appropriate existing data set, such as electronic health records, Medicare/Medicaid, Medical Expenditure Panel Survey, Health Care Utilization Project and Health and Retirement Study, to address a specific population health research question.

- Design and perform a study consisting of a retrospective analysis of an existing data set to address a population health research question of interest.

- Design efficient computer programs for data management and manipulation, statistical analysis, as well as presentation using R (or another statistical programming language, such as SAS).

- Apply advanced statistical methods for analyzing count data, categorical data, and time to event data: specifically, Poisson regression models, multinomial and ordinal logistic regression models, and Cox proportional hazard models.

- Perform predictive modeling employing different strategies for model selection (best subsets and shrinkage approaches), imputation of missing values, and splitting data into training and test data sets.

### Required Concentration Courses (6 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MPHP 432</td>
<td>Statistical Methods II</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 515</td>
<td>Secondary Analysis of Large Health Care Data Bases</td>
<td>3</td>
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</table>

### Concentration Elective (3 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MPHP 482</td>
<td>Qualitative and Mixed Methods in Public Health</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 421</td>
<td>Health Economics and Strategy</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 450</td>
<td>Clinical Trials and Intervention Studies</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 467</td>
<td>Comparative and Cost Effectiveness Research</td>
<td>1</td>
</tr>
<tr>
<td>MPHP 484</td>
<td>Global Health Epidemiology</td>
<td>1 - 3</td>
</tr>
<tr>
<td>PQHS 414</td>
<td>Data Management and Statistical Programming</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 435</td>
<td>Survival Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 440</td>
<td>Introduction to Population Health</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 451</td>
<td>A Data-Driven Introduction to Genomics and Human Health</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 452</td>
<td>Statistical Methods for Genetic Epidemiology</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 459</td>
<td>Longitudinal Data Analysis</td>
<td>3</td>
</tr>
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</table>

### Global Health Concentration

Coordinator - Peter Zimmerman, PhD

Concentration Competencies:

- Describe the relationships among agencies focused on colonial health, tropical medicine, international health and global health in a historical context.

- Prioritize diseases of global health importance and their epidemiological context.

- Apply methods for strengthening and focusing existing capacities and resources for health program sustainability and enhancement.

- Contrast application of technology to impact priority diseases with addressing the underlying social and economic determinants of global health linked to health care delivery systems.

- Apply the fundamental international principles and standards for the protection of human research subjects in diverse cultural setting.

### Required Concentration Courses (6 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 484</td>
<td>Global Health Epidemiology</td>
<td>3</td>
</tr>
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</table>

### Concentration Electives (3 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MPHP 510</td>
<td>Health Disparities</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 461</td>
<td>Urban Health</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 480</td>
<td>Medical Anthropology and Global Health I</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 511</td>
<td>Seminar in Anthropology and Global Health: Topics</td>
<td>3</td>
</tr>
<tr>
<td>LAWS 4101</td>
<td>International Law</td>
<td>3</td>
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<tr>
<td>LAWS 5123</td>
<td>International Trade Law and Policy</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 460</td>
<td>Managing in a Global Economy</td>
<td>3</td>
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</table>

### Health Care Policy & Management Concentration

Coordinator - Kate Nagel, DrPH

Concentration Competencies:

- Apply the principles of program development, planning, budgeting, and resource management in organizational or community initiatives.

- Describe how policy impacts healthcare delivery and outcomes.

- Apply a continuous quality and performance improvement framework to address organizational coordination and performance.

- Identify methods for decision making using evidence-based, systems thinking, and data-driven approaches to health policy and management.

- Identify how access, quality, and cost are influenced by organizational or financial structures.

### Required Concentration Course (6 Credits)

<table>
<thead>
<tr>
<th>Course</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MPHP 468</td>
<td>The Continual Improvement of Healthcare: An Interdisciplinary Course</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 421</td>
<td>Health Economics and Strategy</td>
<td>3</td>
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<tr>
<td>OR</td>
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<tr>
<td>MPHP 456</td>
<td>Health Policy and Management Decisions</td>
<td>3</td>
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### Concentration Elective (3 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BETH 417</td>
<td>Introduction to Public Health Ethics</td>
<td>3</td>
</tr>
<tr>
<td>HSMC 420</td>
<td>Health Finance</td>
<td>3</td>
</tr>
<tr>
<td>LAWS 5205</td>
<td>Public Health Law</td>
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<tr>
<td>MPHP 433</td>
<td>Community Interventions and Program Evaluation</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 467</td>
<td>Comparative and Cost Effectiveness Research</td>
<td>1</td>
</tr>
<tr>
<td>MPHP 475</td>
<td>Management of Disasters Due to Nature, War, or Terror</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 510</td>
<td>Health Disparities</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 532</td>
<td>Health Care Information Systems</td>
<td>3</td>
</tr>
<tr>
<td>POSC 483</td>
<td>Health Policy and Politics in the United States</td>
<td>3</td>
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</tbody>
</table>
Health Informatics Concentration
Coordinator - Siran Koroukian, PhD

Concentration Competencies:

- Understand the fundamentals of using biomedical ontologies for integration of biomedical and health data
- Differentiate between standard health data exchange formats and vocabularies
- Explain how clinical data originating from different systems are collected and coded and how they are normalized, aggregated, and analyzed
- Describe how biomedical terminological systems are used in natural language processing workflow for unstructured biomedical text
- Describe the ethical, regulatory, managerial, financial, and practical aspects of data security

Required Concentration Courses (6 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQHS 416</td>
<td>Introduction to Computing in Biomedical Health Informatics</td>
<td>3</td>
</tr>
<tr>
<td>IIME 473</td>
<td>Fundamentals of Clinical Information Systems</td>
<td>3</td>
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Concentration Elective (3 Credits)

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<tr>
<th>Course</th>
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<th>Credits</th>
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<tbody>
<tr>
<td>HSMC 432</td>
<td>Health Care Information Systems</td>
<td>3</td>
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<tr>
<td>HSMC 446</td>
<td>Models of Health Care Systems</td>
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</tr>
<tr>
<td>HSMC 457</td>
<td>Health Decision Making &amp; Analytics</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 432</td>
<td>Statistical Methods II</td>
<td>3</td>
</tr>
<tr>
<td>NUND 510</td>
<td>Application of Health Information Technology and Systems</td>
<td>1</td>
</tr>
<tr>
<td>PQHS 515</td>
<td>Secondary Analysis of Large Health Care Data Bases</td>
<td>3</td>
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Health Promotion & Disease Prevention Concentration
Coordinator - Erika Trapl, PhD

Concentration Competencies:

- Assess needs for health interventions for the general public as well as at-risk populations
- Systematically evaluate health promotion strategies across typologies of evidence
- Apply system complexity concepts in the context of nested individuals, social networks, organizations, and communities (i.e., systems nested within systems) in the analysis of public health problems and solutions
- Develop health education/health promotion strategies that create an understanding of and respect for the importance of culture in practice and policy
- Apply social and behavioral theory and planning models and evidence-based health promotion strategies for a variety of populations in the development of a health education/health promotion plan

Required Concentration Courses (6 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>MPHP 433</td>
<td>Community Interventions and Program Evaluation</td>
<td>3</td>
</tr>
<tr>
<td>MPHP 413</td>
<td>Health Education, Communication, and Advocacy</td>
<td>3</td>
</tr>
</tbody>
</table>

Select 1 Concentration Course from the list below (3 Credits)

- MPHP 464 Obesity and Cancer: Views from Molecules to Health Policy
- MPHP 475 Management of Disasters Due to Nature, War, or Terror
- MPHP 485 Adolescent Development
- MPHP 510 Health Disparities
- ANTH 461 Urban Health

Dual Degree Options

Because of the breadth of the field of public health, the MPH Program is an ideal degree to integrate with other professional schools and graduate programs at Case. University leadership has recognized collaboration as one of the priorities for the future of the university, and has approved 11 MPH dual degree programs. They are:

- JD/MPH (School of Law)
- MA or PhD/MPH (Department of Anthropology, School of Graduate Studies)
- MA/MPH (Department of Bioethics, School of Medicine)
- MBA/MPH (Weatherhead School of Management)
- MD/MPH (School of Medicine)
- MS/MPH (Department of Nutrition)
- MSN/MPH (School of Nursing)
- MSSA/MPH (Social Administration, Mandel School of Applied Social Sciences)
- DMD/MPH (School of Dentistry)
- BA/MPH (Integrated Graduate Studies (IGS) Program)
- MSM-HC (Weatherhead School of Management)

Generally, dual degree students complete both degrees by adding one year of study to the partner degree. For example, an MD student could add one year to the four-year MD Program to complete his/her MD/MPH dual degree in five years. In addition to the requirements for the partner degree program, all dual degree students will complete 27 credits of core MPH requirements (18 core credits plus 9 Culminating Experience credits). Of the remaining 15 credits, it is anticipated that 9 will be selected from courses taught by the Department of Population and Quantitative Health Sciences. The remaining 6 credits can be selected from the list of approved courses in the partner program. Students wishing to take courses not previously approved in the dual degree plan may petition to do so in writing to both partner programs. In most cases, it will be assumed that dual degree students will adopt an area of concentration specific to their shared degree area.

Dual degree students should have academic advisors from both the MPH Program and the partner program faculty. Advisors of dual degree students are encouraged to develop dialogues with their partner advisors and collaborate on students’ programs of study. This dialogue should be accomplished by a minimum of one annual group meeting of both advisors with the student to be arranged by the student. During the initial meeting, before the end of the student’s first semester, a Planned Program of Study (PPOS) is developed. The PPOS can be revised later, also with the approval of both advisors. The PPOS should include (if relevant) a written description of how outside courses will benefit the student’s public health education. Academic performance issues, or any other issues, are presented by the advisors to the MPH Dual Degree Partners Committee for final disposition. The MPH Dual Degree Partners Committee will adjudicate any difference in opinion between advisors.
The Director of the MPH Program, assisted by the Administrative Director, is the coordinator of the dual degree programs and provides services for student support, including special events and publications dedicated to serving the needs of dual degree students and building their sense of scholarship and community as a group.

Dual Degree Contacts

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MS Biomedical & Health Informatics
Questions and Information:

Nickalaus Koziura, EdM
Master of Science - Biomedical & Health Informatics Program
Case Western Reserve University
10900 Euclid Avenue, W-G74
Cleveland, Ohio 44106-4945
216.368.5957 - phone
informatics@case.edu

The Master of Science in Biomedical and Health Informatics (BHI) program offers non-thesis and thesis-based options. While the usual time to completion with a full-time schedule is 16 months, students have the option of doing the non-thesis program intensively in 11 months.

The BHI program offers pragmatic, interdisciplinary areas of study immediately relevant in contemporary health systems or research enterprises. Our Master's degree program is unique in that it encompasses both biomedical research and clinical care informatics with applications to precision medicine, accountable care organizations, and reproducible science. Our program provides grounding across multiple disciplines and will be of interest if you seek a career in which you:

• Analyze patient diagnoses, treatments and outcomes, based on electronic health records, to inform best practices in clinical care
• Design or manage studies in the clinical setting to inform quality and safety process improvements
• Collaborate in biomedical research, including the analysis of large genetic and various “omics” studies, integrated with clinical or population data, to advance the understanding of diseases
• Design and manage studies that draw from clinical, cohort or population data to inform the assessment and development of devices, therapeutics or other interventions

We bring together a diverse group of faculty from across Case Western Reserve University – the School of Medicine, clinical faculty from our affiliated hospitals, the Weatherhead School of Business, and the School of Engineering – for a cross-disciplinary approach that offers the opportunity to craft tailored areas of study grounded in core competencies:

• Data analytics
• Biomedical, clinical and/or population health research
• Computational and systems research design
Non-Thesis Program (with 11-month intensive option)

27 credits of course work and a 3 credit project or internship/practicum, with a report that is evaluated by the student’s mentoring/advisory committee.

Thesis Program (no intensive option)

This is for students who may want to continue into a PhD program. It requires 24 credits of course work and six credits developing and presenting a thesis, evaluated by the mentoring/advisory committee.

Required Core Courses (9 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>MPHP 532</td>
<td>Health Care Information Systems</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 431</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 416</td>
<td>Introduction to Computing in Biomedical Health Informatics</td>
<td>3</td>
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</tbody>
</table>

Biomedical and Health (3 Credits)

Choose one of the following:

- EBME 410 Medical Imaging Fundamentals 3
- MPHP 406 History and Philosophy of Public Health 3
- PQHS 440 Introduction to Population Health 3
- PQHS 451 A Data-Driven Introduction to Genomics and Human Health 3
- PQHS 465 Design and Measurement in Population Health Sciences 3
- PQHS 490 Epidemiology: Introduction to Theory and Methods 3

Computation and System Design (3 Credits)

Choose one of the following:

- EECS 433 Database Systems 3
- EECS 458 Introduction to Bioinformatics 3
- EECS 477 Advanced Algorithms 3
- EECS 493 Software Engineering 3
- PQHS 471 Machine Learning & Data Mining 3

Data Analytics (3 Credits)

Choose one of the following:

- EBME 419 Applied Probability and Stochastic Processes for Biology 3
- PQHS 432 Statistical Methods II 3
- PQHS 453 Categorical Data Analysis 3
- PQHS 459 Longitudinal Data Analysis 3
- PQHS 467 Comparative and Cost Effectiveness Research 1
- PQHS 515 Secondary Analysis of Large Health Care Data Bases 3

Thesis OR Practicum/Internship

- PQHS 651 Thesis M.S. 6
- OR
- PQHS 602 Practicum 3

Elective 3

PhD Biomedical & Health Informatics

Questions and Information:

Nickalaus Koziura, EdM
PhD - Biomedical & Health Informatics Program
Case Western Reserve University
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Cleveland, Ohio 44106-4945
216.368.5957 - phone
informatics@case.edu

The PQHS faculty team is dedicated to mentoring PhD students in developing a career grounded in research that can be applied across many areas of biomedical, clinical and population health, and bioinformatics. We take time getting to know candidates and in cultivating junior colleagues who can expect that our interdisciplinary approach will offer a solid intellectual grounding for a future career.

The PhD BHI program builds on the BHI Master’s – or Master’s programs from other institutions – and offers a focus on core domain areas:

- Data analytics
- Biomedical, clinical and/or population health research
- Computational and system research design

The PhD program is a full-time, research oriented program, based in Cleveland, that typically takes four years (post-Master’s) to complete. PhD candidates take core requirements intended to support capabilities essential to the interdisciplinary research that this program advances. Additionally, there are courses at the 400 level and higher across these domain areas available for a tailored program, based on recommendations from the student’s mentorship/advisory committee and the student’s areas of interest. In total, there are 36 credits of coursework plus 18 of dissertation research, all in line with CWRU PhD program requirements.

All first-year full-time students in the PhD program are fully funded by the School of Medicine (Stipend, Tuition, and Health Insurance are included). After the conclusion of their first year, students will be supported by grants (research and training) held by their research mentor.

In addition to coursework in their first year, all students will do three research rotations chosen from an approved list of potential mentors. The purpose of a rotation is to provide students with exposure to the laboratory/scientific culture pervasive in that discipline and research group, and to determine if the student-mentor fit is appropriate. Faculty members conduct their independent research, and run their laboratories using a variety of styles. The rotation gives the student and faculty member an opportunity to determine if they have similar work styles, and if the scientific culture and training will lead to successful training of the student. By the end of the first year, all students will choose a mentor and a lab in which to do their dissertation work.

Students will master the rigorous scientific and analytic methods necessary to be at the forefront of efforts to not only describe, but also effectively evaluate and improve health. Exposure to cutting edge research will be facilitated by our department-wide seminar that includes talks by world-leading experts both from off- and on-campus. As part of their training, all students will participate in these seminars, including as speakers. This will help develop the necessary communication skills that are expected of successful researchers.

The PhD in Biomedical Health Informatics welcomes applicants from a diverse field of backgrounds and training experiences. Graduates from accredited universities and colleges will be considered for admission to the department. Applicants may apply straight from baccalaureate
training, from advance degree programs (MS, MPH, MD), or from the professional field. All applicants must satisfy both CWRU and department requirements for graduate admission.

Core Curriculum
All incoming PhD students take a required common core curriculum supplemented by additional coursework as determined by their mentoring or dissertation committees.

### Required Core Courses (12 Credits)
- **MPHP 532** Health Care Information Systems 3
- **PQHS 416** Introduction to Computing in Biomedical Health Informatics 3
- **PQHS 431** Statistical Methods I 3
- **PQHS 432** Statistical Methods II 3

### Biomedical and Health (3 Credits)
Choose one of the following:
- **EBME 410** Medical Imaging Fundamentals 3
- **MPHP 406** History and Philosophy of Public Health 3
- **PQHS 440** Introduction to Population Health 3
- **PQHS 451** A Data-Driven Introduction to Genomics and Human Health 3
- **PQHS 465** Design and Measurement in Population Health Sciences 3
- **PQHS 490** Epidemiology: Introduction to Theory and Methods 3

### Computation and System Design (3 Credits)
Choose one of the following:
- **EECS 433** Database Systems 3
- **EECS 454** Analysis of Algorithms 3
- **EECS 458** Introduction to Bioinformatics 3
- **EECS 477** Advanced Algorithms 3
- **EECS 493** Software Engineering 3
- **PQHS 471** Machine Learning & Data Mining 3

### Data Analytics (3 Credits)
Choose one of the following:
- **EBME 419** Applied Probability and Stochastic Processes for Biology 3
- **PQHS 453** Categorical Data Analysis 3
- **PQHS 459** Longitudinal Data Analysis 3
- **PQHS 467** Comparative and Cost Effectiveness Research 1
- **PQHS 515** Secondary Analysis of Large Health Care Data Bases 3

### Required Research Courses (3 Credits)
- **PQHS 444** Communicating in Population Health Science Research (2 Credits - Students take this course twice) 1
- **PQHS 445** Research Ethics in Population Health Sciences 0
- **IBMS 500** On Being a Professional Scientist: The Responsible Conduct of Research 1
- **PQHS 501** Research Seminar (Must take for at least 6 semesters) 0

### Electives (4 Courses, 12 credits)
The selection of elective courses is made by each student in consultation with mentoring committee

### Dissertation (18 total credits)
- **PQHS 701** Dissertation Ph.D. (PhD students can take between 1-9 credits of 701 per semester) 1-9

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**PhD Epidemiology and Biostatistics**

Questions and Information:

Nickalaus Koziura, EdM

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The mission of the Doctoral Program in Epidemiology and Biostatistics in the Department of Population and Quantitative Health Sciences is to prepare students for an active, fulfilling, and lifelong research career, with the goal of improving human health.

The program draws on the core disciplines of epidemiology and biostatistics, broadly defined, but may also include a wide range of other academic areas, ranging from human genetics to health policy. As part of their training students will develop the knowledge, skills, and competencies necessary to be leading researchers in areas that provide improved understanding of how to advance public health. Through challenging coursework and research opportunities, both independent and collaborative, students will develop a thorough understanding of the multiple determinants of population health outcomes, the individual and structural factors that may lead to disparities in those outcomes, and the way in which specific policies and interventions can influence the nature and impacts of population health determinants. A key aspect of the program is to train students to define important, unanswered questions and design appropriate strategies to solve our pressing health problems, locally, nationally and globally. In addition, the program in Epidemiology and Biostatistics is committed to developing the skills necessary for lifelong learning as we recognize this as being key to continued success.

The program is designed to train students to address critical research questions to advance human and population health utilizing a wide variety of research tools and trans-disciplinary collaborations. This is distinct from historical training in a single discipline (e.g., statistics or genetics) or expertise in a small number of technical skills. The educational mission of the PhD Program in Epidemiology & Biostatistics is to train students using an integrated approach that draws broadly from the population and quantitative health sciences. These include global, population, public, and community health, biostatistics, epidemiology, health behavior and prevention, genomic epidemiology, bioinformatics, and computational biology. This training provides the foundation for trainees to play integral roles in successfully solving our most pressing health problems.

Through our rigorous coursework, exposure to discussion of important health related issues, and their research experiences during graduate training, students will develop into junior colleagues of the faculty who will develop the capacity to work independently. To develop into the research leaders expected of our graduates, each student will take a
common set of first and second-year courses that provides extensive exposure to each of the areas noted above. By the end of their first-year students will choose a mentor and laboratory in which to do their dissertation work. Research areas span all of the above and often combine these approaches with the expectation that cross-disciplinary studies will result in broader and more complete solutions to complex public health problems.

Exposure to cutting edge research will be facilitated by our department-wide seminar that includes talks by world-leading experts both from off- and on-campus. As part of their training all students will participate in these seminars, including as speakers. This will help develop the necessary communication skills that is expected of successful researchers.

Graduates from accredited universities and colleges will be considered for admission to the department. All applicants must satisfy both CWRU and department requirements for graduate admission. Upon acceptance into the PhD program, each student will be assigned an academic advisor, who will guide the student through department and graduate school regulations, assist him or her in designing the initial planned program of study, and track the student's progress toward degree completion.

Research and training will be guided by a committee of faculty including the student's research advisor. The research advisor will have the major responsibility for facilitating, guiding, and advising the student in his or her research, but this will be done in consultation with the faculty committees. A Mentoring Committee, selected after first year of PhD training, will help students select courses and educational goals most useful for their research interests. This committee will be replaced at the end of the second year by a Dissertation committee that will play an important role in guiding the student's research project.

On completion of all Core Curriculum course requirements, students take a qualifying examination that is necessary to remaining and advancing in the program. Exceptions to required courses based on prior course work will be decided on a case by case basis.

Curriculum

The Doctor of Philosophy degree in Epidemiology and Biostatistics in the Department of Population and Quantitative Health Sciences comprises 42 credits from the following components:

- Core Curriculum (22 credits)
- Electives (20 credits)
- Department Research Seminar (6 semesters)
- Passing the Qualifying Exam
- Dissertation Research (18 credits)

Core Curriculum

The Core Curriculum is designed to provide PhD students with a strong foundation in epidemiology and biostatistics and related areas - the fields that comprise population and quantitative health sciences - and the methodological and analytic training to conduct rigorous, high quality research in the student's selected specialization or concentration.

Core required courses include:

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<thead>
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<tr>
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<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
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<td>Statistical Methods II</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 440</td>
<td>Introduction to Population Health</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 465</td>
<td>Design and Measurement in Population Health Sciences</td>
<td>3</td>
</tr>
<tr>
<td>PQHS 472</td>
<td>Integrated Thinking in Population and Quantitative Health Sciences</td>
<td>2</td>
</tr>
<tr>
<td>PQHS 444</td>
<td>Communicating in Population Health Science Research (**1 unit, taken twice)</td>
<td>2</td>
</tr>
<tr>
<td>PQHS 501</td>
<td>Research Seminar</td>
<td>0</td>
</tr>
</tbody>
</table>

Electives

Electives are chosen in consultation with the student's mentor and mentoring committee.

Seminars (0 credits)

Attending research seminars is integral to our graduate program and student's professional development. Students are required to attend weekly research seminars. These seminars provide a forum for students to develop skills in scientific presentation, thought and communication, and balance general and concentration-specific speakers and topics. Meeting locations may vary from week to week depending upon the speaker. Each student is required to attend in person six semesters of seminars. All students are required to present once a year during research seminars after their first year in the program.

Qualifying Exam

Following the completion of the core required courses at the end of their second year, students will take an oral exam based on required coursework that involves analyses of a novel data set. This will include a description of the results, their interpretation and a short proposal on alternative or future research directions based on these findings. Students will be given two attempts to pass this examination. A second failure will result in dismissal from the program.

Dissertation (18 credits)

After passing the qualifying examination and completing second-year course work, students will select a dissertation committee and develop a thesis proposal, based on anticipated research for their dissertation. This will be presented to the student’s Dissertation committee that will evaluate the written document and an oral defense of the document. This will be completed no later than the end of the fall semester of the third year. Successful completion of this exam will move the student to candidacy. Each student will be allowed two attempts to pass the oral defense of the proposal.

Students are required to complete 18 credits of dissertation (PQHS 701 Dissertation Ph.D.) prior to graduation.

Questions and Information:

Nickalaus Koziura, EdM

Graduate Certificate in Health Informatics
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informatics@case.edu
Students who want to explore Biomedical and Health Informatics without – or before – committing to a Master’s, can take a series of four or five courses that provide an overview and grounding in the fundamentals with practical applications in research, clinical care and population health. If you choose to continue to a Master’s program within our department, all courses are transferable.

Courses required for the certificate program:

- MPHP 532/HSMC 432 - Introduction to Health Informatics
- PQHS 416 - Introduction to Computing in Biomedical Health Informatics

Electives can be selected to tailor a concentration that resonates with your interests.

Concentrations include:

- Health Informatics
- Clinical Research Informatics
- Bioinformatics

A 12-credit or 15-credit certificate is available, taking from one year to two-and-a-half years to complete, depending on a student's chosen pace. Certificates are granted from the CWRU School of Medicine, Department of Population and Health Information Sciences. Only the 15-credit certificate will show on an official CWRU transcript.

**MPHP Courses**

**MPHP 101. Introduction to Public Health. 3 Units.**
The purpose of this course is to introduce students to the science and art of public health through understanding historical and current issues through public health case histories and controversies. Students will be introduced to social, behavioral, cultural, and environmental influences on population health. Emphasis is placed on social justice as a central component of public health, with an overview of health inequity and commitment to vulnerable populations. Core public health practices relating to health promotion program design, community assessment and improvement planning, health communication, health policy and enforcement, and health behavior change will be featured. The course will promote understanding of health care and public health systems domestically and globally, including preparedness for and response to public health emergencies.

**MPHP 301. Introduction to Epidemiology. 3 Units.**
This course begins with the exploration of the history, philosophy and uses of epidemiology. It then moves to the basic descriptive functions of epidemiology such as condition, frequency and severity. Data is used to describe qualitatively and quantitatively diseases and injuries in a population. Applications include identifying patterns of disease and injury over time and geography. The course then moves to analytical epidemiology with focus on estimation, inference, bias, confounding and adjustment in the determination of what factors are associated with, or cause disease or injury. The different kinds of study designs are introduced including ecologic, cross-sectional, case-control, retrospective and prospective cohort, and experimental designs such as clinical trials. Students are introduced to evidence-based public health with analysis of harm, benefit and cost, and intervention effectiveness. The course concludes with applications to policy, covering outbreak investigation/testing/screening, public health policy and special epidemiologic applications including molecular and genetic epidemiology, environmental health and safety, unintentional injury and violence prevention and behavioral sciences. Recommended preparation: A course in statistics taken before or concurrently with MPHP 301.

**MPHP 306. History and Philosophy of Public Health. 3 Units.**
The purpose of this course is to introduce students to the science and art of public health through an understanding of the history and philosophies that represent its foundation. Students will learn about the essentials of public health and applications of those precepts throughout history and in the present. The course will examine public health case histories and controversies from the past and present, in order to better understand solutions for the future. Offered as MPHP 306 and MPHP 406. Prereq: Enrollment limited to juniors and seniors only.

**MPHP 313. Health Education, Communication, and Advocacy. 3 Units.**
Historical, sociological, and philosophical factors that have influenced definitions and the practice of health education and health promotion are studied. Advanced concepts in health communication theory will also be explored. This course is designed to educate, motivate, and empower undergraduate and graduate students to become advocates for their own health, the health of their peers, and the health of the community. Offered as MPHP 313 and MPHP 413.

**MPHP 405. Statistical Methods in Public Health. 3 Units.**
This one-semester survey course for public health students is intended to provide the fundamental concepts and methods of biostatistics as applied predominantly to public health problems. The emphasis is on interpretation and concepts rather than calculations. Topics include descriptive statistics; vital statistics; sampling; estimation and significance testing; sample size and power; correlation and regression; spatial and temporal trends; small area analysis; statistical issues in policy development. Examples of statistical methods will be drawn from public health practice. Use of computer statistical packages will be introduced. Prereq: Enrollment limited to MPH students (Plan A or Plan B) and EPBI students only. All others require instructor consent.

**MPHP 406. History and Philosophy of Public Health. 3 Units.**
The purpose of this course is to introduce students to the science and art of public health through an understanding of the history and philosophies that represent its foundation. Students will learn about the essentials of public health and applications of those precepts throughout history and in the present. The course will examine public health case histories and controversies from the past and present, in order to better understand solutions for the future. Offered as MPHP 306 and MPHP 406. Prereq: Enrollment limited to MPH students (Plan A or Plan B) and EPBI students or instructor consent.
MPHP 411. Introduction to Health Behavior. 3 Units.
Using a biopsychosocial perspective, an overview of the measurement and modeling of behavioral, social, psychological, and environmental factors related to disease prevention, disease management, and health promotion is provided. Offered as PQHS 411 and MPHP 411. Prereq: Enrollment limited to MPH students (Plan A or Plan B) and EPBI students or consent.

MPHP 413. Health Education, Communication, and Advocacy. 3 Units.
Historical, sociological, and philosophical factors that have influenced definitions and the practice of health education and health promotion are studied. Advanced concepts in health communication theory will also be explored. This course is designed to educate, motivate, and empower undergraduate and graduate students to become advocates for their own health, the health of their peers, and the health of the community. Offered as MPHP 313 and MPHP 413.

MPHP 421. Health Economics and Strategy. 3 Units.
The purpose of this course is to develop the analytical skills necessary for understanding how the U.S. health care sector operates, how it has evolved, the forces at work behind perceived deficiencies (in quality and cost control), and the impact of alternative policy proposals. Special attention is giving to recent developments in the healthcare marketplace, and the strategic considerations they create for providers and insurers. These issues are addressed through the lens of microeconomic theory. Under this framework, outcomes result from the interaction of decisions made by participants in the healthcare economy (e.g., patients, providers, insurers, government), with those decisions governed by the preferences, incentives and resource constraints facing each decision-maker. Principles of microeconomics will be reviewed as necessary to ensure consistent understanding of basic concepts. The course is designed to appeal to a broad audience, particularly students interested in healthcare management, public health, medical innovation, health law, and public policymaking. Offered as HSMC 421 and MPHP 421.

MPHP 426. An Introduction to GIS for Health and Social Sciences. 3 Units.
This course is designed to give students a first exposure to understanding how GIS is integral to understanding a wide variety of public health problems. It introduces students to current spatial approaches in health research and provides a set of core skills that will allow students to apply these techniques toward their own interests. Subject matter will include chronic diseases, infectious diseases, and vector borne diseases examples. Other topics related to social determinants of health and current events (e.g., violence, overdoses, disaster and homelessness) will also be incorporated. Students will be exposed to different types of data and different applications of these data (for example, hospitals, police departments), enabling them to think “outside the box” about how GIS can be utilized to solve real-world problems. Students will learn classic mapping and hotspot techniques. In addition, they will be introduced to novel ways to collect geospatial field data using online sources (Google Street View), primary data collection (spatial video) and mixed method approaches (spatial video geonarratives), all of which represent the cutting edge of spatial epidemiology. Offered as MPHP 426 and PQHS 426.

MPHP 429. Introduction to Environmental Health. 3 Units.
This survey course will introduce students to environmental and occupational health topics including individual, community, population, and global issues. Students will develop an understanding of the human health impacts of physical, biological, and chemical agents in the environment and workplace including basic principles of toxicology. Presentation of concepts including risk assessment, communication and management as well as discussion of environmental and occupational practices, policies and regulations that promote public and population health is included.

MPHP 431. Statistical Methods I. 3 Units.
Application of statistical techniques with particular emphasis on problems in the biomedical sciences. Basic probability theory, random variables, and distribution functions. Point and interval estimation, regression, and correlation. Problems whose solution involves using packaged statistical programs. First part of year-long sequence. Offered as ANAT 431, BIOL 431, CRSP 431, PQHS 431 and MPHP 431.

MPHP 432. Statistical Methods II. 3 Units.
Methods of analysis of variance, regression and analysis of quantitative data. Emphasis on computer solution of problems drawn from the biomedical sciences. Design of experiments, power of tests, and adequacy of models. Offered as BIOL 432, PQHS 432, CRSP 432 and MPHP 432. Prereq: PQHS/EPBI 431 or equivalent.

MPHP 433. Community Interventions and Program Evaluation. 3 Units.
This course prepares students to design, conduct, and assess community-based health interventions and program evaluation. Topics include assessment of need, evaluator/stakeholder relationship, process vs. outcome based objective, data collection, assessment of program objective achievement based on process and impact, cost-benefit analyses, and preparing the evaluation report to stakeholders. Recommended preparation: PQHS/EPBI 490, PQHS/EPBI 431, or MPHP 405. Offered as PQHS 433 and MPH 433. Prereq: MPHP 411

MPHP 439. Public Health Management and Policy. 3 Units.
This course is designed to introduce students to the basics of health policy-making and includes a background on the basic structure and components of the US Health Care System (such as organization, delivery and financing). It will also cover introductory concepts in public health management, including the role of the manager, organizational design and control, and accountability. We will address relevant legal, political and ethical issues using case examples. At the end of the course, students will understand how health policy is developed and implemented in various contexts, and the challenges facing system-wide efforts at reform. This is a required course for the MPH degree. Grades will be based on a series of assignments. Prereq: Enrollment limited to MPH students (Plan A or Plan B) and EPBI Students or instructor consent.

MPHP 450. Clinical Trials and Intervention Studies. 3 Units.
Issues in the design, organization, and operation of randomized, controlled clinical trials and intervention studies. Emphasis on long-term multicenter trials. Topics include legal and ethical issues in the design; application of concepts of controls, masking, and randomization; steps required for quality data collection; monitoring for evidence of adverse or beneficial treatment effects; elements of organizational structure; sample size calculations and data analysis procedures; and common mistakes. Recommended preparation: PQHS/EPBI 431 or consent of instructor. Offered as PQHS 450 and MPHP 450.
MPHP 451. A Data-Driven Introduction to Genomics and Human Health. 3 Units.
This course introduces the foundational concepts of genomics and genetic epidemiology through four key principles: 1) Teaching students how to query relational databases using Structure Query Language (SQL); 2) Exposing students to the most current data used in genomics and bioinformatics research, providing a quantitative understanding of biological concepts; 3) Integrating newly learned concepts with prior ones to discover new relationships among biological concepts; and 4) providing historical context to how and why data were generated and stored in the way they were, and how this gave rise to modern concepts in genomics. Offered as PQHS 451, GENE 451, and MPHP 451.

MPHP 456. Health Policy and Management Decisions. 3 Units.
This seminar course combines broad health care policy issue analysis with study of the implications for specific management decisions in organizations. This course is intended as an applied, practical course where the policy context is made relevant to the individual manager. Offered as HSMC 456 and MPHP 456.

MPHP 464. Obesity and Cancer: Views from Molecules to Health Policy. 3 Units.
This course will provide an overview of the components of energy balance (diet, physical activity, resting metabolic rate, dietary induced thermogenesis) and obesity, a consequence of long term positive energy balance, and various types of cancer. Following an overview of energy balance and epidemiological evidence for the obesity epidemic, the course will proceed with an introduction to the cellular and molecular biology of energy metabolism. Then, emerging research on biologically plausible connections and epidemiological associations between obesity and various types of cancer (e.g., colon, breast) will be presented. Finally, interventions targeted at decreasing obesity and improving quality of life in cancer patients will be discussed. The course will be cooperatively-taught by a transdisciplinary team of scientists engaged in research in energy balance and/or cancer. Didactic lectures will be combined with classroom discussion of readings. The paper assignment will involve application of course principles, lectures and readings. Offered as PQHS 464 and MPHP 464.

MPHP 466. Promoting Health Across Boundaries. 3 Units.
This course examines the concepts of health and boundary spanning and how the synergy of the two can produce new, effective approaches to promoting health. Students will explore and analyze examples of individuals and organizations boundary spanning for health to identify practice features affecting health, compare and contrast practices and approaches, and evaluate features and context that promote or inhibit boundary spanning and promoting health. Offered as MPHP 466, PQHS 466, SOCI 466, NURS 466 and BETH 466. Prereq: Graduate student status or instructor consent.

MPHP 467. Comparative and Cost Effectiveness Research. 1 Unit.
Comparative effectiveness research is a cornerstone of healthcare reform. It holds the promise of improved health outcomes and cost containment. This course is presented in a convenient 5-day intensive format in June. There are reading assignments due prior to the 1st session. Module A, Days 1-2: Overview of comparative effectiveness research (CER) from a wide array of perspectives: individual provider, institution, insurer, patient, government, and society. Legal, ethical and social issues, as well as implications for population and public health, including health disparities will also be a component. Module B, Day 3: Introduction to the various methods, and their strengths, weaknesses and limitations. How to read and understand CER papers. Module C, Days 4-5: Cost-Effectiveness Analysis. This will cover costing, cost analysis, clinical decision analysis, quality of life and cost-effectiveness analysis for comparing alternative health care strategies. Trial version of TreeAge software will be used to create and analyze a simple cost-effectiveness model. The full 3-credit course is for taking all 3 modules. Modules A or C can be taken alone for 1 credit. Modules A and B or Modules B and C can be taken together for a total of 2 credits. Module B cannot be taken alone. If taking for 2 or 3 credits, some combination of term paper, project and/or exam will be due 30 days later. Offered as PQHS 467 and MPHP 467.

MPHP 468. The Continual Improvement of Healthcare: An Interdisciplinary Course. 3 Units.
This course prepares students to be members of interprofessional teams to engage in the continual improvement in health care. The focus is on working together for the benefit of patients and communities to enhance quality and safety. Offered as PQHS 468, MPHP 468, and NURS 468.

MPHP 475. Management of Disasters Due to Nature, War, or Terror. 3 Units.
The purpose of this course is to make participants aware of the special needs of children and families in disaster situations and understand public health approaches to address these needs. The learning objectives for this course are: 1) Identify the most important problems and priorities for children in disaster situations, 2) Identify the organizations most frequently involved in providing assistance in disaster situations and define their roles and strengths, 3) Describe the reasons why children are among the most vulnerable in disaster events, 4) Conduct emergency nutritional assessments for children, 5) Develop health profiles on displaced children and plan interventions based on results, 6) Define common psychosocial issues of children and the means to address them, 7) List basic points of international law including the Geneva Convention that relate to all persons involved in disaster situations, 8) List important security issues, 9) Appreciate ethical issues involved in disaster situations and employ skills of cross cultural communication, 10) Recognize and respond to special issues for children involved in biological and chemical terrorist attacks.
MPHP 477. Internship at Health-Related Government Agencies. 3 Units.
This independent study course will incorporate a one-semester-long internship at health-related government agencies (Ohio Department of Health, Ohio Department of Job and Family Services, or Cleveland City Health Department). The choice of the agency will depend on the student's academic interests and research goals. The objective is to develop a level of familiarity with the organizational and operational aspects of such agencies, and to gain an understanding of agencies' and bureaus' interactions with the legislative body, as well as the processes of developing, implementing, managing, and monitoring health initiative. The instructor and the liaison persons at the agencies will be responsible for planning structured encounters of interns with key administrators and policy makers, and to select a research project, based on the intern's research interests and the agencies' research priorities. Interns will be required to submit a draft of the report to the instructor at the end of the semester. The approved, final report will be submitted to the agency. The project will be evaluated for its methodological soundness and rigor. Students will be required to be at the agency one day a week. Recommended preparation: PQHS/EPBI 515.

MPHP 482. Qualitative and Mixed Methods in Public Health. 3 Units.
Understanding complex public health issues requires both qualitative and quantitative inquiry. The exploration of the perceptions and experiences of people is as essential as analyzing the relationships among variables. Often, the integration of the two methods is required in order to effectively address the significant health issues faced by today's society. It is the purpose of this course to facilitate a meaningful and substantive learning process around engaging in, and critically analyzing, qualitative and mixed methods research in public health. This includes gaining first-hand experience in research design and collecting, managing, analyzing, and interpreting data for the purposes of making data-driven program and policy recommendations. In addition, students will have the opportunity to engage with local professionals engaged in qualitative and mixed methods research.

MPHP 483. Introduction to Epidemiology for Public Health Practice. 3 Units.
This course is designed to introduce the basic principles and methods of epidemiology. Epidemiology has been referred to as the basic science for public health. Application of epidemiologic principles is critical to disease prevention, as well as in the development and evaluation of public policy. The course will emphasize basic methods (study design, measures of disease occurrence, measures of association, and causality) necessary for epidemiologic research. It is intended for students who have a basic understanding of the principals of human disease as well as statistics. Prereq: Must be an MPHP Plan A or MPHP Plan B, or EPBI student in order to enroll in the course.

MPHP 484. Global Health Epidemiology. 1 - 3 Units.
This course provides a rigorous problem-centered training in the epidemiology, prevention, treatment, and control of infectious diseases and, more generally, global health. This is an advanced epidemiology that embraces an active learning environment. Students are expected to invest time out of the classroom reading and working with classmates. Classes will be conducted with discussions, debates, group projects, and group presentations. By taking this course, students will develop a framework for interpreting, assessing, and performing epidemiologic research on issues of global importance. The course will be divided into three modules: 1) Global Health Epidemiology 2) Helminth Epidemiology, and 3) Epidemiology of Disease Elimination. Each module is worth 1 credit hour and may be taken separately. Each module will have a separate project and/or exam. The final exam time will be used for group presentations and panel discussion. Active class participation is required through discussions, case studies, and group projects. Offered as PQHS 484, INTH 484, and MPHP 484.

MPHP 485. Adolescent Development. 3 Units.
Adolescent Development can be viewed as the overriding framework for approaching disease prevention and health promotion for this age group. This course will review the developmental tasks of adolescence and identify the impact of adolescent development on youth risk behaviors. It will build a conceptual and theoretical framework through which to address and change adolescent behavior to promote health.

MPHP 490. Epidemiology: Introduction to Theory and Methods. 3 Units.
This course provides an introduction to the principles of epidemiology covering the basic methods necessary for population and clinic-based research. Students will be introduced to epidemiologic study designs, measures of disease occurrence, measures of risk estimation, and casual inference (bias, confounding, and interaction) with application of these principles to specific fields of epidemiology. Classes will be a combination of lectures, discussion, and in-class exercises. It is intended for students who have a basic understanding of the principals of human disease and statistics. Offered as PQHS 490 and MPHP 490. Prereq or Coreq: PQHS/EPBI 431 or Requisites Not Met permission.

MPHP 499. Independent Study. 1 - 18 Units.

MPHP 510. Health Disparities. 3 Units.
This course aims to provide theoretical and application tools for students from many disciplinary backgrounds to conduct research and develop interventions to reduce health disparities. The course will be situated contextually within the historical record of the United States, reviewing social, political, economic, cultural, legal, and ethical theories related to disparities in general, with a central focus on health disparities. Several frameworks regarding health disparities will be used for investigating and discussing the empirical evidence on disparities among other subgroups (e.g., the poor, women, uninsured, disabled, and non-English speaking populations) will also be included and discussed. Students will be expected to develop a research proposal (observational, clinical, and/or intervention) rooted in their disciplinary background that will incorporate materials from the various perspectives presented throughout the course, with the objective of developing and reinforcing a more comprehensive approach to current practices within their fields. Offered as CRSP 510, PQHS 510, MPHP 510, NURS 510, and SASS 510.

MPHP 532. Health Care Information Systems. 3 Units.
This course covers concepts, techniques and technologies for providing information systems to enhance the effectiveness and efficiency of health care organizations. Offered as HSMC 432 and MPHP 532.
MPHP 540. Operational Aspects of Global Health and Emergency Response. 3 Units.
Among professional in the medical field and the field of public health, there is a gap in knowledge, structure and research in best practices surrounding emergency response. This gap results from the limited number of training programs in the United States that focus on this very specialized field and the limited number of academic partnerships with international non-governmental organizations (NGOs). This course helps remedy this gap by introducing public health students and international emergency medicine fellows to the overall structure and operations of international humanitarian coordination systems, types of emergency response, morbidity and mortality associated with various emergencies, and the actors and institutions involved. The course highlights, through reading, workshops, and examples, the real world issues that must be faced and overcome in the field during emergency response operations.

MPHP 650. Public Health Practicum. 1 - 3 Units.
The Public Health Practicum is an integral component of the MPH curriculum, allowing students to apply, develop, and refine their conceptual knowledge and skills as part of a planned, supervised, and evaluated community-based experience. The Practicum is designed to move students beyond the walls of academia, to understand the political, economic, social, and organizational contexts within which public health activities are conducted. To complete the Practicum, students must complete three credits of MPHP 650, dedicating at least 120 hours to a substantial public health experience, and attend Community Health Research and Practice (CHRP) group meetings. Prereq: Complete at least 9 credit hours in the MPH program and be in good academic standing.

MPHP 652. Public Health Capstone Experience. 1 - 9 Units.
Public health field practicum, involving a placement at a community-based field site, and a Master’s essay. The field placement will provide students with the opportunity to apply the knowledge and skills acquired through their Master of Public Health academic program to a problem involving the health of the community. Students will learn to communicate with target groups in an effective manner; to identify ethical, social, and cultural issues relating to public health policies, research, and interventions; to identify the process by which decisions are made within the agency or organization; and to identify and coordinate use of resources at the placement site. The Master’s essay represents the culminating experience required for the degree program and may take the form of a research thesis, an evaluation study, or an intervention study. Each student is required to formally present the experience and research findings. In any semester in which a student is registered for MPHP 652 credit, it is required that the student attend the Community Health Research and Practice (CHRP) group at a minimum of two sessions per 3 credits. CHRP is held once a week for approximately an hour and a half for the duration of fall, spring, and summer semesters. MPHP 652 credit is available only to Master of Public Health students.

MPHP 653. Public Health Capstone Experience. 1 - 6 Units.
The Public Health Capstone is a multi-semester project intended to provide students with the opportunity to develop a broad understanding of their chosen topic area, the ability to communicate effectively with target groups and professionals, and develop skills necessary for scientific investigation. The Public Health Capstone provides students with the opportunity to apply the knowledge and skills acquired through their Master of Public Health academic program to a problem involving the health of the community. Students work in conjunction with a community organization; therefore, the Capstone is expected to be mutually beneficial to both the student’s educational goals as well as the host organization. At the conclusion of the Capstone experience, students are required to submit a capstone essay, which represents the culminating experience required for the degree program and may take the form of a research thesis, an evaluation study, or an intervention study. Each student is required to formally present the experience and research findings. While engaged in the Public Health Capstone, students are expected to attend the Community Health Research and Practice (CHRP) seminar, held weekly on Tuesdays at 12:00pm. Counts as SAGES Senior Capstone.

MPHP 655. Dual Degree Field Practicum II. 3 Units.
This course is designed to be taken by MSSA/MPH joint degree students as the second field period of their master’s program. It consists of a field practicum and participation in professional development opportunities. The Field Practicum is an integral component of the MSASS and MPH curriculums, allowing students to apply, develop, and refine their conceptual knowledge and skills as part of a planned, supervised, and evaluated community-based experience. The Practicum is designed to move students beyond the walls of academia, to understand the political, economic, social, and organizational contexts within which social work and public health activities are conducted. These collective experiences provide students with a forum to develop skills, integrate and operationalize the values and ethics inherent in professional practice, and confront social injustice as self-reflective, competent developing practitioners. (EPAAS Program Objective M6 and EPAAS Content Area 4.7) The overall goal of this course is to provide graduate level MSSA/MPH joint degree students with field related opportunities to continue to develop foundation level competencies in the eight MSSAS abilities by helping students apply knowledge of social work and public health theory, skills, values and ethics acquired in the classroom in an agency setting. Offered as MPHP 655 and SASS 655.
PQHS 415. Statistical Computing and Data Analytics. 3 Units.

This course emphasizes on statistical and data analytic problem solving skills, covers elements of statistical computing, and special topics in modern data analytics. This includes numerical methods for statistics, stochastic simulation, symbolic and graphical computation, plus special topics in resampling methods, EM algorithms, Gibbs Sampling/MCMC, projection pursuit, Laplace approximation, parallel computing, and selected methods for big and high dimensional data. The course will use R/Splus predominantly. However, interface of R with another high level programming language such as C, C++, Fortran, JAVA or Python will be essential for Big Data and intensive computation. Some Matlab, Mathematica, and graphviz will be used for symbolic and graphical computation. Prerequisite: Knowledge in statistics, equivalent to that in either STAT 325/425, or STAT 345/445, or PQHS/EPBI 481, or PQHS/EPBI 431, or by permission. Experience with at least one programming language is required: R/Splus, Matlab, C/C++, Fortran, JAVA, or Python. Prereq: STAT 312, STAT 325, STAT 425, STAT 345, STAT 445, PQHS/EPBI 431 or PQHS/EPBI 481.

PQHS 416. Introduction to Computing in Biomedical Health Informatics. 3 Units.

The goals of this course are to provide students with a survey of the computational techniques that underpin biomedical and health informatics. The course will cover methods in computational system development, including biomedical terminologies, ontologies, natural language processing (NLP), logic, Electronic Health Record (EHR) system architecture as well as applications, and topics related to health information systems. This course is intended for students interested in learning the computational foundations of biomedical and health informatics. Students should have at least a bachelor of science level educational background and an understanding of the fields of biomedical and clinical/translational.

PQHS 426. An Introduction to GIS for Health and Social Sciences. 3 Units.

This course is designed to give students a first exposure to understanding how GIS is integral to understanding a wide variety of public health problems. It introduces students to current spatial approaches in health research and provides a set of core skills that will allow students to apply these techniques toward their own interests. Subject matter will include chronic diseases, infectious diseases, and vector-borne diseases. Other topics related to social determinants of health and current events (e.g., violence, overdoses, disaster and homelessness) will also be incorporated. Students will be exposed to different types of data and different applications of these data (for example, hospitals, police departments), enabling them to think "outside the box" about how GIS can be utilized to solve real-world problems. Students will learn classic mapping and hotspot techniques. In addition, they will be introduced to novel ways to collect geospatial field data using online sources (Google Street View), primary data collection (spatial video) and mixed method approaches (spatial video geonarratives), all of which represent the cutting edge of spatial epidemiology. Offered as MPHP 426 and PQHS 426.

PQHS 431. Statistical Methods I. 3 Units.

Application of statistical techniques with particular emphasis on problems in the biomedical sciences. Basic probability theory, random variables, and distribution functions. Point and interval estimation, regression, and correlation. Problems whose solution involves using packaged statistical programs. First part of year-long sequence. Offered as ANAT 431, BIOL 431, CRSP 431, PQHS 431 and MPHP 431.
PQHS 432. Statistical Methods II. 3 Units.
Methods of analysis of variance, regression and analysis of quantitative data. Emphasis on computer solution of problems drawn from the biomedical sciences. Design of experiments, power of tests, and adequacy of models. Offered as BIOL 432, PQHS 432, CRSP 432 and MPH 432. Prereq: PQHS/EPBI 431 or equivalent.

PQHS 433. Community Interventions and Program Evaluation. 3 Units.
This course prepares students to design, conduct, and assess community-based health interventions and program evaluation. Topics include assessment of need, evaluator/stakeholder relationship, process vs. outcome-based objectives, data collection, assessment of program objective achievement based on process and impact, cost-benefit analyses, and preparing the evaluation report to stakeholders. Recommended preparation: PQHS/EPBI 490, PQHS/EPBI 431, or MPH 405. Offered as PQHS 433 and MPH 433.

PQHS 435. Survival Data Analysis. 3 Units.
Basic concepts of survival analysis including hazard function, survival function, types of censoring; non-parametric models; extended Cox models: time dependent variables, piece-wise Cox model, etc.; sample size requirements for survival studies. Prereq: PQHS/EPBI 432.

PQHS 440. Introduction to Population Health. 3 Units.
Introduces graduate students to the multiple determinants of health including the social, economic and physical environment, health services, individual behavior, genetics and their interactions. It aims to provide students with the broad understanding of the research development and design for studying population health, the prevention and intervention strategies for improving population health and the disparities that exist in morbidity, mortality, functional and quality of life. Format is primarily group discussion around current readings in the field; significant reading is required.

PQHS 444. Communicating in Population Health Science Research. 1 Unit.
Doctoral seminar on writing journal articles to report original research, and preparing and making oral and poster presentations. The end products are ready-to-submit manuscripts and related slide and poster presentations for the required first-year research project in the PhD program in the Department of Epidemiology and Biostatistics. While this course provides a nucleus for this endeavor, students work intensively under the supervision of their research mentors, who guide all stages of the work including providing rigorous editorial support. Seminar sessions are devoted to rigorous peer critiques of every stage of the projects and to in-depth discussions of assigned readings. Recommended preparation: PhD students in the Department of Biostatistics and Epidemiology, Non-PhD EPBI students permitted if space available. Fluency in English writing (e.g., in accord with the Harbrace College Handbook). Prereq: PQHS/EPBI 431 and PQHS/EPBI 490. Coreq: PQHS/EPBI 432.

PQHS 445. Research Ethics in Population Health Sciences. 0 Unit.
This zero credit course is a required add-on for PhD students in EPBI. Students will register and fulfill all requirements for IBMS 500 "Being a Professional Scientist". The purpose of PQHS 445 is to address specialized population health topics not covered by IBMS 500, including international research, human genomics, and/or big data/electronic medical records. There will be no meetings/lectures for this course. Students will complete a short written assignment due at the end of the semester.

PQHS 450. Clinical Trials and Intervention Studies. 3 Units.
Issues in the design, organization, and operation of randomized, controlled clinical trials and intervention studies. Emphasis on long-term multicenter trials. Topics include legal and ethical issues in the design; application of concepts of controls, masking, and randomization; steps required for quality data collection; monitoring for evidence of adverse or beneficial treatment effects; elements of organizational structure; sample size calculations and data analysis procedures; and common mistakes. Recommended preparation: PQHS/EPBI 431 or consent of instructor. Offered as PQHS 450 and MPH 450.

PQHS 451. A Data-Driven Introduction to Genomics and Human Health. 3 Units.
This course introduces the foundational concepts of genomics and genetic epidemiology through four key principles: 1) Teaching students how to query relational databases using Structure Query Language (SQL); 2) Exposing students to the most current data used in genomics and bioinformatics research, providing a quantitative understanding of biological concepts; 3) Integrating newly learned concepts with prior ones to discover new relationships among biological concepts; and 4) Providing historical context to how and why data were generated and stored in the way they were, and how this gave rise to modern concepts in genomics. Offered as PQHS 451, GENE 451, and MPH 451. Prereq: PQHS/EPBI 431 and PQHS/EPBI 490 or Requisites Not Met permission.

PQHS 452. Statistical Methods for Genetic Epidemiology. 3 Units.
Analytic methods for evaluating the role of genetic factors in human disease, and their interactions with environmental factors. Statistical methods for the estimation of genetic parameters and testing of genetic hypotheses, emphasizing maximum likelihood methods. Models to be considered will include such components as genetic loci of major effect, polygenic inheritance, and environmental, cultural and developmental effects. Topics will include familial aggregation, segregation and linkage analysis, ascertainment, linkage disequilibrium, and disease marker association studies. Recommended preparation: PQHS/EPBI 431 and PQHS/EPBI 451.

PQHS 453. Community Interventions and Program Evaluation. 3 Units.
Students will complete a short written assignment due at the end of the semester.
PQHS 453. Categorical Data Analysis. 3 Units.
Categorical data are often encountered in many disciplines including in the fields of clinical and biological sciences. Analysis methods for analyzing categorical data are different from the analysis methods for continuous data. There is a rich a collection of methods for categorical data analysis. The elegant "odds ratio" interpretation associated with categorical data is a unique one. This online course will cover cross-sectional categorical data analysis theories and methods. From this course students will learn standard categorical data analysis methods and its applications to the biomedical and clinical studies. This particular course will focus mostly on statistical methods for categorical data analysis arising from various fields of studies including clinical studies; those who take it will come from a wide variety of disciplines. The course will include video lectures, group discussion and brainstorming, homework, simulations, and collaborative projects on real and realistic problems in human health tied directly to the student's own professional interests. Focus will be given to logistic regression methods. Topics include (but not limited to) binary response, multi-category response, count response, model selection and evaluation, exact inference, Bayesian methods for categorical data, and supervised statistical learning methods. This course stresses how the core statistical principles, computing tools, and visualization strategies are used to address complex scientific aims powerfully and efficiently, and to communicate those findings effectively to researchers who may have little or no experience in these methods. Recommended preparation: Advanced undergraduate students, and graduate students in Biostatistics or other quantitative sciences with a background in statistical learning methods.

PQHS 457. Current Issues in Genetic Epidemiology: Design and Analysis of Sequencing Studies. 3 Units.
Statistical methods to deal with the opportunities and challenges in Genetic Epidemiology brought about by modern sequencing technology. Some computational issues that arise in the analysis of large sequence data sets will be discussed. The course includes hands-on experience in the analysis of large sequence data sets, in a collaborative setting. Prereq: PQHS/EPBI 451 and PQHS/EPBI 452.

PQHS 459. Longitudinal Data Analysis. 3 Units.
This course will cover statistical methods for the analysis of longitudinal data with an emphasis on application in biological and health research. Topics include exploratory data analysis, response feature analysis, growth curve models, mixed-effects models, generalized estimating equations, and missing data. Prereq: PQHS/EPBI 432.

PQHS 464. Obesity and Cancer: Views from Molecules to Health Policy. 3 Units.
This course will provide an overview of the components of energy balance (diet, physical activity, resting metabolic rate, dietary induced thermogenesis) and obesity, a consequence of long term positive energy balance, and various types of cancer. Following an overview of energy balance and epidemiological evidence for the obesity epidemic, the course will proceed with an introduction to the cellular and molecular biology of energy metabolism. Then, emerging research on biologically plausible connections and epidemiological associations between obesity and various types of cancer (e.g., colon, breast) will be presented. Finally, interventions targeted at decreasing obesity and improving quality of life in cancer patients will be discussed. The course will be cooperatively-taught by a transdisciplinary team of scientists engaged in research in energy balance and/or cancer. Didactic lectures will be combined with classroom discussion of readings. The paper assignment will involve application of course principles, lectures and readings. Offered as PQHS 464 and MPHP 464.

PQHS 466. Design and Measurement in Population Health Sciences. 3 Units.
This course focuses on common design and measurement approaches used in population health sciences research. This course covers the preliminary considerations used in selecting qualitative, quantitative and mixed methods research approaches including an understanding of different philosophical worldviews, strategies of inquiry and methods and procedures for each approach. The course also includes an introduction to survey design and related concepts of latent variables, factor analysis and reliability and validity. Students will develop an in-depth knowledge of these design and measurement approaches through readings, lectures, group discussions and written and oral project presentations. Prereq: PQHS/EPBI 440, PQHS/EPBI 431, PQHS/EPBI 490, PQHS/EPBI 432, PQHS/EPBI 460, PQHS/EPBI 444 and PQHS/EPBI 445.

PQHS 466. Promoting Health Across Boundaries. 3 Units.
This course examines the concepts of health and boundary spanning and how the synergy of the two can produce new, effective approaches to promoting health. Students will explore and analyze examples of individuals and organizations boundary spanning for health to identify practice features affecting health, compare and contrast practices and approaches, and evaluate features and context that promote or inhibit boundary spanning and promoting health. Offered as MPHP 466, PQHS 466, SOCI 466, NURS 466 and BETH 466. Prereq: Graduate student status or instructor consent.
Comparative and Cost Effectiveness Research. 1 Unit.
Comparative effectiveness research is a cornerstone of healthcare reform. It holds the promise of improved health outcomes and cost containment. This course is presented in a convenient 5-day intensive format in June. There are reading assignments due prior to the 1st session. Module A, Days 1-2: Overview of comparative effectiveness research (CER) from a wide array of perspectives: individual provider, institution, insurer, patient, government, and society. Legal, ethical and social issues, as well as implications for population and public health, including health disparities will also be a component. Module B, Day 3: Introduction to the various methods, and their strengths, weaknesses and limitations. How to read and understand CER papers. Module C, Days 4-5: Cost-Effectiveness Analysis. This will cover costing, cost analysis, clinical decision analysis, quality of life and cost-effectiveness analysis for comparing alternative health care strategies. Trial version of TreeAge software will be used to create and analyze a simple cost-effectiveness model. The full 3-credit course is for taking all 3 modules. Modules A or C can be taken alone for 1 credit. Modules A and B or Modules B and C can be taken together for a total of 2 credits. Module B cannot be taken alone. If taking for 2 or 3 credits, some combination of term paper, project and/or exam will be due 30 days later. Offered as PQHS 467 and MPHP 467. PQHS 468. The Continual Improvement of Healthcare: An Interdisciplinary Course. 3 Units.
This course prepares students to be members of interprofessional teams to engage in the continual improvement in health care. The focus is on working together for the benefit of patients and communities to enhance quality and safety. Offered as PQHS 468, MPHP 468, and NURS 468. PQHS 471. Machine Learning & Data Mining. 3 Units.
Vast amount of data are being collected in medical and social research and in many industries. Such big data generate a demand for efficient and practical tools to analyze the data and to identify unknown patterns. We will cover a variety of statistical machine learning techniques (supervised learning) and data mining techniques (unsupervised learning), with data examples from biomedical and social research. Specifically, we will cover prediction model building and model selection (shrinkage, Lasso), classification (logistic regression, discriminant analysis, k-nearest neighbors), tree-based methods (bagging, random forests, boosting), support vector machines, association rules, clustering and hierarchical clustering. Basic techniques that are applicable to many of the areas, such as cross-validation, the bootstrap, dimensionality reduction, and splines, will be explained and used repeatedly. The field is fast evolving and new topics and techniques may be included when necessary. Prereq: PQHS/EPBI 431. PQHS 472. Integrated Thinking in Population and Quantitative Health Sciences. 2 Units.
The determinants of common disease are multifactorial and may involve complex interactions among factors, both known and unknown. These risk factors span domains as diverse as social determinants to biochemical lesions. However, most studies of disease risk usually involve a single class of determinants, defined within a single academic discipline. The goal of this course is to teach students to recognize and define explicit and implicit assumptions about studies of disease and to understand how one may integrate different domains of knowledge to improve our understanding of disease etiology and ultimately prevention and treatment efforts. They will learn to understand assumptions built into conceptual models used to describe and predict disease risk. Prereq: PQHS 431 and PQHS 440 and PQHS 490. PQHS 473. Integrated Thinking in Population and Quantitative Health Sciences II. 2 Units.
The determinants of common disease are multifactorial and may involve complex interactions among factors, both known and unknown. These risk factors span domains as diverse as social determinants to biochemical lesions. The goal of this course is to teach students to recognize and define explicit and implicit assumptions about studies of disease and to understand how one may integrate different domains of knowledge to improve our understanding of disease etiology and ultimately prevention and treatment efforts. This is the second of a two course sequence required of all PhD in Epidemiology and Biostatistics students. PQHS 472 is the first course in the sequence and is a required prerequisite. This course meets weekly and in-person. Prereq: PQHS 472. PQHS 480. Introduction to Mathematical Statistics. 3 Units.
An introduction to statistical inference at an intermediate mathematical level. The concepts of random variables and distributions, discrete and continuous, are reviewed. Topics covered include: expectations, variance, moments, the moment generating function; Bernoulli, binomial, hypergeometric, Poisson, negative binomial, normal, gamma and beta distribution; the central limit theorem; Bayes estimation, maximum likelihood estimators, unbiased estimators, sufficient statistics; sampling distributions (chi-square, t) confidence intervals, Fisher information; hypothesis testing, uniformly most powerful tests and multi-decision problems. Prereq: MATH 122, MATH 124 or MATH 126. PQHS 481. Theoretical Statistics I. 3 Units.
Topics provide the background for statistical inference. Random variables; distribution and density functions; transformations, expectation. Common univariate distributions. Multiple random variables; joint, marginal and conditional distributions; hierarchical models, covariance. Distributions of sample quantities, distributions of sums of random variables, distributions of order statistics. Methods of statistical inference. Offered as STAT 345, STAT 445, and PQHS 481. Prereq: MATH 122 or MATH 223 or Coreq: PQHS/EPBI 431. PQHS 482. Theoretical Statistics II. 3 Units.
Point estimation: maximum likelihood, moment estimators. Methods of evaluating estimators including mean squared error, consistency, "best" unbiased and sufficiency. Hypothesis testing; likelihood ratio and union-intersection tests. Properties of tests including power function, bias. Interval estimation by inversion of test statistics, use of pivotal quantities. Application to regression. Graduate students are responsible for mathematical derivations, and full proofs of principal theorems. Offered as STAT 346, STAT 446 and PQHS 482. Prereq: STAT 345 or STAT 445 or PQHS/EPBI 481. PQHS 484. Global Health Epidemiology. 1 - 3 Units.
This course provides a rigorous problem-centered training in the epidemiology, prevention, treatment, and control of infectious diseases and, more generally, global health. This is an advanced epidemiology that embraces an active learning environment. Students are expected to invest time out of the classroom reading and working with classmates. Classes will be conducted with discussions, debates, group projects, and group presentations. By taking this course, students will develop a framework for interpreting, assessing, and performing epidemiologic research on issues of global importance. The course will be divided into three modules: 1) Global Health Epidemiology 2) Helminth Epidemiology, and 3) Epidemiology of Disease Elimination. Each module is worth 1 credit hour and may be taken separately. Each module will have a separate project and/or exam. The final exam time will be used for group presentations and panel discussion. Active class participation is required through discussions, case studies, and group projects. Offered as PQHS 484, INTH 484, and MPHP 484.
PQHS 490. Epidemiology: Introduction to Theory and Methods. 3 Units.
This course provides an introduction to the principles of epidemiology covering the basic methods necessary for population and clinic-based research. Students will be introduced to epidemiologic study designs, measures of disease occurrence, measures of risk estimation, and casual inference (bias, confounding, and interaction) with application of these principles to specific fields of epidemiology. Classes will be a combination of lectures, discussion, and in-class exercises. It is intended for students who have a basic understanding of the principals of human disease and statistics. Offered as PQHS 490 and MPHP 490. Prereq or Coreq: PQHS/EPBI 431 or Requisites Not Met permission.

PQHS 499. Independent Study. 1 - 18 Units.

PQHS 500. Design and Analysis of Observational Studies. 3 Units.
An observational study investigates treatments, policies or exposures and the effects that they cause, but it differs from an experiment because the investigator cannot control assignment. We introduce appropriate design, data collection and analysis methods for such studies, to help students design and interpret their own studies, and those of others in their field. Technical formalities are minimized, and the presentations will focus on the practical application of the ideas. A course project involves the completion of an observational study, and substantial use of the R statistical software. Topics include randomized experiments and how they differ from observational studies, planning and design for observational studies, adjustments for overt bias, sensitivity analysis, methods for detecting hidden bias, and focus on propensity score methods for selection bias adjustment, including multivariate matching, stratification, weighting and regression adjustments. Recommended preparation: a working knowledge of multiple regression, some familiarity with logistic regression, with some exposure to fitting regression models in R. Offered as CRSP 500 and PQHS 500.

PQHS 501. Research Seminar. 0 Unit.
This seminar series includes faculty and guest-lecturer presentations designed to introduce students to on-going research at the University and elsewhere. Seminars will emphasize the application of methods learned in class, as well as the introduction of new methods and tools useful in research.

PQHS 502. Introduction to Statistical Consulting. 1 Unit.
What challenges are faced by a Biostatistician working in a collaborative and consulting environment? In order to successfully interact with a client, in addition to a solid foundation in statistical methods, the consultant needs to be prepared to deal with issues such as ill-posed research questions, unrealistic expectations on the part of a client, difficulty in understanding the subject of the consultation, thorny ethical issues, and many others. Courses on statistical consulting are essential components of graduate programs in Statistics. Other courses teach students statistical methods and how to use them to address various problems, but those problems are presented by course instructors who typically have as the goal teaching the appropriate choice and utilization of available statistical tools. This course prepares students to the challenges involved in 'real life' consulting situations, exposing the students to different encounter types, while honing their communication and statistical skills and raising their awareness of their professional responsibilities.

PQHS 505. Seminar in Global Health Epidemiology. 0 Unit.
This seminar series examines a broad range of topics related to infectious disease research in international settings. Areas of interest are certain to include epidemiology, bioethics, medical anthropology, pathogenesis, drug resistance, vector biology, cell and molecular biology, vaccine development, diagnosis, and socio-cultural factors contributing to or compromising effective health care delivery in endemic countries. Speakers will include a diverse group of regional faculty and post-doctoral trainees, as well as visiting colleagues from around the world. Students will be asked to read a journal article written by the speaker and then discuss this article with the speaker after their seminar.

PQHS 510. Health Disparities. 3 Units.
This course aims to provide theoretical and application tools for students from many disciplinary backgrounds to conduct research and develop interventions to reduce health disparities. The course will be situated contextually within the historical record of the United States, reviewing social, political, economic, cultural, legal, and ethical theories related to disparities in general, with a central focus on health disparities. Several frameworks regarding health disparities will be used for investigating and discussing the empirical evidence on disparities among other subgroups (e.g., the poor, women, uninsured, disabled, and non-English speaking populations) will also be included and discussed. Students will be expected to develop a research proposal (observational, clinical, and/or intervention) rooted in their disciplinary background that will incorporate materials from the various perspectives presented throughout the course, with the objective of developing and reinforcing a more comprehensive approach to current practices within their fields. Offered as CRSP 510, PQHS 510, MPHP 510, NURS 510, and SASS 510.

PQHS 515. Secondary Analysis of Large Health Care Data Bases. 3 Units.
Development of skills in working with the large-scale secondary data bases generated for research, health care administration/billing, or other purposes. Students will become familiar with the content, strength, and limitations of several data bases; with the logistics of obtaining access to data bases; the strengths and limitations of routinely collected variables; basic techniques for preparing and analyzing secondary data bases and how to apply the techniques to initiate and complete empirical analysis. Recommended preparation: PQHS/EPBI 414 or equivalent; PQHS/EPBI 431 or PQHS/EPBI 460 and PQHS/EPBI 461 (for HSR students).
PQHS 550. Meta-Analysis & Evidence Synthesis. 2 - 3 Units.
Systematic reviews use reproducible methods to systematically search the literature and synthesize the results of a specific topic area. Meta-analysis is a specific analytic technique used to pool results of individual studies. Systematic reviews are useful ways to establish one's knowledge in a particular field of study, and can highlight gaps in research which can be pursued in future work. They can also inform the background of a grant. This course is designed to introduce students to the methods of conducting a high quality systematic review and meta-analysis of intervention studies. We will cover the design, methods, and analytic techniques involved in systematic reviews. These concepts will prepare students to conduct their own systematic review or evaluate the systematic reviews of others. Sessions will be lectures, labs, and presentations. Topics include developing a search strategy, abstracting key data, synthesizing the results qualitatively, meta-analytic techniques, grading the quality of studies, grading the strength of the evidence, and manuscript preparation specific to systematic reviews and meta-analysis of intervention studies. Caveat: If you would like to conduct a systematic review of your own that can be published after the course ends, you will need to have several other class members or colleagues willing to work with you on the project. The systematic review should be on a topic where you expect no more than 20-30 included studies in order to be able to complete the review soon after the course ends. Offered as CRSP 550 and PQHS 550. Prereq: CRSP 401, PQHS/EPBI 431, MPHP 405, NURS 532 or Requisites Not Met permission.

PQHS 601. Master's Project Research. 1 - 18 Units.

PQHS 602. Practicum. 3 Units.
This course focuses on gaining experience as a biostatistician and enhancing the skills needed to become an effective biostatistician, serving as consultant and collaborator. The objectives of this mentored experience course are: to learn the role of the consulting biostatistician and the accompanying responsibilities, experience the life cycle of a project, develop and apply the interpersonal and communications skills required for a biostatistician, strengthen skills learned in the program, and often to enhance the skill set of the student, as well as to gain insight into the life and career of a biostatistician. This experience helps prepare the student for future job interviews and jobs, and may lead directly to a job. The deliverable is a professionally written report in the format of a report student for future job interviews and jobs, and may lead directly to a job. The deliverable is a professionally written report in the format of a report or Requisites Not Met permission.

PQHS 651. Thesis M.S.. 1 - 18 Units.
(Credit as arranged.)

PQHS 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

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<th>Name</th>
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