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School of Medicine

The mission of the Case Western Reserve University School of Medicine (http://casemed.case.edu) is to advance the health of humankind through the four interrelated components of Education, Research, Clinical Care and Public Service.

The School of Medicine provides two tracks leading to the MD degree: the longstanding School of Medicine program, also called the University track, and the Cleveland Clinic Lerner College of Medicine at Case Western Reserve University, also known as the College track, which first admitted students in 2004. The School boasts a longstanding Medical Scientist Training Program, or MSTP, and, through the School of Graduate Studies, programs resulting in PhD and MS degrees, as well as certificates in disciplines led by faculty in the School of Medicine.

As a research institution, the School of Medicine has a tradition of national leadership. The School of Medicine consistently ranks in the top tier of the nation’s medical schools for federal research funding from the National Institutes of Health, and is proud of its Clinical Translational Service Award in partnership with its affiliates. In fiscal year 2010, the School earned more than $340 million in grants from the NIH including grants through the affiliated Cleveland Clinic Lerner College of Medicine. Faculty and trainee research is routinely reported in the nation’s top journals, leading to biomedical discoveries and improved health.

The School of Medicine engages the community in public service in many ways. The School of Medicine’s commitment links researchers and medical students to the community. The school’s faculty provide 90 percent of the indigent health care in Cuyahoga County and a majority of the care for indigent patients in Ohio. A major economic influence on the northern Ohio area, the School of Medicine and its affiliated hospitals are among the largest employers of personnel in the area and further stimulate the economy by providing concepts for technology transfer to the business sector. On the international level, the School of Medicine has a global health and diseases program focusing on AIDS, tuberculosis, malaria and other diseases that directly threaten world health.

The school is very proud of the contributions made by its educators and graduates but doesn’t rest on its laurels. The curriculum constantly responds to the latest findings in education and medicine and sets the pace for other schools with input from gifted and committed scholars.

At least eleven Nobel Prize holders have ties to the School of Medicine:

• John J.R. Macleod, MB, ChB, DPH, physiology professor at Case from 1903 to 1918, 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.
• Corinelle J.F. Heymans, MD, who was a visiting scientist in the Department of Physiology in 1927 and 1928, received the Nobel Prize in Physiology or Medicine in 1938 for work on carotid sinus reflexes.
• Frederick C. Robbins, MD, shared the 1954 Nobel Prize in Physiology or Medicine for his work on the polio virus, which led to the development of polio vaccines. He received the award two years after joining the medical school. Dr. Robbins was active at the school until his death in 2003, at which time he held the titles of medical school dean emeritus, University Professor emeritus, and emeritus director of the Center for Adolescent Health.
• Earl W. Sutherland Jr., MD, who had been professor and director of pharmacology from 1953 to 1963, 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, PhD, who earned his biochemistry degree at the university in 1952, received the 1980 Nobel Prize in Chemistry for pioneering research in recombinant DNA technology.
• H. Jack Geiger, MD, a 1958 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 International Physicians for the Prevention of Nuclear War, and Physicians for Human Rights (PHR), which shared the 1997 Nobel Peace Prize as part of the International Campaign to Ban Landmines.
• George H. Hitchings, PhD, who had been a biochemistry instructor from 1939 to 1942, shared the 1988 Nobel Prize in Physiology or Medicine for research leading to the development of drugs to treat leukemia, organ transplant rejection, gout, the herpes virus and AIDS-related bacterial and pulmonary infections.
• Alfred G. Gilman, MD, PhD, a 1951 graduate of the engineering school, shared the 1994 Nobel Prize for Physiology or Medicine for identifying the role of G proteins in cell communication.
• Ferid Murad, MD, PhD, a 1965 graduate of the medical school, shared the 1998 Nobel Prize in Physiology or Medicine for discoveries concerning nitric oxide as a signaling molecule in the cardiovascular system.
• Paul C. Lauterbur, PhD, a 1951 graduate of the engineering school and a visiting professor of radiology at Case in 1993, shared the 2003 Nobel Prize in Physiology or Medicine for pioneering work in the development of magnetic resonance imaging.
• Peter C. Agre, MD, who completed a fellowship in hematology at Case while a medical student at Johns Hopkins, shared the 2003 Nobel Prize in Chemistry for discoveries that have clarified how salts and water are transported out of and into the cells of the body, leading to a better understanding of many diseases of the kidneys, heart, muscles and nervous system.

Two other distinguished alumni have served as U.S. surgeon general: Jesse Steinfeld, MD, a 1949 graduate, was surgeon general from 1969 to 1973, and David Satcher, MD, PhD, who graduated in 1970 and was surgeon general from 1998 to 2002.

Dr. Satcher also served as director of the Centers for Disease Control and Prevention from 1993 to 1998, and another medical school graduate, Julie Gerberding, MD, MPH, followed in his footsteps, in 2002 becoming the first woman to be named CDC director.

History

Since its founding in 1843, the Case Western Reserve University School of Medicine has been an innovator in medical education and a leader in pioneering research. Beginning as the Medical Department of Western Reserve College (and popularly known then as the Cleveland Medical College), the school moved into its first permanent home, in downtown Cleveland, in 1846. In 1915, a 20-acre site was secured for a medical center in University Circle, the current home of Case Western Reserve University, its School of Medicine, and two of the school’s affiliated hospitals, University Hospitals of Cleveland and the Louis Stokes Cleveland Department of Veterans Affairs Medical Center. University Circle also is home to many of the country’s outstanding cultural and educational institutions.
The school was 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 called then) 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 in an era when doing so seemed unthinkable. Many other medical schools followed suit, and these components remain at the core of the medical school’s curriculum today.

In 1924, the School of Medicine moved into the most modern and best-equipped preclinical science building in the country at that time. That building, donated by Cleveland industrialist Samuel Mather, remains an integral part of the medical school complex. It was named the Harland Goff Wood Building in 1993 in honor of the late chair and professor of biochemistry and former provost of the university.

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. In 1994, the health sciences complex was named for now-retired U.S. Congressman Louis Stokes. The proximity of these excellent research and educational centers to other prestigious university departments, including science, engineering and social sciences, stimulates uniquely creative interaction among researchers and educators.

Another giant leap in research capabilities came in the early 1990s, when the Richard F. Celeste Biomedical Research Building, named for the former Ohio governor, was opened. The $70 million building, attached to the Wood Building, added 154,000 square feet of research space and includes conference spaces, a lecture hall, public spaces and a cafeteria.

The School of Medicine was the first medical school to provide laptop computers to all its students. Today, students use their laptops to access the entire syllabus as well as numerous electronic resources deemed essential by faculty. Students have access to the WiFi network at the medical school and across campus. Technology is used to enhance, not replace, the faculty-student interaction that occurs in the classroom, the laboratory and small group discussions.

In 2002, the School of Medicine became only the third institution in history to receive the best review possible from the body that grants accreditation to U.S. and Canadian medical degree programs, the Liaison Committee on Medical Education. Also in 2002, the school built on its tradition of innovation in education when the university and the Cleveland Clinic entered into an agreement to form the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University, with the first students matriculating in 2004. The “College Track” is a program within the Case Western Reserve University School of Medicine. The 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 Track.

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 will occur, is located on 180 acres adjacent to the Case Western Reserve campus.

Occupying 50 buildings, the main campus includes a hospital, an outpatient clinic, a children’s hospital, heart and vascular institute, cancer institute, eye institute, research institute and supporting labs and facilities. To better serve the Cleveland suburbs with primary care services, Cleveland Clinic operates 16 family health centers, eight regional hospitals and medical offices throughout Northeast Ohio, staffed with Cleveland Clinic primary care physicians, as well as many medical and surgical specialists. State-of-the-art imaging services are available, and several locations contain pharmacies and outpatient surgery centers that provide same-day surgical services close to home. In 2011, the clinic recorded more than 4.2 million outpatient visits throughout the health system and 155,000 hospital admissions. Among them were patients from all 50 states and more than 100 countries. More than 2,800 full-time physicians and scientists and 11,000 nurses represent 120 medical specialties and subspecialties. Cleveland Clinic is consistently named as one of the nation’s top hospitals by U.S. News & World Report, and our heart and heart surgery program has been ranked No. 1 by U.S. News since 1995. Go here (http://my.clevelandclinic.org/default.aspx) for more information.
The 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. To learn more about MetroHealth and its locations and services, go here (http://metrohealth.org).

The 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 healthcare 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. For more information, go here (http://www.cleveland.va.gov).

Institutes and Centers

Advanced Platform Technology Research Center of Excellence

216.791.3800 x6003
Ronald J. Triolo, PhD, Executive Director
Gilles Pinault, MD, Medical Director

The Advanced Platform Technology (APT) Research Center of Excellence (http://www.aptcenter.research.va.gov) is a multi-institutional center composed of investigators from Case Western Reserve University and the Louis Stokes Cleveland Department of Veterans Affairs. Building on the 25+ year history of rehabilitation research in northeast Ohio, the Center was created in 2005 with a $5.0 million award from the Veterans Health Administration [VHA] Rehabilitation Research and Development Service as a national VA Research Center of Excellence. This commitment was subsequently renewed in 2010 for a second 5-year term with an additional award of $5.0 million. An additional $6 million award in 2010 from the State of Ohio’s Department of Development further validated the Center’s ability to achieve its primary mission to serve the clinical needs of veterans with motor, sensory and cognitive deficits and limb loss. The total value of the APT-related research portfolio is presently $45 million.

The APT Center is providing leadership to create and deliver innovative devices based on cutting-edge microelectronics, materials and MEMS fabrication and is a catalyst for the discovery and development of new technologies and techniques that can be employed in the rehabilitation process to provide independence for veterans and other individuals with disabilities. These techniques include basic and clinical research programs and the development and administration of new device-based therapies to patients within the emphasis areas of neural interfaces, prosthetics and orthotics, health monitoring & maintenance and enabling technologies. The Center provides affiliated investigators seed funding, administrative support (grants preparation and management, regulatory and statistical support), professional engineering & prototyping and an established quality system for the documentation and control of device design and production. Leveraging its investigators’ exceptional track records in a variety of disciplines, the Center is promoting the translation of its research into clinical and commercial applications. Current clinical applications being investigated include intelligent braces, respiratory support, sensation and control of a prosthetic hand, urinary incontinence, behavioral recovery after traumatic brain injury and, monitoring brain activity.

Case Comprehensive Cancer Center

216.844.8797
http://cancer.case.edu
Stanton L. Gerson, MD, Director, Case Comprehensive Cancer Center
Anne M. Duli, MPA, Associate Director, Research Administration and Finance
The Case Comprehensive Cancer Center (Case CCC) is one of only 41 National Cancer Institute-designated Comprehensive Cancer Centers in the country. The Case CCC integrates the cancer research activities of the largest medical collaborative in Ohio, Case Western Reserve University (CWRU), University Hospitals Case Medical Center and Cleveland Clinic - under a single leadership structure. Our researchers dedicate themselves to improving cancer outcomes through basic studies into signaling pathways giving rise to cancer and its generic and epigenetic causes, pursuing novel therapeutic targets, and analyzing lifestyle interventions to prevent cancer and detect it earlier.

The Case CCC has over 360 collaborating scientists and physicians who have successfully competed for over $119 million in annual funding. These investigators are organized into eight interdisciplinary scientific programs and have access to 15 Scientific Core Facilities. A unified clinical research effort consisting of 12 multidisciplinary clinical disease teams develop and prioritize clinical trials among the partner institutions.

Located in Cleveland, Ohio, the Case CCC serves a population with higher than average cancer rates. Research programs extend to CWRU affiliates MetroHealth Medical Center (the region’s county hospital) and Louis Stokes Veterans Affairs Hospital and to 13 community medical centers operated by University Hospitals and Cleveland Clinic.

As a consortium cancer center, Case CCC has become a powerful example of the potential generated by complementary institutions coming together for the benefit of research and discovery, patient treatments and community impact. Through its partners, Cancer Center programs extend throughout Northeast Ohio to offer residents access to cancer care through participation in community outreach, cancer prevention, cancer survivorship initiatives and a robust clinical trials operational effort coordinated across academic medical centers and community sites.

**Case Cardiovascular Center**

216.368.3391
Mukesh K. Jain, MD, Director, Case Cardiovascular Research Institute
Daniel I. Simon, MD, Director, University Hospitals Harrington-McLaughlin Heart & Vascular Institute Director, Case Cardiovascular Center

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.uhospitals.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 care 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**

216.844.8076
James Basilion, PhD, Co-Director
Robert Gilkeson, MD, Co-Director
Chris Flask, PhD, Scientific Director

The CCIR (http://ccir.case.edu) is a joint venture between Case Western Reserve University School of Medicine and University Hospitals of Cleveland. The CCIR through its 40 faculty and state-of-the-art clinical and preclinical imaging capabilities promotes interdisciplinary and translational imaging research. The CCIR also serves as a shared resource for CWRU’s Cystic Fibrosis Center, the Case Comprehensive Cancer Center, the Center for Stem Cell and Regenerative Medicine, and the Clinical and Translational Science Collaborative (CTSC). 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 basic researchers in many disciplines.

Preclinical imaging facilities include four high resolution MRI scanners, a microPET/CT scanner, a microSPECT/CT imaging system, and three bioluminescence/fluorescence systems. In addition, magnetic relaxometry scanners for high throughput screening of developmental MRI contrast agents, and recent addition of a cryofluorescence imaging system to obtain high resolution, 3D optical imaging capabilities enhance our technologies. CCIR staff provides quantitative image analysis as needed for specific applications. The CCIR clinical imaging research facilities offer a full range of imaging support. The facility includes 4 MRI scanners and one human PET/CT for clinical research studies. The CCIR has also recently completed a $1.2M construction project to create a new radiopharmaceutical facility. Together with our existing cyclotron and radioisotope delivery system, our imaging center now has the capacity to conduct a variety of molecular PET imaging studies from preclinical animal studies all the way to routine clinical studies.

**The Center for AIDS Research**

216.368.0271
Jonathan Karn, PhD, Director
Michael Lederman, MD, Co-Director

Since its founding in 1994, the Case Western Reserve University/University Hospitals Center for Aids Research (Case CFAR (http://casemed.case.edu/cfar)) has been a center of excellence for both clinical and basic science AIDS research. Investigators participating in the Case CFAR draw on resources from the Case Western Reserve University School of Medicine, University Hospitals Case Medical Center, MetroHealth Medical Center and the Cleveland Clinic Foundation and the Joint Clinical Research Center in Kampala Uganda. As the only
NIH-funded CFAR in the Midwestern United States, 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 Case CFAR include international research, especially with respect to research in tuberculosis and HIV malignancy, microbiocides, 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 Case 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 Case CFAR provides: Leadership and strategic planning that promotes and supports outstanding HIV/AIDS research at our participating institutions, 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.

The Center for Child Health and Policy at Rainbow Babies & Children’s Hospital
216.844.6253
Leona Cuttler, MD, Director
Ann Nevar, MPA, Supervisor

Established in 2007, the Center for Child Health and Policy at Rainbow Babies & Children Hospital (http://www.uhhospitals.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
http://cci.case.edu/cci/index.php/Main_Page
Pamela Davis, MD, PhD, Director

James Spilsbury, PhD, Academic Development Core Director
Nathan Morris, PhD, Statistical Sciences Core Director
Guo-Qiang Zhang, PhD, Medical Informatics Division Chief

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 60 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 Foundation, and MetroHealth System. The CCI has supported hundreds of clinical research and epidemiology projects, including local and national multicenter, longitudinal studies. The CCI has three cores that work together to provide fully integrated research support to all investigators: Academic Development Core, Division of Medical Informatics, and Statistical Sciences Core.

The Academic Development Core manages the Master’s Degree Program in Clinical Research (Clinical Research Scholars Program) - see “Clinical Research MS” tab above) as well as a newly created 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 Division of Medical Informatics is primarily charged with developing informatics solutions to many of the barriers clinical investigators face in efficiently processing, storing and sharing research data; and with providing informatics tools and infrastructure for the CCI and the larger research community. In order to meet these goals, the Division of Medical Informatics develops data standards for research database development and data management that aim to maximize the value (accuracy, completeness, availability, security) of research data, develops technological solutions and tools in support of the other CCI cores, develops tools and systems to facilitate understanding of research data (including data dictionaries, data sharing tools, and repositories for biological data) and conducts research in new methodologies for clinical research informatics, clinical and health informatics, comparative effectiveness research, information discovery, data integration, data mining, and translational research. The Division of Medical Informatics staff consists of research programmers and systems analysts with not only a wide range of technical expertise, but with experience using semantic web technology in support of clinical research.
The Statistical Sciences Core provides data management and statistical support on 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, 2 MS biostatisticians, and 1 data manager, each with several years of collaborative experience in an academic medical center. Statistical software packages that are supported by the CCI Statistical Sciences Core include SAS, SPSS, R/S-Plus, JMP, NCSS PASS, Minitab, and Stata.

Center for Global Health and Diseases

216.368.6321
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 health care 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 focuses 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

216.368.6986
Megan McNamara, MD, Director, CAML

The Center for Medical Education, established in 2010, is currently being reorganized to better align with the needs of learners across the educational continuum – from students to residents to graduate students to faculty. The Center for Medical Education (CMed) 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 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.

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

Center for Modeling Integrated Metabolic Systems

216.368.4066
Gerald M. Saidel, PhD, Director

The Center for Modeling Integrated Metabolic Systems (MIMS) (http://casemed.case.edu/mims) combines mathematical modeling, computersimulation, and in vivo experimentation to quantify relationships between cellular metabolism and physiological responses of tissue-organ systems and the whole body. The MIMS Center was inspired by
Dr. Marco E. Cabrera (deceased), who together with Prof. Gerald M. Saidel, co-directed this Center. It was established in 2002 with a $11.8 million grant (P50-GM066309) from NIGMS of the National Institutes of Health as a Center of Excellence in Complex Biomedical Systems (later Systems Biology). The MIMS Center involves multi-disciplinary research teams from Case Western Reserve University, Case Medical Center of University Hospitals of Cleveland, and Cleveland Clinic.

The primary aim of the MIMS Center is to develop mechanistic, mathematical models to simulate cellular metabolism in various tissues and organs (i.e., skeletal muscle, heart, brain, and adipose tissue) and to integrate these components in whole-body models. These biologically and physiologically based computational models incorporate cellular metabolic reactions and transport processes of a large number of chemical species. Model parameters quantitatively characterize metabolic pathways and regulatory mechanisms under normal and abnormal conditions including obesity and hypoxia as well as in disease states including type-2 diabetes, cystic fibrosis, and chronic kidney disease. The large-scale, complex mathematical models are solved numerically using sophisticated computational algorithms to simulate and analyze experimental responses to physiological and metabolic changes. Model parameters are optimally estimated by minimizing differences between model simulated outputs and experimental data using large-scale, nonlinear optimization algorithms. Experimentally validated models are used to predict the effects of altering metabolic processes with disease states, pharmacological agents, diet, and physical training.

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, Ph.D, with over $80 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 bioinformatics services including 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/.

Proteomics entails the in depth structural analysis of individual proteins in human and animal cells. In studying proteins and their changes, bioinformatics enables researchers to take an integrated -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.

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 technologies to understand the function and interactions of macromolecular complexes.

The CPB has three divisions: Proteomics and Genomics, Bioinformatics, and Macromolecular Structure.

Proteomics and Genomics Division

The mission of the Division of Proteomics and Genomics is to support research in protein and gene expression analysis, protein and gene modifications, and protein interactions in a wide variety of biological contexts. The division also develops new tools in Proteomics and Genomics research. This includes multiple Proteomics Cores to support these activities.

Bioinformatics Division

The mission of the Division of Bioinformatics is to support interdisciplinary research and training in many areas of bioinformatics including analysis of DNA and protein sequences, protein interaction networks, linkage and association studies for simple and complex traits, and gene and protein expression profiles. This includes a Bioinformatics Core that provides research support for these activities.

Macromolecular Structure Division

The mission of the Division of Macromolecular Structure is to support interdisciplinary research in new methods of structure determination, the combination of computational and experimental structural biology approaches, and developing and maintaining infrastructure for macromolecular structure determination. The Division will work closely and coordinate their activities with faculty and Departments in the University who use structural information to understand function as well as other Centers that provide leadership in Structural Biology and Biophysics.

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: http://proteomics.case.edu/index.html or e-mail: proteomics@case.edu (//proteomics@case.edu).

Center for Psychoanalytic Child Development

The Center for Psychoanalytic Child Development is to be led by a child psychoanalyst affiliated with the Hanna Perkins Center for Child Development, located in Shaker Heights, Ohio. The Center’s goals include the development of courses, practica, and supervisory experiences appropriate for medical students, residents, and fellows.

The Center for RNA Molecular Biology

216.368.1852
http://www.case.edu/med/macenter/home.htm
Timothy W. Nilsen, PhD, Director

The Center for RNA Molecular Biology 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 RNA Center is currently composed of 8 primary faculty members and 10 secondary members.

The RNA Center contains the largest concentration of RNA molecular biologists in the nation. Collectively, the faculty of the RNA Center cover nearly every aspect of RNA research. Current research in the Center focuses on several of these 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, RNA 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, and University Hospitals System. 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. In addition, a comprehensive laboratory manual on RNA technology has been co-authored by the Center’s director, Dr. Nilsen.

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 (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 care professions and biomedical workforce. The Center also coordinates the Mini Medical School Program presented every Spring and Fall to educate the community in 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

216.778.4993
John R. Sedor, MD, co-director
Tyler Miller, MD, co-director
Donald E. Hricik, MD, co-director
Walter Boron, MD, PhD, co-director

Kidney disease is the ninth leading cause of death according to the Centers for Disease Control data. Health care costs for approximately 500,000 patients, who are being treated with dialysis [artificial kidney machine] or who received a kidney transplant, consumed almost 1% of the federal budget in 2008. Up to 26 million U.S. residents have evidence of serious kidney disease.

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 and the Department of Physiology and other clinical and basic departments. Research interests of the faculty include glomerular development and disease, epithelial cell biology and ion transport, tubular physiology, genetic epidemiology, health services research, renal transplantation, health disparities research and clinical trials. Research faculty applies cellular, molecular biological, genetic, genomic and epidemiological methods to in vitro models, animal models and/or patients. Many projects by Center investigators use health data, culled from robust 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.

The Center for Translational Neuroscience

216.368.6116
David M. Katz, PhD, Director

The goals of the Center for Translational Neuroscience are to develop scientific interactions that promote understanding of the pathology of neurological diseases and to develop novel therapeutic strategies for the treatment of those diseases. The Center pursues these goals through Translational Interest Group meetings and events, and through the Neurological Institute, in the University Hospitals Case Medical Center, where clinicians and investigators have a direct conduit between research and developing treatments.

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 translation 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
Mark I. Aeder, MD, 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 health care, and the need for improved patient-caregiver communication. Since its founding in 2006, the MSSSC continues to work with an ever expanding list of health care partners to become an integral resource for the education of health care students and professionals in the Northeastern Ohio region and throughout Ohio. The MSSSC and The Institute for Surgical Innovation (ISI) combine to form the Case Western Reserve University Center for Skills and Simulation (CWRU-CSS).

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 uses to teach individual techniques; High fidelity trainers – manikins with programming capabilities; Virtual reality – real life interactive trainers for surgery, cardiology and other disciplines; Second life – avatar interactions in a computerized world; and Hybrid combinations of the above.

The CWRU-CSS is an American College of Surgeons Level 1 Accredited Educational Institute. During the past five years, the Center has provided educational opportunities and course for learners at all levels from high school students, medical, 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 MetroHealth Medical Center, graduate education for practicing physicians and surgeons, nursing and other health care providers at all levels, first responders including EMS and fire/rescue, flight nurse training and military reserve medical units.

The Swetland Center for Environmental Health
216.368.8521
Dorr G. Dearborn, MD, PhD, Director
http://casemed.case.edu/swetland/

The Swetland Center for Environmental Health (http://casemed.case.edu/swetland) is an environmental clinical center within the Department of Environmental Health Sciences of the CWRU School of Medicine. The focus of the Center is on environmental health problems of the Cleveland community, especially as they relate to toxic exposures of children and their families. The Swetland Center has four major components relating to clinical care, research, public health, and medical education. The Center has an Environmental Health Clinic based at UHCMC and conducts clinical-based environmental research fostered by strong relationships with the local public health agencies, which address important local environmental problems including the built environment and indoor air quality. Medical education is a major component of the Swetland Center where it is developing environmental health as a theme throughout the education of medical students, residents, fellows, and community physicians. This environmental curriculum at CWRU includes yearly medical student community projects for the entire first year class on environmental health concerns. While the Center is relatively new, its Director, Dr. Dearborn, has had housing-related public health and research collaborations with both local health agencies for the past two decades.

National Center for Regenerative Medicine
216.368.3614
http://ncrm.us
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 (http://www.case.edu/cse/nec) is a coordinated group of scientists and engineers dedicated to research and education at the interface between neuroscience and engineering. Researchers 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 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. Facilities include an electrode fabrication laboratory and surgical suite for acute and sterile surgery, staffed by two full time technicians. 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). The center also holds several laboratories in neural regeneration, neural interfacing, neural prosthetics, materials for neural interfacing computer modeling and in-vitro electrophysiology. Research occurs at many levels starting from cellular and molecular to animal experimentation and into the clinic. 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 paralysed patients, preventing seizures, motor disorders, incontinence aspiration or obstructive sleep apnea.

**Prevention Research Center for Healthy Neighborhoods**

216.368.1918
Elaine Borawski, PhD, Director

The Prevention Research Center for Healthy Neighborhoods (PRCHN) (http://casemed.case.edu/ctscommunity/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, entering 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 community nutrition and food policy, tobacco prevention and control, environments supporting healthy eating and active living, and place-based health and behavior surveillance. This includes core research project – Freshlink - that aims to increasing 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 provides 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 from five schools within the University (College of Arts and Sciences, the Frances Payne Bolton School of Nursing, the Mandel School of Applied Social Sciences, and the School of Dental Medicine), supports the mission of the Center. Representatives from these local agencies and organizations serve on the PRCHN’s Network of Community Advisors (NOCA), offering guidance to identify emerging issues, set research and programmatic priorities, and ensure the community’s voice informs our work.

**Skin Cancer Research Institute**

216.368.0324
Kevin D. Cooper, MD, Director

The Skin Cancer Research Institute (http://medwww.case.edu/dept/dermatology/Centers/SCRI.html) engages the foremost experts in dermatology and oncology to work collaboratively across disciplines to identify new ways to treat and prevent skin cancers. The Skin Cancer Research Institute (SCRI) at Case Western Reserve University exists 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 (http://www.case.edu/med/bioethics/stemcellethics) serves as a focal point for campus-wide and international interdisciplinary scholarship and research. Housed in the Department of Bioethics, the Stem Cell Ethics Center provides an avenue to educate policy makers, regulators, and the general public about all forms of stem cell research 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 Visual Sciences Research Center

The Visual Sciences Research Center (VSRC) (http://case.edu/med/ophthalmology/VisualSciencesResearchCenter.html/VSRCHomepage.html) was founded at Case Western Reserve University in 1996. The VSRC now comprises a multidisciplinary and comprehensive research program in vision and ophthalmology, with over 30 members in CWRU departments including Ophthalmology and Visual Sciences, Anatomy, Biomedical Engineering, Genetics, Medicine, Molecular Biology & Microbiology, Epidemiology & Biostatistics, Neurology, Neurosciences, Pathology, Pediatrics, Pharmacology, Physiology, and Biophysics. VSRC scientists study basic and clinical aspects of the eye and involve three interdisciplinary research theme groups: Aging and Diabetes, Retinal Degeneration, and Ocular Immunology. The mission of the Visual Sciences Research Center is to promote the study of basic and clinical problems of the eye and visual system that may lead to improvements in the prevention and treatment of major blinding disorders worldwide. Through a multidisciplinary and comprehensive research program in vision and ophthalmology involving both basic and clinical departments at Case Western Reserve University, the VSRC seeks to advance the visual sciences at the University and to promote its efforts to the scientific community.

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 (http://casemed.case.edu/pediatrics/CF) is a translational center composed of investigators from Case Western Reserve University and University Hospitals of Cleveland. The Center’s research is funded by over $4 million in grants 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.

Endowed Lectures

Publications

Publications describing the School of Medicine are produced by the Office of Development, Alumni Relations, and Communications. Many articles and news reports are accessible via the Web under "news and highlights." (http://case.edu/medicine/news) The medical school produces an annual report highlighting accomplishments in research, education and service.

For example, AlumniNews, produced by the Office of Alumni Relations, features updates to keep alumni connected to past colleagues, current students and happenings at the School of Medicine. This biannual newsletter publishes in the spring and fall, and all alumni who spent the majority of their time within the School of Medicine (MD and PhD alumni) should receive a printed issue in the mail. Copies are also delivered to locations around the medical school to reach MD and PhD students, and a link to a PDF version is emailed to all students. This university wide-publication is distributed electronically to all CWRU alumni once a month. Each school within the university submits one news bullet for publication and can be viewed online (http://casemed.case.edu/alumni/publications/alumninews.cfm). The Reunion Newsletter is distributed to all alumni who are celebrating milestone reunion years from the School of Medicine. This newsletter is published three times during the year for celebratory years. The third issue each year serves as a follow-up on the celebration. This last publication is also sent to the next year's reunion classes to create momentum and get alumni involved in upcoming reunions.

Endowed Lectures

The Nikaan B. Anderson Lecture

Established in 1974 by friends of the late professor of anesthesiology (from 1969 until his death in 1974), this annual lecture is presented by teachers of the science of anesthesia.
The Claude S. Beck Scholarship Visiting Lectureship

This lecture, about cardiovascular surgery, was established in 1989. At what is now known as the Case Western Reserve University School of Medicine, Claude S. Beck, MD, was demonstrator of surgery in 1924 to 1925; professor of neurosurgery in 1940; and the first professor of cardiovascular surgery in the United States from 1952 until 1965.

The Richard E. Behrman, MD, Lecture In Child Development

Established in 2001 with contributions from friends of colleagues of this former School of Medicine dean (1980 to 1989), this annual lecture is delivered by distinguished scholars in child development.

The Jack H. Berman, MD, Lecture

Established in 1999 by family, friends and colleagues of this alumnus and associate clinical professor, guest lecturers discuss the basic science behind disease and its application to patient care through this program.

The Louis A. Bloomfield Memorial Lecture

Established in 1955 in memory of the Cleveland attorney Theodore R. Bloomfield by his widow and his son, this lecture brings outstanding members of the medical profession from around this country and abroad to discuss new concepts and developments in medicine with the medical community and allied professions.

The William E. Bruner, MD, DSc, Lecture in Ophthalmology

This lecture was established in 2002 in memory of the father of Clark E. Bruner and grandfather of William E. Bruner II, MD, a 1975 medical school alumnus, with gifts coming from them as well as Susan F. Bruner.

The Courtney Burton Frontiers of Medicine Lecture

This annual lecture is presented by an outstanding individual who has achieved or helped achieve a significant advance in medicine or a closely related field and whose presentation would be of great interest to members of the medical profession. It is supported by a fund established in 1993. Courtney Burton Jr., was chair of the board of Oglebay Norton Co. from 1957 until shortly before his death in 1992.

The Alfred Cahen Memorial Lecture

This lecture series in gastroenterology has been supported by a fund established in 1965 by Lottie Cahen, widow of the founder and former president of World Publishing Co., in memory of her late husband.

The Frohring Presidential Lectureship in Medicine and Engineering

Lecturers in medicine and engineering deliver this lectureship at the discretion of the University president thanks to a fund begun in 1993 by Paul R. Frohring.

Nathan S. Greenfield Family Visiting Lecturers in Pharmacology

Through an endowment, Rosalee Greenfield Weiss, PhD, and Raymond A. Weiss, PhD, established this annual lecture in 1997 to honor her father, Nathan S. Greenfield, a pharmacist who owned Wade Park Pharmacy in Cleveland from 1914 to 1956; her mother, Corinne Sternheimer Greenfield; and Lynn Stuart Weiss, daughter of the benefactors, who died of cancer in her mid-20s in 1971.

The Zella Hall Lecture

This annual lecture or series of lectures is presented by one or more distinguished visiting researchers selected by the dean of the School of Medicine or his or her designee. It they are made possible because of support received in 1998 by the estate of Zella Hall.

The Hanna Lectures

Founded in 1913 by G. W. Crile, 1864-1943, in honor of H. Melville Hanna, philanthropist and founder of the MA Hanna Co., the Hanna Lectures are delivered by distinguished basic scientists from this country and abroad.

The William D. Holden Lectureship in Surgery

Established in 1985 by the members of the Department of Surgery of MetroHealth Medical Center in honor of their former chair and Payne Professor of Surgery, this series of lectures in surgery is delivered by distinguished leaders in American surgery.

The Lorand V. Johnson Lecture

This lecture, for residents and visiting staff members in ophthalmology, was established in 1967 by the Wright Foundation.

The Kaiser Permanente Endowed Lectureship in Bioethics

This lecture is presented by a distinguished visiting lecturer with the goal of advancing the study of bioethics. It was established in 1994.

The Rita Ann Kicher Lecture

In this annual lecture, established in 1996, a distinguished visiting lecturer promotes quality health care by emphasizing new developments in the identification and treatment of life-threatening cardiac arrhythmia. Rita Ann Kicher was the daughter of Thomas Kicher, PhD, a triple alumnus, long-time faculty member, and dean (1992-1997) of the Case School of Engineering. At the time of her death, she was a systems analyst at University Hospitals of Cleveland’s Center for Quality Assessment and Utilization Management.

The Clifford L. Kiehn, MD, and John Desprez, MD, Visiting Lecturers in Plastic and Reconstructive Surgery

These lecturers are distinguished visitors whose presentations advance the study of plastic and reconstructive surgery. The lectureship was established in 1994. Dr. Kiehn is the former head of plastic and reconstructive surgery, and Dr. Desprez followed him in that role.

The Jerome I. Kleinerman, MD, Lectureship in Pulmonary Pathobiology

This lectureship is named for an internationally respected lung specialist and professor emeritus of pathology at the School of Medicine. Established in 2000 by the late Dr. Kleinerman’s daughters, friends and colleagues, the lectureship each year supports a distinguished visiting lecturer whose presentation advances the study of pulmonary pathology. The lecturer is selected by a faculty committee that includes members having appointments at MetroHealth Medical Center.
The members of the committee are chosen by the dean of the School of Medicine.

The Robert R. Kohn Lecture
The lecture honors an alumnus of the Class of 1957 and was established in his memory in 1989 by family, friends and colleagues to advance the study of pathology.

The Lester Krampitz Lecture and Education Fund
The fund was established in 1982 by family, friends and colleagues of former faculty member Lester Krampitz, MD, to honor him with a lecture fund in microbiology. It is intended to facilitate the interchange of ideas, a process Dr. Krampitz, who joined the faculty in 1946 and retired in 1978, believes is vital to scientific research.

The Carl H. Lenhart Surgical Lecture
Established in 1955 by friends of this alumnus of the Class of 1904, in his memory, this lecture presents outstanding speakers on clinical developments in surgery.

The Alan Moritz, MD, Endowment Fund
This fund was established in 1991 by friends and colleagues of the late forensic pathologist, medical school faculty members, and university provost.

The Olof H. Pearson, MD, Lecture
Established in 1999 by family and friends of the late endocrinologist, oncologist and faculty member, this lecture features a cancer-related topic at the School of Medicine.

The Robert S. Post, MD, Visiting Lectureship
Established in 1995 by Dr. Post’s friends and colleagues in the Community Dialysis Center, in memory of the former faculty member and head of nephrology, this lecture features a distinguished visiting expert in the field of nephrology.

The Edward W. Purnell Lectureship in Ophthalmology
Established in 1991 and named for the late physician, surgeon, researcher, and medical school head of ophthalmology, this lecture features a visiting expert in the Department of Ophthalmology.

The Frederick C. Robbins Lecture in the Department of Medicine Visiting Lecturer
Established in 1995 by the Department of Medicine in honor of Frederick C. Robbins, MD, dean emeritus of the School of Medicine, university professor emeritus, and Nobel Prize winner, this lecture features a distinguished visiting expert each year in the Department of Medicine.

The Henry Z. Sable, MD, PhD, Endowment Fund
Established in 1997 by Mrs. Florence M. Sable in honor of her late husband, who was professor emeritus of biochemistry, this lecture advances the study of biochemistry via a visiting expert selected by the chairperson of the Department of Biochemistry.

The Roy Scott Lecture
Established by colleagues, students, family and friends in memory of the former head of the Department of Medicine of MetroHealth Medical Center, this lecture involves an annual two-day visit of a leading cardiologist, who presents the lecture and grand rounds to house officers and students of the School of Medicine.

The Robert Sternlicht Visiting Lecturers in Pharmacology and Cancer Biology
Originally established in 1990 by friends and family and named the Robert Sternlicht Memorial Fund, these lectures feature distinguished experts whose presentations will advance the study of oncology at the School of Medicine. Lecturers are chosen by the chair of the Department of Pharmacology and the director of the comprehensive cancer center. Robert Sternlicht was the son of Himan Sternlicht, PhD, associate professor emeritus of pharmacology.

The Merton F. Utter Memorial Lecture
Established in 1981 in memory of the former professor of biochemistry and chair of the Department of Biochemistry, this lecture is delivered by a scientist of the highest caliber in a field related to those in which Dr. Utter was interested. Lecturers are chosen by the chair of the Department of Biochemistry.

The Austin S. Weisberger Lecture
Established in 1972 in the Department of Medicine, this lecture honors the memory of the man who, at the time of his death in 1970, was the John Huntington Hord Professor and chair of the Department of Medicine of the School of Medicine and University Hospitals.

The Harland G. Wood Endowment Fund in the Department of Biochemistry
Established in 1994 in memory of the late chair and professor of biochemistry and former provost of the university, this fund supports an annual Page-Wood symposium, co-sponsored by the School of Medicine and the Cleveland Clinic Foundation, featuring a leader in the field of biochemistry, an annual guest lecturer in biochemistry, and an annual guest lecturer selected by faculty with the rank of assistant professor in the Department of Biochemistry.

Administration
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Dean, School of Medicine, and Senior Vice President for Medical Affairs

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Vice Dean for Oncology
Doctor of Medicine (MD)

Programs Leading to MD

Today, applicants can choose from three paths to obtain a medical degree at Case Western Reserve University: the University Program, the College Program (Cleveland Clinic Lerner College of Medicine of Case Western Reserve University), and the Medical Scientist Training Program (p. 29). 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, organ system-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 education and academic affairs carries the dean’s academic and administrative authority and has direct supervisory responsibility over 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 class cohort performance in each program’s competencies; and 3) the evaluation of the overall content and appropriateness of the educational program and curriculum 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, and oversight of the curriculum, student assessment and program evaluation.

Expectations for Personal and Professional Characteristics

Students are evaluated on 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:** Provides 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:** Completes tasks promptly and well. Present on time and actively participates in clinical and didactic activities. Always follows through and is exceptionally reliable.

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

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

**Tolerance** demonstrates 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 maintains professional composure and exhibits good clinical judgment in stressful situations.

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

**Graduation**

A medical student who has satisfactorily met the standards and achievement levels for the core competencies of the medical school program in which he or she is enrolled may be granted the degree of doctor of medicine (MD) by Case Western Reserve University, provided that:

1. He or she has been registered at Case Western Reserve University School of Medicine for at least four academic years, (five years for the College Program) or has transferred to the University Program after two years at another accredited medical school.
2. The Committee on Students for the University Program or the Medical Student Promotions and Review Committee for the College Program approves his or her record of performance, and the faculty recommends him or her to the trustees for graduation.
3. He or she has discharged all financial obligations to the university and to the program in which he or she is enrolled.
4. He or she has taken the U.S. Medical Licensing Examination (USMLE) Steps 1 and 2 and the USMLE Step 2 Clinical Skills Examination, and has obtained a minimum passing score on the examinations as determined by the USMLE Composite Committee. There are other academic requirements that must be met which are delineated in another section. The requirements for graduation of any class may be altered by action of the faculty of the School of Medicine.

**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.

**The Electronic Curriculum**

The School of Medicine has developed an integrated electronic curriculum for all years of the medical curriculum that contains a list of learning objectives as well as the resources that allow the students to achieve the objectives. These resources include references to traditional textbooks and journal articles, original textual material, PowerPoint files, illustrations, animations, videos, audio files, and links to Internet-based learning resources (including original journal articles in electronic format). These resources are made available on the Internet by an NT/Internet server system.

University Program students have access to the Internet and the electronic curriculum from their assigned personal desks via fiber optic Ethernet connection to CWRUnet and via wireless access when away from their desks. College Program students have access to the Internet
and the College Program curriculum via wireless access at the Cleveland Clinic.

**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/student-groups1.html). (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, the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University (College Program), 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, T-308
10900 Euclid Avenue
Cleveland, Ohio 44106-4920
Phone: 216.368.3450 or casemed-admissions@case.edu

**Office for Admissions and Student Affairs-College Program**

Cleveland Clinic Lerner College of Medicine of Case Western Reserve University
9500 Euclid Avenue NA21
Cleveland, Ohio 44195
Phone: 216.445.7170 or 866.735.1912 or cclcm@ccf.org (http://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 the process on the internet 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://www.aamc.org/students/applying/amcas) (AMCAS) receives an applicant's electronic application, he or she 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 both the University Program and the College Program.

Applicants should complete this secondary application as instructed. After the applicant has submitted the secondary application and all supporting materials, the appropriate admissions committee will review the information and decide whether to invite the applicant for an interview. After the interview, the committee will decide whether to extend an offer of admission. Applicants are notified of the committee’s decision no later than April 30.

**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, exposure 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**

In anticipation of the changes in the 2015 MCAT (https://www.aamc.org/students/applying/mcat), we have modified our pre-requisite requirements. Given the variability in the way undergraduate institutions are modifying their curricular structure for the 2015 MCAT, we have made our pre-requisites requirements and recommendations more flexible. Please closely review the pre-requisite charts (http://casemed.case.edu/admissions/process/requirements.cfm) for each program.

If these pre-requisites 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 one year of challenging, upper-level sciences at one of these institutions prior to application.

If all science pre-requisites 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 pre-requisite courses were taken at a community college, the committee will evaluate them on a case-by-case basis.

AP credits are acceptable for general chemistry. They are not acceptable for organic chemistry.

As an 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. Most applicants to medical school, however, are chemistry or biological science majors.

**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 on 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 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 full scholarship covering tuition and fees. Programs such as the Medical Scientist Training Program, the MD/PhD in health services research program, and others offer financial support for participants. For more information, see other entries in this publication and contact the specific program.

Also, the University Program offers a number of merit scholarships annually to each class through its Dean's Scholars program and David Satcher, MD, PhD-Rubens Pamies, MD Minority Student Scholarship 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.

To Those Currently in College

The admissions committee give preference to candidates who will have completed the requirements for a bachelor of arts or bachelor of science degree. Most accepted candidates rank in the top one-third of their classes, and a large proportion of them have outstanding scholastic records.

The committee's main considerations are the overall quality of college performance and general ability and potential. In most instances, applicants are given priority if they have completed all minimum academic requirements and have taken the MCAT by the time they submit their AMCAS applications. Although no special emphasis is placed on the applicant's major / field of study, the committee strongly favors the concept of a broad, general college education.

Students who have been out of college a year or more:

Those who have been out of college for a year or more are encouraged to apply. Approximately half of the students at the School of Medicine have a year or more between the time they graduate from college and the time they enter medical school, and about 10 percent of them begin medical school when they are 30 years old or older.

Those two or more years removed from full-time college coursework should plan to take challenging, advanced-level (junior-, senior- or graduate-level) courses in the biological sciences to prepare for entry.

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 the second month of medical school, students begin the Rotating Apprenticeship in Medicine Program (RAMP). This program involves students in several patient care settings. In January of the first year, the Community Patient Care Preceptorship (CPCP) rotations begin. Each student works with a community physician one afternoon a week for 3 months.

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 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, 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.

3. Promoting integration of the biomedical and population sciences with clinical experience;
4. Transferring concepts and principles learned in one context to other contexts;
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Foundations of Medicine and Health
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1. The Human Blueprint: Comprised of endocrine, reproductive development, genetics, molecular biology, and cancer biology.
2. Food to Fuel: Encompasses gastro-intestinal system, nutrition, energy, metabolism and biochemistry.
3. Homeostasis: Includes cardiovascular system, pulmonary system, renal system, cell regulation, and pharmacology.
4. Host Defense and Host Response: Focuses on host defense, microbiology, blood, skin, and the auto-immune system.

Several themes stretch longitudinally across these blocks, including anatomy, histopathology and radiology, as well as clinical mastery. Teamwork, interprofessional collaboration and bioethics are likewise incorporated longitudinally.

Blocks 2-6 follow a common pattern. Each block has a Clinical Immersion Week and each has a Reflection and Integration Week. During the 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**: RAMP: Rotating Apprenticeships in Medicine Practice is a Year 1 course where students rotate through patient care encounters in multiple settings. This course is designed to expose students to various clinical settings to enhance observational and reflection skills in the context of the doctor/patient relationship and the role of physicians in society. CPCP: Community Patient Care Preceptorship during either Year 1 or Year 2 students spend 11 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 and an innovative online curriculum.

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 clinical 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 of that integrate core specialties in at one site for 8 or 12 weeks. Core 1 combines Internal Medicine, Family Medicine, and Geriatrics 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 Emergent 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 Foundation, MetroHealth Medical Center and the Louis Stokes VA Medical Center.

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.

**Urban Health Pathway**

In addition to our innovative curriculum, students in the University Program have the option of specializing in a longitudinal 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.

**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 (SSSEQs), 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 SSSEQs 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 each 12 week teaching 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 Mastery 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. Personal 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 “satisfactory” or “identified for remediation” 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.

Medical students must obtain a passing score on the United States Medical Licensing Examination (USMLE) Step 1, Step 2 Clinical Knowledge (CK) and Step 2 Clinical Skills (CS) to be eligible for graduation.

Overview of the College Program

The Cleveland Clinic Lerner College of Medicine (CCLCM) 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 prosections 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 Foundations 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 areas 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), at Deans’ Dinners where they discuss research careers with the speakers over dinner following a formal presentation of the speaker’s research, 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 9 competencies. 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 extends 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
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 including a discussion of an Institutional Review Board (IRB) proposal with members of the IRB. 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. Molecular Medicine PhD students join to participate in ARM sessions. 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. During the year, the students may be divided into small groups to develop research hypotheses and design studies to evaluate the hypotheses.

Deans’ Dinners are held two times a year separately for the first and second year classes to provide students the opportunity to attend a formal research seminar by a distinguished physician investigator, followed by dinner and an informal question and answer period to learn how that investigator achieved success in his/her career. This is an opportunity to discuss different career options and pathways, the challenges of balancing research and clinical work, and approaches to balancing career and family or other interests. The goal is to provide role modeling as a supplement to the advising and mentoring systems of the core basic science course. 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 4 days a week for 2 hours, with the remainder of each day devoted to self-directed learning modules that cover basic anatomical information (and are available online), and Case Directed Anatomy Sessions on Monday mornings for which students study clinical cases designed to introduce anatomical concepts and facts before coming to the lab. In the lab, students rotate among a number of stations using cadaver projections to demonstrate anatomy relevant to the cases and radiological images such as 3-dimensional CT scans. For example, a case of a patient who has suffered 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.

**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 occur 4 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.

At the end of 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 this case. (All PBL cases used in the curriculum are available online), and Case Directed Anatomy Sessions on Monday mornings for which students study clinical cases designed to introduce anatomical concepts and facts before coming to the lab. In the lab, students rotate among a number of stations using cadaver projections to demonstrate anatomy relevant to the cases and radiological images such as 3-dimensional CT scans. For example, a case of a patient who has suffered 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, and ethics, 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 # and #-receptors but also the pharmacology 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), Neurological and Behavioral Sciences (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
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 Foundation of Medicine Seminar Series. The Foundation 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 January 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 classwork 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 Neurological and Behavioral Sciences (6 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. Foundations of Medicine Seminar Series begin in September of Year 1 and end 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 and to prepare for the USMLE Step 2 CS Examination. 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.

Basic 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. Basic Core 1 combines Family Medicine, Internal Medicine and Geriatrics for 12 weeks, Basic Core 2 combines Pediatrics and OB/Gyn for 12 weeks, Basic Core 3 combines Neurology and Psychiatry for 8 weeks, and Basic 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 December 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; however, in unusual circumstances students under the guidance of their Physician and Research Advisors and with permission from the Research Education Committee may divide their research over the final three years, depending on the student’s research project. 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 other institutions (e.g., the NIH), with 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 “Meets or Exceeds” (“ME”) 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. We have designed an assessment process that 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 College Program’s 9 competencies is collected and managed 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 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 Summary for the College Program**

A medical student who has satisfactorily completed all the required work in CCLCM may be granted the degree of Doctor of Medicine (MD) with Special Qualifications in Biomedical Research by Case Western Reserve University, provided that:

1. He/she has been registered at Case Western Reserve University School of Medicine for at least five academic years and not more than 6 years for CCLCM.
2. CCLCM Medical Student Promotions and Review Committee approve his/her record of performance including thesis, and the faculty recommends him/her to the School of Medicine’s Committee on Students for graduation.
3. He/she has discharged all financial obligations to Case Western Reserve University and to the program in which he/she is enrolled.
4. He/she has passed the U.S. Medical Licensing Examination (USMLE) Step 1, USMLE Step 2 Clinical Knowledge (CK) and Step 2 Clinical Skills (CS).
5. He/she has passed the CWRU School of Medicine Clinical Skills Examination.
6. The Research Thesis and Defense have been completed within 3 months after completing research or by February 15th of the 5th year, whichever is earlier.
7. Every CCLCM student completes a total of 217 weeks in the following activities:
   - 44 weeks in Year 1
   - 41 weeks in Year 2
   - 72 Clinical Weeks consisting of:
   - 48 Weeks of Basic Cores and Acting Internships:
     - 12 weeks Basic Core 1: Family Medicine, Internal Medicine, Geriatrics
     - 12 weeks Basic Core 2: Pediatrics, Obstetrics/Gynecology
     - 8 weeks Basic Core 3: Neurology, Psychiatry
     - 8 weeks Basic Core 4: Surgery, Undifferentiated Care
     - 8 weeks Acting Internships (2) 4 weeks each; one must be in Cleveland
   - 20 weeks minimum of clinical elective rotations
   - In addition to the 20 weeks...
     - 2 weeks are counted from the Years 1 and 2 Longitudinal Experiences
     - 2 weeks of the required Capstone course are counted
   - 12 non-clinical weeks of electives
   - 48 weeks of thesis research

**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 are also offered in General Medical Sciences

**MD/PhD (MSTP)**

The Medical Scientist Training Program (http://bulletin.case.edu/schoolofmedicine/dualdegreeprograms/#medicalsciencestrainingprogramtext) leading to the MD/PhD in various biomedical programs is listed in above grey tab.

**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).

**MD/MA in Bioethics**

The 27-credit-hour Master of Arts in Bioethics program, including a 12-hour foundations course taken during the first year of medical school, emphasizes the interdisciplinary and interprofessional nature of the field. It is designed to provide advance training in bioethics for those who anticipate encountering ethical issues in the course of their primary careers. 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. 51), call 216.368.6196, or e-mail bioethics@case.edu (bioethics@case.edu).

**MD/MS in Applied Anatomy**

The core curriculum of this 30-hour, non-thesis master of science master of science in applied anatomy degree program integrates aspects of modern molecular biochemistry, cell biology and physiology with the traditional aspects of anatomical structure and nomenclature of cells, tissues and organs. Electives allow students to pursue individual interests in special areas of research and health care. 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. 34) of the General Bulletin.

**MD/MS Biomedical Investigation**

The goal of the joint MD/ Masters of Science in Biomedical Investigation program at Case School of Medicine is to train medical students in basic or clinical research approaches so that the physician graduate may conduct research to advance health. Students will earn a plan B type MS from Graduate Studies, and the name of the joint degree will reflect the particular track pursued by the student (eg MD/MS Biochemistry). The tracks proposed in this joint MD/MS program are derived from existing type B MS programs at the School of Medicine into a joint program 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 601 non-graded credits) culminating in a written report and examination. Students are anticipated to complete all graduate courses before entering the research year, allowing full focus on the research experience. Thus, this program will require 5 years overall to complete the requirements for both degrees. 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 students to receive graduate credit for medical coursework, they must register for IBMS credit (see below) in advance of the preclinical medical school semester. Students are likely to complete the required two semesters of research 601 after the pre-clinical years in medical school, although the research could occur in other years. Before initiating full time research, the trainee must submit a final Program plan to the Program Oversight Committee that summarizes the courses taken, the proposed thesis topic, and the names and credentials of the MS Thesis Committee. During the research period, the student is expected to participate in track-specific graduate activities including retreats, student talks, journal clubs and other program functions. Only under unusual circumstances will the student be allowed to satisfy the research requirement in non-contiguous semesters.

Each track within the joint MD/MS Program has specific course requirements, described in each graduate department MS section. Available tracks include: Biochemistry (p. 45), Clinical Research (CRSP) (p. 82), Epidemiology (p. 62), Nutrition (p. 118), Pathology (p. 124), Pharmacology (p. 134), Physiology & Biotechnology (p. 140). As a minimum, graduation requires successful completion of 9 graded credits of graduate courses, 6 graded credits of IBIS medical curriculum, 18 non graded credits of research, and additional non graded credits for departmental seminar and the exam and zero credits for scientific integrity training (IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research or CMED 500 Scientific Integrity in Biomedical Research) in the program. Students are required to pass an examination (IBIS 600 Exam in Biomedical Investigation) established for each student, generally reflecting the preparation and oral defense of a written report on the project.

For more information please contact the College Program Advisor, Dr. Dennis Stacey (staceyd@ccf.org) or the University Program Advisor, Dr. William Merrick (william.c.merrick@case.edu).

**Typical Plan of Study**

<table>
<thead>
<tr>
<th>Year</th>
<th>Units</th>
<th>Spring</th>
<th>Summer</th>
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<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some tracks begin research - 601</td>
<td>3</td>
<td></td>
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<td></td>
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<td>3</td>
</tr>
<tr>
<td>Second Year</td>
<td>Track-specified Grad Course</td>
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<td></td>
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<tr>
<td></td>
<td>Track-specified Grad Course</td>
<td>3</td>
<td></td>
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<tr>
<td></td>
<td>Track-specified Grad Course</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exam in Biomedical Investigation (IBIS 600)</td>
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</tr>
<tr>
<td></td>
<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500) or Scientific Integrity in Biomedical Research (CMED 500)</td>
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<tr>
<td></td>
<td>Year Total:</td>
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<td>3</td>
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<tr>
<td>Third Year</td>
<td>Research - Track Specific 601</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research - Track Specific 601</td>
<td>6-9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year Total:</td>
<td>9</td>
<td>6-9</td>
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<tr>
<td>Fourth Year</td>
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</tr>
<tr>
<td></td>
<td>Medical School Curriculum - no credit</td>
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<td></td>
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<td></td>
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</table>

**Total Units in Sequence:** 37-40

Departmental Seminar is also taken for 1 credit hour - timing depends upon the track.
MD/PhD in Health Policy and Health Services Research

This program prepares students for careers in academic medicine, health policy, public health, and/or health care management. An important area of focus within this training program is methods and issues in study design that pertain to research examining the health and health care problems of urban and vulnerable populations.

Application to and acceptance in the PhD program in Health Policy/Health Services Research follows admission to the School of Medicine. Dual-degree students are fully integrated with graduate students in other tracks within the Department of Epidemiology and Biostatistics. Dual-degree students typically complete the PhD coursework and the dissertation requirement by their end of their fifth year after matriculation, with the MD awarded at the end of the seventh year. Support for tuition and a stipend is available for a limited number of students each year.

For more information, see Epidemiology and Biostatistics section (p. 64) or contact the departmental coordinator for Graduate Studies, Victor Courtney (victor.courtney@case.edu), at 216.368.5957.

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) (p. 15) page for information about the MD curriculum.

MSTP Program by Year

Year 1
- University Program MD curriculum
- Summer research rotation
- 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
- All PhD work, including dissertation defense and publications, to be completed before starting the 3rd year medical curriculum

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 summers before the first two years of medical school, students complete 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 administrative 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 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 for 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

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Biological Sciences I (IBIS 401)</td>
<td>1 - 9</td>
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<tr>
<td>Clinical Science I (IBIS 411)</td>
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<td>Research Rotation in Medical Scientist Training Program (MSTP 400)</td>
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<td></td>
</tr>
<tr>
<td>Integrated Biological Sciences II (IBIS 402)</td>
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</tr>
<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></td>
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</tr>
<tr>
<td>Year Total:</td>
<td>3-20</td>
<td>3-20</td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Biological Sciences III (IBIS 403)</td>
<td>1 - 9</td>
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<td>Clinical Science III (IBIS 413)</td>
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<td>Graduate School courses</td>
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<tr>
<td>601 Research (in specific program)</td>
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<td>Year Total:</td>
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<td>8-10</td>
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</table>

Total Units in Sequence: 17-70

- 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
are to identify objectives for the program, to allow students to initiate different student committees. The overall goals of the MSTP Council Council meets once each month to discuss activities that are run by MSTP Council coordinates many activities of the Case MSTP. The an oral or poster presentation. March. Students in their research years present their thesis work through: This is a one-day retreat on campus, usually in early Winter retreat program planning for the upcoming academic year. focusing on scientific presentations, professional development and training of physician scientists. 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.
IBIS Courses

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

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

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

IBIS 404. Integrated Biological Sciences IV. 0 - 9 Units.  
A continuation of IBIS 403.

IBIS 411. Clinical Science I. 2 Units.

IBIS 412. Clinical Science II. 2 Units.

IBIS 413. Clinical Science III. 2 Units.

IBIS 414. Clinical Science IV. 0 - 2 Units.

IBIS 424. Integrated Biological Sciences in Medicine. 6 Units.  
This course is open only to candidates enrolled in the M.D./M.S. program (University plan). Registration is for the Spring semester of the second year in medical school. The course will cover the areas of cardiology, pulmonary, hematology, renal physiology and gastroenterology. Assessment will be by examination (to include quizzes, multiple choice questions, and essays). Recommended preparation: First three semesters of medical school and currently a medical student in good standing.

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 reaching required levels of competency 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 461. Clinical Science (for M.P.H./M.D. Students). 1 - 6 Unit.

IBIS 466. Medical School Electives (for M.P.H./M.D. Students). 1 - 6 Unit.

IBIS 600. Exam in Biomedical Investigation. 0 Units.  
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.

MSTP Courses

MSTP 400. Research Rotation in Medical Scientist Training Program. 0 - 9 Units.  
All students must complete research rotations in a minimum of three different MSTP-approved laboratories and submit rotation reports and rotation evaluations for each to the MSTP office. All three of the rotations must be completed before the beginning of each student's third year of the program. The main purpose of research rotations is to aid the student in selecting a laboratory for their thesis work.

Graduate Programs in the Biomedical Sciences

Malana Bey (malana.bey@case.edu), Administrator  
216.368.5655  
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 Office of Graduate Education 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/gradstudentstudies/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

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.

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.
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 for the education and training of all Ph.D. 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).

Student Affinity Groups

Graduate students interact in vibrant groups in the School of Medicine including the Biomedical Graduate Student Organization (http://casemed.case.edu/gradprog/bgso.cfm) and the Minority Graduate Student Organization (http://casemed.case.edu/gradprog/mgso.cfm), as well as university-wide student organizations such as the Graduate Student Senate (http://case.edu/gss). In addition, doctoral students in the School of Medicine organize the annual Biomedical Graduate Student Symposium (http://filler.case.edu/org/bgss/site/Home.html).

Postdoctoral Fellows and Postdoctoral Scholars are appointed through the Office of Postdoctoral Affairs (http://postdoc.case.edu). The Office of Graduate Education provides monthly Professional Skills Programs for trainees.

Biomedical Sciences Training Program (BSTP)

Phone: 216.368.3347
http://www.case.edu/med/BSTP/
Martin Snider (mds5@case.edu), PhD, Director
Debbie Noureddine (drn2@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. Students in the BSTP have the opportunity to study within any research discipline represented in the training programs. This opportunity gives students a tremendous range of research choices. 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. 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 (p. 86) 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 stem from 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 required. Recent classes have earned an average of 70th percentile in each area. A GRE subject test is desirable, but is not required. The Test of English as a Foreign Language (TOEFL) is required for foreign 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 (CBIO 453 Cell Biology I, CBIO 455 Molecular Biology I). These two 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. A minimum of three rotations must be completed during the year.

Choosing a Thesis Advisor

During the first year, students select an advisor for their dissertation research. Each student also joins the doctoral training program with which the advisor is affiliated. Once a student has chosen a PhD program, the specific 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.

Participating Training Programs

- Biochemistry (p. 47)
- Cell Biology (p. 103)
- Genetics and Genome Sciences (p. 100)
- Molecular Biology and Microbiology (p. 103)
- Molecular Virology (p. 103)
- Neurosciences (p. 111)
• Nutrition (p. 120)
• Pathology (http://bulletin.case.edu/schoolofmedicine/pathology)
• Pharmacology (p. 136)
• Physiology and Biophysics (p. 141)
• Systems Biology and Bioinformatics (p. 86)

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 and 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 and journal clubs and other activities.

BSTP Courses

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

CBIO Courses

CBIO 453. Cell Biology I. 4 Units.
Part of the first semester curriculum for first year graduate students along with CBIO 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.

CBIO 455. Molecular Biology I. 4 Units.
Part of the first semester curriculum for first year graduate students along with CBIO 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 Courses

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

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

The goal of the Department of Anatomy is to provide individuals with the skills and experiences that will allow them to develop and maintain successful careers as researchers and teachers. The strengths of both the faculty and students of the department help to lead to the achievement of this goal. Graduate studies in the Department of Anatomy can lead to the master of science degree in applied anatomy. The master’s degree may be obtained as part of a joint degree program for qualified individuals participating in other programs at the university, such as the joint MD/MS degree. Every MS graduate student in the Department of Anatomy must successfully complete 21 credits in the core curriculum of anatomical sciences, human gross anatomy, histology, neuroanatomy and embryology. An additional two credits offered by the department in seminar and research presentations also are required. Elective course work and, for the thesis MS students, laboratory rotations and research, complete the graduate students’ program of study. Research areas of particular strength among faculty in the Department of Anatomy include biological anthropology, cell injury, control of respiration, and non-molecular developmental neurobiology. The department has existing collaborative research efforts with basic scientists in several clinical departments, including medicine, orthopedics, pediatrics, neurology and neurosurgery.

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 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 rigorous 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 Planned 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 21 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. As a type B "comprehensive" program, a research thesis is not required for the MS Applied Anatomy, although research experience may be obtained as elective coursework 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 11/2-21/2 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 (21 credits) comprising the Anatomical Sciences Core Curriculum are specifically delineated, whereas the elective courses (9 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.

**MS Applied Anatomy, Plan of Study**

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<th>First Year</th>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Histology and Ultrastructure (ANAT 412)</td>
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<tr>
<td>General Histology Laboratory (ANAT 413)</td>
<td>2</td>
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<td>Scientific Presentations (ANAT 497)</td>
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<td>Elective</td>
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<th>Units</th>
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<th>Spring</th>
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<tr>
<td>Neurological Anatomy (ANAT 414)</td>
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<tr>
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<th>Spring</th>
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<td>Histology and Ultrastructure (ANAT 412)</td>
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<td>General Histology Laboratory (ANAT 413)</td>
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<td>Apply to MS program</td>
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<td>Scientific Presentations (ANAT 497)</td>
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<th>Spring</th>
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<tr>
<td>Neurological Anatomy (ANAT 414)</td>
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<tr>
<td>Applied Anatomy Seminar (ANAT 498)</td>
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<td>MD/MS - Begin clinical/research rotations</td>
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<td>Master of Science ASCC Comprehensive Examination (January/February)</td>
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<th>Spring</th>
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<td>Surgical Anatomy II</td>
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<tr>
<td>Year Total</td>
<td>1-4</td>
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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 353. Anatomy for the Artist. 3 Units.
Reflecting the interdisciplinary nature of medical illustration, the course will have two complementary components. Morning sessions will involve instruction in human anatomy followed by direct observation and drawing of that anatomy from the cadaver. The entire body will be covered, including both the internal structures as well as those that directly impact the surface anatomy, to provide the student with a comprehensive understanding of the human form in its totality. Afternoon sessions will have students study the perceptual problems of drawing from the live model, focusing on the anatomical structure and functionality of the skeletal and muscular system. Muscle action and involvement in human movement and form will be analyzed and applied.

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 Unit.
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 410. Cadaver dissection-based human anatomy with histology, neuroanatomy, embryology, and physiology. 6 Units.
Human Anatomy 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 and clinical correlates. 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.

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 413. General Histology Laboratory. 2 Units.
Microscopic structure of tissues and organs. Laboratory course associated with ANAT 412 (see ANAT 412 description). Recommended preparation: ANAT 312 or ANAT 412 or concurrent enrollment.

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 415. Functional Neuroanatomy. 4 Units.
This course focuses on concepts underlying the structure and function of important sensory and motor systems in both the central and peripheral nervous systems. Emphasis is placed on learning how different patterns of neuronal connectivity give rise to certain perceptions and motor behaviors. Additionally, the composition and distribution of peripheral nerves -- spinal, cranial, and autonomic -- is studied. Particular attention is paid to the anatomy and function of those structures innervated by the cranial nerves. A variety of teaching-learning activities is employed - among them, lectures, small-group discussions, student presentations, and examination of preserved brains and brain sections.
ANAT 420. Forensic Pathology. 3 Units.
Forensic Pathology is that discipline where medicine and the law meet. Forensic pathologists strive to determine the cause, manner, and mechanism of death, and how to prevent unnatural death from occurring. This course reviews the field of forensic pathology, from sudden natural death, to homicide, to child abuse. Students will be exposed to an autopsy, and tour a crime laboratory. These tours are mandatory. Grading is based on performance on an examination and review and presentation of a forensic paper. Actual case material will be used. Students are therefore expected to maintain the highest professional and ethical standards.

ANAT 424. Neural Integrative and Regulatory Mechanisms. 3 Units.
This course is designed as a sequence to ANAT 414, Neurological Anatomy, or any other “introductory” course in neuroanatomy. Topics to be addressed include central regulation of pain, the regulation of somatic and visceral motor activity, neurotransmitter substances, the basal forebrain, the blood-brain barrier, levels of consciousness, sleep-wake mechanisms, cognitive behaviors and memory. Appreciation of the three-dimensional anatomy and vasculature of the spinal cord and brain will be gained through brain dissection and study of stained and unstained sections. Recommended preparation: ANAT 414 or permission.

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, EPBI 431 and MPH 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 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. Two student-led seminars and one lab each week. Most labs will take place at the Cleveland Museum of Natural History. One weekend field trip to Cleveland Metroparks Zoo. This course satisfies a laboratory requirement for the biology major. Offered as ANAT 445, BIOL 345, and BIOL 445. Prereq: BIOL 214.

ANAT 452. Writing a Scientific Paper. 2 Units.
For graduate and post-doctoral students. Participants must have experimental data (not necessarily complete) with which they will write a full scientific paper. Course is limited to two participants.

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 the required term paper. Offered as BIOL 362 and BIOL 462 and ANAT 462.

ANAT 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of 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 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 477. 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 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 497. Scientific Presentations. 1 Unit.
These courses provide a foundation and experience for making scientific presentations. Scheduled simultaneously with ANAT 498 and students from both courses are present, but the requirements for passing differ. Students in ANAT 497 prepare PowerPoint and poster presentations. Oral presentations by students taking ANAT 498 will occur during the class periods for the remainder of the semester. Students taking 497 and 498 must participate in these discussions. Students must take ANAT 497: Scientific Presentations before ANAT 498: Applied Anatomy Seminar.

ANAT 498. Applied Anatomy Seminar. 1 Unit.
These courses provide a foundation and experience for making scientific presentations. Scheduled simultaneously with ANAT 497 and students from both courses are present, but the requirements for passing differ. Students in ANAT 497 prepare PowerPoint and poster presentations. Oral presentations by students taking ANAT 498 will occur during the class periods for the remainder of the semester. Students taking 497 and 498 must participate in these discussions. Students must take ANAT 497: Scientific Presentations before ANAT 498: Applied Anatomy Seminar.

ANAT 499. Independent Study. 1 - 4 Unit.
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 Unit.
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 513. Surgical Anatomy of the Thorax and Abdomen. 4 Units.
This course is intended for graduate and fourth-year medical students interested in surgery and surgical subspecialties. This integrated course will review basic gross anatomy, provide advanced training in gross and surgical anatomy, introduce common clinical problems and their anatomical consequences, and basic surgical approaches. Recommended preparation: ANAT 411 and permission of instructor.

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.
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 by oral or written account, for example course, area of supply, relations, morphology, etc. Recommended Preparation: Comprehensive knowledge of human anatomy, such as ANAT 411.

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 530. Medical Sculpture: Basic Facial Reconstruction. 2 Units.
This introductory course takes a step-by-step approach to forensic facial reconstruction. Students will study the placement and function of head and neck muscles and learn about average tissue depths. An oil-based clay will be used to add muscles and contours to a human skull cast at the depth indicated by tissue markers to successfully recreate facial features.

ANAT 531. Medical Sculpture: Advanced Facial Reconstruction. 2 Units.
Students must be able to interpret soft tissue data with a minimal amount of help. Students will be provided a cast human skull on which to complete a facial reconstruction using an oil-based clay using tissue depth data information from that skull. Once completed, a photograph of that individual is available to compare the achieved likeness. A final exercise will have students advance the age of the individual using age rendering techniques (adaptable to work with fugitives and missing persons). Recommended preparation: ANAT 530.

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. 3 Units.
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 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 614. Practicum in Neurological Anatomy. 1 Unit.
A course of study designed especially for the preparation of teachers that involves the supervised practical application of previously studied theory. The graduate student will administer all laboratory sessions, assisting students with identification of structures and with understanding of the functional aspects of neuroanatomical pathways. The graduate student will meet with the course director once per week to discuss the student's performance and progress and to plan for upcoming class sessions. The course director will assist the student in developing the organizational skills necessary to be a course director as the student learns to anticipate questions, define problematic areas, and recognize varying learning styles. The graduate student will be evaluated by the course director with reference to the graduate student's overall progress and performance as a teacher. Recommended preparation: ANAT 414.

ANAT 651. Thesis M.S.. 1 - 9 Unit.
Master's Thesis Plan A.

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

Anesthesiology and Perioperative Medicine
Allison Morgan (allison.morgan@uhhospitals.org), MA, Education Manager

The Department of Anesthesiology and Perioperative Medicine medical division of the University Hospitals Case Medical Center includes more than fifty attending anesthesiologists on staff supervising resident anesthesiologists and anesthetists to provide the best patient care.

The Anesthesiologist Assistant Program at Case Western Reserve University began in 1969 and originally awarded a baccalaureate degree, evolving into a professional postgraduate curriculum in 1987 and granting the Master of Science degree. In general, admission to an AA program requires a bachelor's degree with prescribed prerequisites typical of premedical course work and successful completion of the MCAT. The application deadline is October 1 of each year for admission into the June class. The 24-month AA program is accredited by the Commission on Accreditation of Allied Health Education Programs (CAAHEP) and is based on the Standards for Anesthesiologist Assistant Program. Graduates must complete a curriculum that includes 66 credit hours (six semesters) of classroom and clinical instruction. The first three semesters integrate basic science and clinical instruction.

The program is led by Joseph M. Ritifici, MEd, (Joseph.Ritifici@uhhospitals.org) and Matthew Norcia, MD (Matthew.Norcia@UHhospitals.org). More information can also be obtained from Allison Morgan, Education Manager, Cleveland.

CWRU also oversees the Master of Science in Anesthesia Program's Houston, Texas Campus (http://casemed.case.edu/anesthesiaprogram/program/houston.cfm) and Washington, D.C. Campus (http://casemed.case.edu/anesthesiaprogram/program/dc.cfm).

Master of Science in Anesthesia Degree
The Master of Science in Anesthesia (MSA) Program mission 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:

A. Bachelor's degree from an accredited college or university

Documentation of each of the prerequisites listed below having been completed with a grade of B or higher within five (5) years prior to the application deadline at an accredited American or Canadian institution of higher learning. For those courses that have been repeated, the highest grade will be used in the calculation.

• 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*
• If any of the above courses marked with an asterisk were completed (with a grade of B or higher) in excess of five (5) years prior to the application deadline, they will meet the prerequisite criteria IF the composite score of the MCAT is 25 or higher.

B. Medical College Admission Test

• minimum composite score of 20
• test must have been completed within 3 years of application deadline
• when the MCAT has been taken more than once, component scores from different exams may not be combined

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

All materials must be received by the deadline, October 1st. Candidates participate in interviews with members of the Admission Committee, which is comprised of faculty and staff members of the MSA Program. All academic requirements must be completed satisfactorily before matriculation. Prospective candidates are permitted and encouraged to shadow an anesthetist in the OR. Prior approval for this visitation is required.

The 24-month program includes 66 credit hours (six semesters) of classroom and clinical instruction. The first three semesters integrate basic science and clinical instruction. During the remaining 3 semesters, students complete month-long rotations in all subspecialties of anesthesiology: ambulatory surgery, burns and trauma, cardiothoracic surgery, general surgery, neurosurgery, obstetrics, pediatric, 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 Case 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://casemed.case.edu/anesthesiaprogram).

### MS Anesthesiologist Assistant, Plan of Study

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<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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| **Total Units in Sequence:** | 66 |

| Total Clinical Hours Required (Basic Science Year) | 560 |
| Total Clinical Hours Required (Clinical Year) | 1440 |

| **Total Units** | 2000 |

### 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. 2 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. 2 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 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.
Biochemistry is the study of the molecular basis of cellular 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 bachelor of arts degree and bachelor of science degree in biochemistry and graduate programs leading to the master of science, doctor of philosophy, and dual-degree programs as follows: doctor of medicine/doctor of philosophy degree; doctor of medicine/masters of science in biomedical investigation; juris doctor/masters of science in biochemistry.

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 interests within the department include a spectrum of modern biochemical topics in six broad areas: enzymology, protein chemistry, structural biology, gene expression, cell biology, and molecular medicine/gene therapy. The department has state-of-the-art equipment and facilities for research in modern biochemistry. More complete information about the undergraduate and graduate programs may be obtained by contacting the departmental office or by using the URL above.

Research Areas
Research of Department of Biochemistry faculty members covers a broad spectrum of topics from events at the level of electron movement in biochemical reactions to the intracellular trafficking of proteins. Research in the department is broadened by collaborations with faculty in other university departments and with scientists at other Cleveland research institutions. The specific areas of active research within the department are outlined below.

Proteins and Enzymes
Proteins are components of all living tissue, and their function is critical for life processes. Understanding the chemical mechanisms of enzymatic catalysis is essential for determining the role of individual proteins in human disease. Biochemistry faculty study a variety of proteins and enzymes ranging from growth factors to oncogenes.

Structural Biology
The function of a protein is determined by its three-dimensional structure and interactions. Faculty apply many modern techniques to the determination of macromolecular structure, including X-ray crystallography, and multidimensional heteronuclear NMR, fluorescence, Raman, and circular dichroism spectroscopy. Macromolecules under investigation include, transcarboxylase, ribosomes, DNA-protein complexes, and neurochemical enzymes.

Regulation of Gene Expression
The elucidation of mechanisms regulating gene expression is a major goal of modern biology. Biochemistry faculty study the control of transcription by hormones and other regulatory molecules, the interaction between proteins and DNA, the function of oncogenes, the basal and hormone mediated transcriptional machinery, and the processing and translation of RNA.

Cell Biology
The control of the metabolism, differentiation and cell signaling within and between cells is an area of active investigation.

Metabolic Regulation
Biochemistry faculty investigate the control of metabolism in animals, such as dietary and hormonal regulation of gene expression. Transgenic murine technology allows the study of the impact of gene ablation on metabolic processes.

BA Biochemistry (p. 43) I BS Biochemistry (p. 44) I Minor (p. 45)
Undergraduate Programs

Major

The two undergraduate major programs in Biochemistry, BA and BS, are based on the Arts & 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 strongly encouraged. As many as nine hours of Research in Biochemistry (BIOC 391 Research Project) may be credited toward the requirements for graduation. 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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<td>BIOC 373</td>
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<td>BIOC 312</td>
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<td>or BIOC 334</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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BA Biochemistry, Sample Plan of Study

Freshman

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<tr>
<td>or Chemistry of Materials (ENGR 145)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principles of Chemistry Laboratory (CHEM 113)</td>
<td>2</td>
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</tr>
<tr>
<td>SAGES University Seminar I</td>
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<td></td>
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<tr>
<td>Cells and Proteins (BIOL 215) &amp; Cells and Proteins Laboratory (BIOL 215L)</td>
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<td>Independent Activity (PHED 100)</td>
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Year Total: 15-25 - 16-26

Sophomore

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Introductory Organic Chemistry I (CHEM 223)</td>
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<tr>
<td>Introductory Organic Chemistry Laboratory I (CHEM 233)</td>
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<tr>
<td>Introductory Physics I (PHYS 115)</td>
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<tr>
<td>GER Course</td>
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<td>SAGES University Seminar II</td>
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<td></td>
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</tr>
<tr>
<td>Introductory Organic Chemistry II (CHEM 224)</td>
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<tr>
<td>Introductory Organic Chemistry Laboratory II (CHEM 234)</td>
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<td>Introductory Physics II (PHYS 116)</td>
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<td>GER Course</td>
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<tr>
<td>Elective</td>
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Year Total: 15 - 15

Junior

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<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Introductory Physical Chemistry I (CHEM 301)</td>
<td>3</td>
<td></td>
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<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 307)</td>
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</table>
### Bachelor of Science in Biochemistry

**Required Courses:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Fall Units</th>
<th>Spring Units</th>
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<tr>
<td>BIOC 307</td>
<td>Introduction to Biochemistry: From Molecules To Medical Science</td>
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<tr>
<td>BIOC 308</td>
<td>Molecular Biology</td>
<td>4</td>
<td></td>
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<td>BIOC 312</td>
<td>Proteins and Enzymes</td>
<td>3</td>
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</tr>
<tr>
<td>BIOC 334</td>
<td>Structural Biology</td>
<td>3</td>
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<td>BIOC 373</td>
<td>Biochemistry SAGES Seminar</td>
<td>3</td>
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<td>BIOC 393</td>
<td>Senior Capstone Experience</td>
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</tr>
<tr>
<td>BIOL 214 &amp; 214L</td>
<td>Genes, Evolution and Ecology &amp; Genes, Evolution and Ecology Lab</td>
<td>4</td>
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<tr>
<td>BIOL 215 &amp; 215L</td>
<td>Cells and Proteins &amp; Cells and Proteins Laboratory</td>
<td>4</td>
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<td>CHEM 105</td>
<td>Principles of Chemistry I</td>
<td>3</td>
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<tr>
<td>or CHEM 111</td>
<td>Principles of Chemistry for Engineers</td>
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<tr>
<td>CHEM 106</td>
<td>Principles of Chemistry II</td>
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<tr>
<td>or ENGR 145</td>
<td>Chemistry of Materials</td>
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<td>CHEM 113</td>
<td>Principles of Chemistry Laboratory</td>
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<td>or CHEM 323</td>
<td>Organic Chemistry I</td>
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<td>CHEM 224</td>
<td>Introductory Organic Chemistry II</td>
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<tr>
<td>or CHEM 324</td>
<td>Organic Chemistry II</td>
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</table>

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, CHEM 324 Organic Chemistry II.
- **b** One of the approved electives in Biochemistry taken must be either BIOC 312 Proteins and Enzymes or BIOC 334 Structural Biology.

**Chemistry Options:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Fall Units</th>
<th>Spring Units</th>
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<tr>
<td>CHEM 301</td>
<td>Introductory Physical Chemistry I</td>
<td>3</td>
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<tr>
<td>or CHEM 335</td>
<td>Physical Chemistry I</td>
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<td></td>
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<tr>
<td>CHEM 302</td>
<td>Introductory Physical Chemistry II</td>
<td>3</td>
<td></td>
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<tr>
<td>or CHEM 336</td>
<td>Physical Chemistry II</td>
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<td></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>
<td></td>
</tr>
<tr>
<td>MATH 121</td>
<td>Calculus for Science and Engineering I</td>
<td>4</td>
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<tr>
<td>MATH 122</td>
<td>Calculus for Science and Engineering II</td>
<td>4</td>
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<tr>
<td>or MATH 124</td>
<td>Calculus II</td>
<td>3</td>
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<tr>
<td>MATH 223</td>
<td>Calculus for Science and Engineering III</td>
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<tr>
<td>or MATH 225</td>
<td>Calculus III</td>
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<tr>
<td>MATH 224</td>
<td>Elementary Differential Equations</td>
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<td>or MATH 228</td>
<td>Differential Equations</td>
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<tr>
<td>PHYS 121</td>
<td>General Physics I - Mechanics</td>
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<tr>
<td>or PHYS 123</td>
<td>Physics and Frontiers I - Mechanics</td>
<td>4</td>
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<tr>
<td>PHYS 122</td>
<td>General Physics II - Electricity and Magnetism</td>
<td>4</td>
<td></td>
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<tr>
<td>or PHYS 124</td>
<td>Physics and Frontiers II - Electricity and Magnetism</td>
<td>4</td>
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</table>

**Statistics Options:**

- Statistics/data analysis elective | 3
- PHYS 250 | Computational Methods in Physics | 3
- STAT 312 | Basic Statistics for Engineering and Science | 3
- STAT 313 | Statistics for Experimenters | 3
- or equivalent

**Total Units in Sequence:** 120-143

**BS Biochemistry, Sample Plan of Study**

### Freshman

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>15-25</td>
<td></td>
<td>16-26</td>
</tr>
</tbody>
</table>

- Calculus for Science and Engineering I (MATH 121) | 4
- Principles of Chemistry I (CHEM 105) | 3
- or Principles of Chemistry for Engineers (CHEM 111) | 3
- Independent Activity (PHED 100) | 0-10
- SAGES First Semester | 4
- Genes, Evolution and Ecology (BIOL 214) | 4
- & Genes, Evolution and Ecology Lab (BIOL 214L) | 4
- Calculus for Science and Engineering II (MATH 122) | 4
- or Principles of Chemistry II (CHEM 106) | 3
- or Chemistry of Materials (ENGR 145) | 3
- Principles of Chemistry Laboratory (CHEM 113) | 2
- SAGES University Seminar I | 3
- Cells and Proteins (BIOL 215) | 4
- & Cells and Proteins Laboratory (BIOL 215L) | 4
- Independent Activity (PHED 100) | 0-10

**Year Total:** 15-25 16-26

### Sophomore

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>3</td>
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</table>

- Introductory Organic Chemistry I (CHEM 223) | 3
- Introductory Organic Chemistry Laboratory I (CHEM 233) | 2
- Calculus for Science and Engineering III (MATH 223) | 3
- General Physics I - Mechanics (PHYS 121) | 3
- GER Course | 3
- or Introductory Organic Chemistry II (CHEM 224) | 3

**Total Units:** 83-85
Introductory Organic Chemistry Laboratory II (CHEM 234)  2
Elementary Differential Equations (MATH 224)  3
General Physics II - Electricity and Magnetism (PHYS 122)b  4
GER Course  3
Year Total:  15  15

Junior

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Fall</th>
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<tbody>
<tr>
<td>Introductory Physical Chemistry I (CHEM 301)</td>
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<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 307)</td>
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<tr>
<td>SAGES University Seminar II</td>
<td>3</td>
<td></td>
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<tr>
<td>GER Course</td>
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<td></td>
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<td>GER Course or elective</td>
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<tr>
<td>Introductory Physical Chemistry II (CHEM 302)</td>
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<td>Molecular Biology (BIOC 308)</td>
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<td>Introduction to Modern Physics (PHYS 221)</td>
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<tr>
<td>Research Project (BIOC 391)</td>
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<td>Year Total:</td>
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Senior

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Proteins and Enzymes (BIOC 312)</td>
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<tr>
<td>Biochemistry SAGES Seminar (BIOC 373)</td>
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<tr>
<td>Research Project (BIOC 391)</td>
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<tr>
<td>Electives</td>
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<td></td>
</tr>
<tr>
<td>Structural Biology (BIOC 334)</td>
<td>3</td>
<td></td>
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<tr>
<td>Senior Capstone Experience (BIOC 393)</td>
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</tr>
<tr>
<td>Statistics/Data Analysis Elective</td>
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<td></td>
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<tr>
<td>Computational Methods in Physics (PHYS 250)</td>
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<td></td>
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<tr>
<td>Basic Statistics for Engineering and Science Using R Programming (STAT 312R)</td>
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<td>Statistics for Experimenters (STAT 313) (or equiv)</td>
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<td>Year Total:</td>
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Total Units in Sequence: 126-146

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

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.

Minors

Required Courses:
- BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science  4
- BIOC 308 Molecular Biology  4
- One of the following:  3
  - BIOC 312 Proteins and Enzymes
  - BIOC 334 Structural Biology
- Approved technical elective in biochemistry  3

Total Units 14

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 four Masters degrees. The three-year Masters of Science in Biochemical Research provides training in laboratory research. The two-year Masters of Science in Biochemistry provides students with advanced study in biochemistry and related fields. Two other programs provide advanced study in biochemistry in conjunction with degrees in medicine (MD/MS) and law (JD/MS).

Prerequisites for admission into any of the Biochemistry Graduate 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 (verbal, quantitative and an advanced area test, usually biology, biochemistry or chemistry). Some students with otherwise excellent qualifications, but lacking some of the prerequisites may be conditionally admitted with the understanding that specified deficiencies will be made up within a stipulated time span. 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 Biochemical Research**

The program leading to the MS degree in biochemical research is uniquely designed to provide interested students with sufficient background and laboratory experience to enable them to function as senior research assistants and eventually as laboratory supervisors in university departments, research institutes, or industrial laboratories. Students in this three-year program receive a stipend, and tuition costs are covered by the department. The students pursue flexible and individually designed schedules, which prepare them for independent research projects in the second and third years of the program. The program simultaneously develops background knowledge and technical skills in modern biochemistry, which can be applied to several career paths. A more complete description of the program, admission policies, and financial aid is available from the departmental office.

The duration of the MSBR program is 33 months. Applicants who have been working as full-time laboratory technicians may be granted 1 semester credit for one full year of work, and up to 2 semesters credit for two or more years of work. Credit for acceptable didactic coursework may be awarded upon a total of 14 hours. All decisions concerning advanced standing or transfer of credit will be made by the Graduate Education Committee following acceptance into the program and in consultation with the advisor. Courses taken to satisfy other degree requirements (i.e. BA or BS) may not be transferred for credit. A maximum of 6 hours can be transferred toward the course requirements, as set by the Graduate School. The program shall not be extended on the basis of work that needs to be completed in order to achieve a publishable result.

The degree follows Plan A for the Master’s degree. The program requires 36 hours of academic credit (including both research and didactic courses) as well as the writing and defense of a thesis. All courses must be at the 400 level or higher. The course credits include didactic courses (minimum of 12 hours of graded coursework), research (BIOC 601 Biochemical Research) and (BIOC 651 Thesis M.S.). BIOC 651 Thesis M.S. is taken only in the second and third years and requires an examination by the student’s pre-thesis committee and a written thesis. The student’s transcript will be annotated M.S. in Biochemical Research, including the title of the student’s independent project.

Prior to the student’s matriculation, she/he chooses an academic advisor. In general the selection process involves communication with those faculty members who have announced their interest in taking a Master’s student. In some cases the student may be invited to spend up to a week in the prospective advisor’s laboratory to facilitate the decision making process. In the early spring of the first year, pre-thesis committee of three faculty members (at least two of whom must be members of the Biochemistry faculty) is chosen by the student, in consultation with the advisor. In yearly meetings, this committee provides additional scientific expertise, offers support in overcoming research difficulties and evaluates the student’s progress in research coursework.

**MS Biochemical Research Plan of Study**

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<th>First Year</th>
<th>Units</th>
</tr>
</thead>
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<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)</td>
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<table>
<thead>
<tr>
<th>Second 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>Proteins and Enzymes (BIOC 412)</td>
<td>3</td>
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<td>Biochemical Research (BIOC 601)</td>
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<td>Structural Biology (BIOC 434)</td>
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<tr>
<td>Biochemical Research (BIOC 601)</td>
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<tr>
<td>Master’s Comprehensive Exam (EXAM 600)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Year Total:** 7 7

**Total Units in Sequence:** 28

**MS Biochemistry**

The program leading to the MS degree in biochemistry is designed to provide students with knowledge of the latest advancements in biochemistry and related fields. It is intended for students who desire to pursue a career not directly involved with research, such as teaching, or various administrative positions in the pharmaceutical industry. Students typically enroll in three courses for each of four semesters.

The duration of the MSB program is 21 months; it follows the Plan B for the Master’s degree (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements). The default advisor for this program is the Graduate Advisor, but another advisor may be selected. The student’s progress is monitored by the Biochemistry Graduate Advisor and by the Graduate Education Committee. The program requires 36 hours of academic credit of which 18 hours must be graded coursework. Although a “coursework Masters degree,” students in the program often take 6 to 12 hours of BIOC 601 (Biochemical Research) as part of their requirements. All courses must be at the 400 level; they must be on the list of approved electives, or be approved by the advisor.

**MS Biochemistry Plan of Study**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
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<td><strong>Spring</strong></td>
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<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 407)</td>
<td>4</td>
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<tr>
<td>BIOC elective</td>
<td>3</td>
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<td>Molecular Biology (BIOC 408)</td>
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<td>BIOC elective</td>
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**Year Total:** 7 7

<table>
<thead>
<tr>
<th>Second Year</th>
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<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Spring</strong></td>
</tr>
<tr>
<td>Proteins and Enzymes (BIOC 412)</td>
<td>3</td>
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<td>Structural Biology (BIOC 434)</td>
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<tr>
<td>BIOC elective</td>
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</tr>
<tr>
<td>Master’s Comprehensive Exam (EXAM 600)</td>
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</tbody>
</table>

**Year Total:** 6 8

**Total Units in Sequence:** 28
MD/MS Biomedical Investigation-Biochemistry Track

The tracks proposed in the joint MD/MS program are derived from existing type B MS programs (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements) at the School of Medicine into a joint program 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 601 non-graded credits) culminating in a written report and examination. This program will require 5 years overall to complete the requirements for both degrees. 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 (p. 27).

The Biochemistry track is designed to provide students with knowledge of the latest advances in biochemistry and related fields. It is also appreciated that a number of courses offered by other departments may be considered “biochemistry” in the broader sense. Depending on the research project, it may be appropriate for the student to substitute some of the courses below in lieu of one of the biochemistry electives. Should this be the case, the student must receive permission from the Graduate Program Advisor for this substitution prior to registering for the course.

Students in the Biochemistry track must complete:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>IBIS 401 Integrated Biological Sciences I</td>
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</tr>
<tr>
<td>IBIS 402 Integrated Biological Sciences II</td>
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</tr>
<tr>
<td>BIOC 412 Proteins and Enzymes</td>
<td>3</td>
</tr>
<tr>
<td>or BIOC 434 Structural Biology</td>
<td>3</td>
</tr>
<tr>
<td>Electives in Biochemistry (graded)</td>
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<tr>
<td>BIOC 601 Biochemical Research</td>
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<tr>
<td>IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research</td>
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<tr>
<td>IBIS 600 Exam in Biomedical Investigation</td>
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</tbody>
</table>

JD/MS in Biochemistry

This program allows students admitted to the School of Law an opportunity to pursue a master of science degree in Biochemistry as part of an additional year of study. Such training adds expertise to students who anticipate careers in patent law or in areas related to biotechnology or pharmaceutical research. Please see the separate listing in the publication materials provided by the School of Law on this program.

Entrance into this program is achieved first by acceptance into the CWRU School of Law. Upon acceptance, students can then apply to the Biochemistry program for admission into the JD/MS program. As a result of participating 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 concerning 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 accommodate their scheduling needs in obtaining required courses. Dual degree students are advised concerning matters related to the MS in Biochemistry by a JD/MS Advisor as designated by the Graduate Education Committee of the Department of Biochemistry.

PhD Biochemistry

The aim of the PhD in biochemistry program is to prepare students for careers in teaching and research 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. The research areas in the department are described later in this section. In addition to the research activities, graduate students participate in formal courses both within and outside the department, formal and informal seminars, and discussions of current literature. 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. Admissions to the Biochemistry program may be obtained through the Biomedical Sciences Training Program, by direct admission to the department or via the MSTP program.

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 with the understanding that specified deficiencies will be made up within a stipulated time span. Please visit the Department’s web page (http://www.cwru.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 previously completed relevant coursework, (for example, with a MS) may petition to complete alternative courses.

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. Completion of the PhD degree will require 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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Biochemical Research (BIOC 601) 1
or Research Rotation in Biomedical Sciences Training Program (BSTP 400)
or Research Rotation in Medical Scientist Training Program (MSTP 400)

Structural Biology (BIOC 434) 3
BIOC Elective 3
Biochemical Research (BIOC 601) 3
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500) 1
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Total Units in Sequence: 59-91

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, BIOC 407, and BIOL 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, BIOL 308, BIOC 408, and BIOL 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, BIOL 334, BIOC 434, and BIOL 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 308, CHEM 223, CHEM 224. Offered as BIOC 354 and CHEM 454. Prereq: CHEM 223, 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 Unit.
(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 adviser, 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 reports 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 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, BIOC 407, and BIOL 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, BIOL 308, BIOC 408, and BIOL 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 413. Advanced Topics in Molecular and Biochemical Research Ethics. 0 Units.
This course offers continuing education in responsible conduct of research for advanced graduate students. The course will cover the nine federally defined responsible conduct of research (RCR) areas through a combination of lectures, on-line course material and small group discussions. Six 2-hour meetings per semester are planned. Maximum enrollment of 15 students with preference to graduate students in the Department of Molecular Biology and Microbiology, the Department of Biochemistry, and trainees of the Cell and Molecular Biology Training Grant. Offered as: BIOC 413, MBIOS 413.

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 315, PHRM 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, MBIOS 420, MVIR 420, PATH 422, and PHRM 420. Prereq: CBIO 453 and CBIO 455.

BIOC 430. Advanced Methods in Structural Biology. 1 - 6 Unit.
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. Offered as BIOC 430, CHEM 430, PHOL 430, and PHRM 430.
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, BIOL 334, BIOC 434, and BIOL 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 308, CHEM 223, CHEM 224. Offered as BIOC 354 and BIOC 454.

BIOC 460. Introduction to Microarrays. 3 Units.
Microarray technology is an exciting new technique that is used to analyze gene expression in a wide variety of organisms. The goal of this course is to give participants a hands-on introduction to this technology. The course is intended for individuals who are preparing to use this technique, including students, fellows, and other investigators. This is a hands-on computer-based course, which will enable participants to conduct meaningful analyses of microarray data. Participants will gain an understanding of the principles underlying microarray technologies, including: theory of sample preparation, sample processing on microarrays, familiarity with the use of Affymetrix Microarray Suite software and generation of data sets. Transferring data among software packages to manipulate data will also be discussed. Importation of data into other software (GeneSpring and DecisionSite) will enable participants to mine the data for higher-order patterns. Participants will learn about the rationale behind the choice of normalization and data filtering strategies, distance metrics, use of appropriate clustering choices such as K-means, Hierarchical, and Self Organizing Maps. Course Offered as BIOC 460, PATH 460, CNCR 460. Prereq: CBIO 455.

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 476. Cellular Biophysics. 4 Units.
This course focuses on a quantitative understanding of cellular processes. It is designed for students who feel comfortable with and are interested in analytical and quantitative approaches to cell biology and cell physiology. Selected topics in cellular biophysics will be covered in depth. Topics include theory of electrical and optical signal processing used in cell physiology, thermodynamics and kinetics of enzyme and transport reactions, single ion channel kinetics and excitability, mechanotransduction, and transport across polarized cell layers. The format consists of lectures, problem sets, computer simulations, and discussion of original publications. The relevant biological background of topics will be provided appropriate for non-biology science majors. Offered as BIOC 476, NEUR 477, PHOL 476, PHRM 476.

BIOC 519. Molecular Biology of RNA. 3 Units.
Selected topics regarding editing, enzymatic function, splicing, and structure of RNA. Offered as BIOC 519, CLBY 519, and MBIO 519.
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, and PHRM 528.

BIOC 599. RNA Structure and Function. 3 Units. 
This course will cover fundamental aspects of modern RNA biology 
with emphasis on the interplay of three dimensional structure of nucleic 
acids and their function. The main focus of the course is on the recent 
discoveries that indicate a prominent role of RNA as a major regulator 
of cellular function. Topics discussed will include an introduction to RNA 
structure, folding and dynamics, RNA/RNA and RNA-protein interactions, 
and role of RNA in catalysis of biological reactions in ribosome and the 
role of other catalytic RNAs in tRNA biogenesis, pre-mRNA splicing, and 
viral replication. The course also covers the recently discovered RNA 
regulatory switches, large noncoding regulatory RNAs, and the role of 
RNA in human diseases and novel, RNA-based therapeutics. Offered as 
BIOC 599, CLBY 599, and MBIO 599.

BIOC 601. Biochemical Research. 1 - 18 Unit. 
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 617. Special Topics in Biochemistry. 3 Units. 
Special topics courses on areas of current interest in biochemistry.

BIOC 618. Special Topics in Biochemistry. 3 Units. 
Special topics courses on areas of current interest in biochemistry.

BIOC 641. Proposition I. 2 Units. 
Design of research proposal.

BIOC 651. Thesis M.S., 1 - 6 Unit. 
(Credit as arranged.)

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

Department of Bioethics

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 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 at 
MetroHealth Medical Center and has faculty from multiple disciplines, 
including philosophy, religion, law, political science, anthropology, history, 
sociology, nursing and medicine.

Department faculty teach in both core and elective components of the 
medical school curriculum, undergraduate courses in ethics, 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.

Department faculty have gained international prominence for research in 
many areas of biomedical ethics that collectively address the concerns of 
the School of Medicine’s spectrum of biomedical disciplines.

The Department of Bioethics publishes a newsletter, Bioethics Update. 
Bioethics Update contains information and articles on a variety of 
ethical issues of interest to both professional and lay communities. It is 
published three times a year and features faculty research and activities, 
department events, and master's degree alumni information.

Please visit the department website (http://www.case.edu/med/bioethics), 
where visitors can read Bioethics Update online, obtain information about 
the master's degree and PhD programs, and learn about department and 
faculty activities.

Master of Arts in Bioethics Degree

The Department of Bioethics offers a program leading to the Master of 
Arts degree in bioethics, emphasizing the interdisciplinary and inter-
professional nature of the field. This graduate program is designed to 
provide advance training in bioethics for students and professionals 
who anticipate encountering ethical issues in the course of their primary 
careers.

The 27 credit-hour degree can be earned full-time in one year or part-time 
in up to three years. Core courses are taught by department faculty and 
are scheduled so that part-time students can continue their professional 
responsibilities while completing the degree.

The Master of Arts program provides students with a firm understanding of 
the intellectual content of the study of bioethics, of bioethical literature, 
and of the underlying philosophical arguments and empirical assumptions 
that inform it. Students are taught to understand the institutions and 
structures of health care and the ethical issues that arise in medical 
practice. They are trained to identify and analyze a range of clinical ethics 
issues.

All students pursuing a Master of Arts degree in bioethics are required to 
complete the interdisciplinary core of 12 credit hours (the equivalent of 
four courses) in the first two semesters of their first year of study.

The courses, BETH 401 Foundations in Bioethics I, and BETH 402 
Foundations in Bioethics II, each six credits, examine 10 basic topic 
areas in bioethics: death and dying, the therapeutic relationship, method 
and theory in bioethics, organ transplantation, health care justice, 
defining health care needs, reproduction and fertility, families, babies and 
children, research ethics and genetics. Classes meet two evenings per 
week for seminar sessions (two hours per session).

Another required course is BETH 405 Clinical Ethics Rotation. This 
course requires a minimum of 8 hours of clinical experience per week 
during two 10-week rotations. Students spend most of their time 
observing rounds in relevant services (intensive care units, pediatrics, 
geriatrics, etc.) with leading clinicians at several area hospital sites.

Students must complete rotations at two sites. At the conclusion of each 
rotation, students are familiar with the clinical, psychological, social,
professional, and institutional contexts in which ethical problems arise. Also, they are able to identify, analyze and understand ethical issues as they develop.

In addition, all students must complete 12 credit hours of electives. Electives are selected in consultation with a faculty advisor. Electives must enhance the student’s understanding of bioethical issues and must be relevant to the student’s academic goals.

The department currently offers dual-degree programs with the School of Medicine (MD/MA), the School of Medicine’s Department of Genetics (PhD/MA), the School of Law (JD/MA), the Frances Payne Bolton School of Nursing (MSN/MA) the School of Medicine’s Public Health program (MPH/MA) and Mandel School of Applied Social Sciences (MSSA/MA) at CWRU. Students must apply and be accepted to each program to qualify.

Commencing in the fall semester of 2007, the department will offer a new research ethics track within the MA program, designed to prepare specialists who will pursue research ethics-related work as a primary career (IRB coordinators, research administration, etc.) or who will use this specialized training to enhance their primary careers (investigators, regulators, etc.). In addition to the core seminars BETH 401 Foundations in Bioethics I and BETH 402 Foundations in Bioethics II, discussed above, the research ethics track will feature a modified clinical ethics rotation, focused on IRB work and research ethics activities, and four research ethics electives.

Admission policies conform to those of Case Western Reserve University School of Graduate Studies. In general, an applicant for admission and concurrent financial consideration must have completed application forms on file by March 1 for the fall semester.

**MA Bioethics Plan of Study**

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**PhD in Bioethics**

The increasing complexity of the health care system has resulted in a growing need for investigators who can conduct research to address pressing social problems in bioethics. The objective of the bioethics doctoral program is to train scholars who will have specific expertise in the conceptualization, design and conduct of empirical research concerning bioethics questions. Graduates will:

- obtain grounding in the philosophical basis of bioethics to conceptualize and analyze moral problems
- develop a theoretical perspective to guide their research
- be proficient in empirical methodologies (both qualitative and quantitative) so that they can conduct research in bioethics problems
- become researchers who can develop and conceptualize timely and meaningful research questions in bioethics

Graduates of the program have a wide range of opportunities, including careers as independent investigators, serving as a bridge between colleagues in the traditional medical humanities and those in clinical and basic-science departments, and employment in academic bioethics centers, clinical and basic science departments in medical schools and schools of public health, government agencies, and public policy institutes.

PhD students receive a full tuition scholarship, health insurance support and a $20,000-per-year graduate assistantship.

**Course of Study**

Completion of the PhD requires:

- Minimum of 51 credit hours of course work for candidates with bachelor’s degrees; minimum of 42 credit hours for candidates with master’s degrees
- 18 credit hours of dissertation course work
- 125 research hours (supervised research experiences with Department faculty)
- Training in research ethics
- Comprehensive examination preceding advancement to candidacy
- Defense of dissertation proposal
- Completion of dissertation
- Defense of dissertation

**Core Coursework**

- Foundations in Bioethics I & II
- Clinical Ethics Rotation
- Advanced Seminar on Methods in Normative Bioethics I & II
- Empirical Research Methods and Design in Bioethics I & II
- Statistical Methods and Data Management in Bioethics I & II
- Grant Writing
- Critical Readings in Bioethics
- Research hours

Additional course work: three credit hours each in advanced statistics, methods and study design, and theory from the social sciences, and six credit hours of elective courses

**Enrollment in the Doctoral Program**

The doctoral program is highly selective. Candidates should have a strong theoretical background in the social sciences or philosophy, preferably in the form of a master’s degree in a relevant discipline or a clinical degree. Candidates also must demonstrate an ability to work with quantitative data and demonstrate promise of integrating theory and empirical application.

**Applicants must complete an interview and submit:**

- CWRU Graduate School Application
- Transcripts (undergraduate and graduate if applicable)
- GRE scores — verbal, analytic and quantitative sections. Scores will be considered in relation to the applicant’s other credentials.

Applicants may submit scores of other standardized tests in addition to the GRE.
• Three letters of recommendation
• A letter to the admission committee detailing the applicant’s general interests in bioethics and the candidate’s past training and current research interests

PhD Bioethics, Plan of Study

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Total Units in Sequence: 85.5

Courses

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, PHIL 271.

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.
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 and BETH 415A.

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.

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.

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.

This 3-credit hour course will introduce advanced undergraduate and graduate students to theoretical and practical aspects of bioethics in a European context. Continental health professionals and bioethicists work in an environment that differs from the American context in at least three important dimensions: the political structure of their health care systems, the cultural influence of their religious histories, and the theoretical perspective of continental moral philosophy. The University of Salamanca in Spain, one of the oldest universities in Europe (known as the “Oxford of Spain”), will be used in this course as a focal point for examining the interplay of these three dimensions in shaping institutional and professional approaches to specific problems in bioethics, including end of life decisions, organ procurement and allocation, reproductive ethics, health care justice, and environmental bioethics (“eco-ethics”). This course will help advanced students who are already grounded in American bioethics develop the analytical skills necessary for evaluating European bioethical scholarship and policy-making, while helping less advanced students develop a familiarity with fundamental similarities and differences between bioethics in Spain and the U.S. The course will include a one week trip to Salamanca, Spain where students will be taught by instructors and faculty from the University of Salamanca. Teaching will include some guided field experiences and regular discussion sessions with the course faculty. Prior to the trip, students will attend 4 hours of class at Case to become familiar with elements of political theory and moral philosophy relevant to the in-country discussions. Following the trip, students will meet with instructors for an additional 2 hours. Offered as BETH 315E and BETH 415E.
BETH 315F. Bioethics Themes as Expressed in Spanish and American Culture: Film, Television, and Literature. 3 Units.
This 3-credit course will be held in San Sebastian, Spain. Taught by faculty from CWRU and the University of the Basque Country, this course offers students a cross-cultural perspective on bioethics in the United States and Spain. The 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.

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. The 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.

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.

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. Preentry.

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 409. Global Justice and Bioethics. 3 Units.
This course aims to introduce students to the problem of global distributive justice, with an emphasis on both theoretical accounts of justice, and the practical implications of those accounts for important topics in global bioethics. The first half of this course will be devoted to important contemporary works which bring out core philosophical ideas about justice and how we address concerns of justice globally. The second half of this course will focus on current global bioethics topics, such as inequality and poverty, global intellectual property rights, the allocation of healthcare resources, the setting of research priorities, exploitation & the distribution of the benefits of research, and medical tourism. In addition to familiarizing students with the contemporary literature regarding global justice and related topics in bioethics, this course also seeks to help students strengthen their skills in reading, analyzing, interpreting, and engaging with philosophy and bioethics texts. This course is a seminar and will therefore emphasize in-class discussion rather than lecture. Students are expected to prepare by reading all assigned readings before class.
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 405. Clinical Ethics Rotation. 1.5 - 3 Unit.
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 407. Interprofessional Integrative Seminar. 0 Units.
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 404. Clinical Ethics Rotation. 1.5 - 3 Unit.
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 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 414A. 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 and BETH 415A.
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.

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.

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 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.

BETH 415E. International Bioethics: Policy and Practice--US and Spanish Perspectives, Salamanca Spain. 3 Units.
This 3-credit hour course will introduce advanced undergraduate and graduate students to theoretical and practical aspects of bioethics in a European context. Contractual health professionals and bioethicists work in an environment that differs from the American context in at least three important dimensions: the political structure of their health care systems, the cultural influence of their religious histories, and the theoretical perspective of continental moral philosophy. The University of Salamanca in Spain, one of the oldest universities in Europe (known as the "Oxford of Spain"), will be used in this course as a focal point for examining the interplay of these three dimensions in shaping institutional and professional approaches to specific problems in bioethics, including end of life decisions, organ procurement and allocation, reproductive ethics, health care justice, and environmental bioethics ("eco-ethics"). This course will help advanced students who are already grounded in American bioethics develop the analytical skills necessary for evaluating European bioethical scholarship and policy-making, while helping less advanced students develop a familiarity with fundamental similarities and differences between bioethics in Spain and the U.S. The course will include a one week trip to Salamanca, Spain where students will be taught by instructors and faculty from the University of Salamanca. Teaching will include some guided field experiences and regular discussion sessions with the course faculty. Prior to the trip, students will attend 4 hours of class at Case to become familiar with elements of political theory and moral philosophy relevant to the in-country discussions. Following the trip, students will meet with instructors for an additional 2 hours. Offered as BETH 315E and BETH 415E.
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 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. Ethics and the Business of Biomedicine. 3 Units.
Central to current national discourse are concerns about business ethics, costs, and profits in relation to health care. These concerns are primarily driven by major shifts in health care during the 20th century. These shifts include: the transformation of professional medical practice from a service orientation to a market orientation; the emergence of powerful pharmaceutical and health care corporations; the development of new, innovative, and expensive biomedical technologies by for-profit enterprises. This course will focus on questions about values (e.g., distributive justice, rights, human dignity, community welfare in relation to the business of medicine. Topics covered include: 1) commodification in relation to health care; 2) the just distribution of health care goods and services in market economies; 3) pharmaceutical research, development, and marketing; and 4) ethical issues in the sale of human body parts and ethically contentious services (like contract surrogacy). While course topics will be addressed primarily in reference to the United States, students will have some opportunity to analyze specific issues regarding these topics from an international perspective.

BETH 420. Critical Issues in Research Ethics. 3 Units.
This course is open to graduate students with an interest in health-related research ethics. Enrollment preference will be given to Masters-level bioethics students in the Research Ethics Track (RET). The course provides students with a comprehensive study of critical issues in research ethics, including the modern history of research ethics in science and medicine, the ethics of clinical trial design and conduct, advanced issues in informed consent, the ethics of animal experimentation, and key issues in genetics research. Coursework will include case studies and in-depth readings to highlight topic areas. Discussions of ethical and regulatory frameworks that influence decision-making, policy development, and the conduct of biomedical and social-behavioral science research will allow students to explore the nuances, gaps, challenges, and concerns present in research, particularly research involving human subjects. Topics will be addressed within the framework of integrating research ethics into the scientific process. Students are expected to lead class discussions and write a course-relevant paper. Enrollment will be limited to 15 students. Class will meet weekly for 3 hours.

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 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.

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, EPBI 466, SOCI 466, NURS 466 and BETH 466. Prereq: Graduate student status or instructor consent.

BETH 503. Research Ethics and Regulation. 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 603.

BETH 504. Critical Readings in Bioethics. 3 Units.
This course will focus on both normative (traditional) and descriptive (empirical) approaches to bioethics. It will be co-directed by two faculty members, one with a specialization in normative bioethics and one with a specialization in descriptive bioethics.

BETH 505. Methods in Normative Bioethics I. 3 Units.
The first of the two required Methods seminars is designed to give graduate students an intensive introduction to the modes of moral reasoning that have been adopted and adapted by contemporary Bioethics, and the major critical perspectives that have been brought to bear upon them.

BETH 506. Methods in Normative Bioethics II. 3 Units.
The second of the two required Methods seminars is designed to give graduate students an intensive introduction to the modes of moral reasoning that have been adopted and adapted by contemporary Bioethics, and the major critical perspectives that have been brought to bear upon them.
BETH 507. Research Design in Bioethics I. 3 Units.
The first of two empirical research courses will introduce students to theoretical and methodological approaches in the design and implementation of empirical research on topics in biomedical ethics. Students will be provided with a comprehensive and robust exploration of empirical models for the development of bioethics research and the skills for critically assessing the optimal methods for designing studies relevant to ethical issues in biomedicine.

BETH 508. Research Design in Bioethics II. 3 Units.
The second of two empirical research courses will introduce students to theoretical and methodological approaches in the design and implementation of empirical research on topics in biomedical ethics. Students will be provided with a comprehensive and robust exploration of empirical models for the development of bioethics research and the skills for critically assessing the optimal methods for designing studies relevant to ethical issues in biomedicine.

BETH 511. Grant Writing. 3 Units.
This course will teach students the fundamentals of writing a grant proposal. We will concentrate on NIH-style applications, although the principals of grant writing can be applied to any venue. In the process of working through devising a research question and study design, students will be encouraged to use this as an opportunity to think about their dissertation topic. In addition to applying theoretical and research design knowledge gained through their other core course work, the course will also teach students about how to complete application forms and to create a budget. We will also familiarize students with the peer review process. Each student will produce a draft grant application. The students will form a mock peer review section and will critique the grants.

BETH 512. Clinical Ethics Rotation - Ph.D. 1.5 Unit.
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 10 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 520/521 or concurrent enrollment.

BETH 520. Foundations in Bioethics I - Ph.D. 3 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.

BETH 521. Foundations in Bioethics II - Ph.D. 3 Units.
The second 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.

BETH 602. Special Topics in Bioethics. 1 - 3 Unit.
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 Units.
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 Unit.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Environmental Health Sciences

The Department of Environmental Health Sciences is devoted to the study of the fundamental mechanisms responsible for disease processes initiated or aggravated by environmental agents. Indoor and outdoor environments consist of complex interacting systems. These systems require the development of new approaches to understanding the basis of their action. Current research interests of the faculty include chemical and environmental carcinogenesis, genetic and reproductive toxicology, cytogenetics, radiation biology, and clinical and forensic toxicology.

The Department of Environmental Health Sciences offers the MS degree and an MD/MS program for students who have received formal acceptance to the School of Medicine and are interested in expanding their training in the area of environmental health sciences. This program
allows students to complete the requirements for both degrees within a four-year period.

**MS Environmental Health Science**

The Master of Science degree program is designed to increase the student's knowledge of environmental health science as well as to provide a firm foundation in the life sciences. The program is multidisciplinary and emphasizes cancer biology, environmental toxicology, and nutrition and toxicology. It is based on a core classroom curriculum in the biological sciences, including biochemistry, biostatistics, microbiology, genetics, molecular biology, pharmacology, epidemiology, and toxicology.

**Admissions**

Applicants must complete a CWRU Graduate Application. Tuition or stipends will not be provided for the master of science program (no additional tuition is required for enrolled medical students).

**Degree Requirements**

Currently, a student can obtain a MS with a thesis based on an individual research project [Plan A] or may obtain a MS based solely on course work and a comprehensive exam [Plan B]. Both degrees require completion of 27 semester hours of credit. Under Plan A, up to 9 of the 27 semester hours can be obtained through research. Students also prepare a written thesis and complete an oral defense for a Plan A Degree. Completion of a Plan B, MS Degree, requires satisfactory performance on a written comprehensive exam taken after the student has finished their 27 hours of coursework. Also, for Plan B, it's recommended that the student take CBIO 453 Cell Biology I & CBIO 455 Molecular Biology I [8 Credits] or BIOC 407 Introduction to Biochemistry: From Molecules To Medical Science [4 Credits] & BIOC 408 Molecular Biology [4 Credits].

Of the 27 semester hours of coursework required for the MS degree, 9 hours of credit are fulfilled by the EVHS Core Curriculum. This Core Curriculum is comprised of three 3 credit courses: EVHS 401 Fundamentals of Environmental Health Sciences: Biochemical Toxicology and EVHS 402 Fundamentals of Environmental Health Sciences: Risk Assessment. Finally, as part of the 12 credits of Core Courses, a student must take a Statistics course of their choosing (must be approved by the Department).

The required course list is as follows:

**Course List**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>EVHS 401</td>
<td>Fundamentals of Environmental Health Sciences: Biochemical Toxicology</td>
<td>3</td>
</tr>
<tr>
<td>EVHS 402</td>
<td>Fundamentals of Environmental Health Sciences: Risk Assessment</td>
<td>3</td>
</tr>
<tr>
<td>EVHS 435</td>
<td>Environmental Health Law and Policy</td>
<td>3</td>
</tr>
<tr>
<td>EVHS 506</td>
<td>Independent Study in Environmental Health Sciences</td>
<td>1 - 6</td>
</tr>
<tr>
<td>EVHS 651</td>
<td>Master's Thesis Research</td>
<td>1 - 9</td>
</tr>
</tbody>
</table>

**Courses**

**EVHS 401. Fundamentals of Environmental Health Sciences: Biochemical Toxicology. 3 Units.**

This course details the fundamentals of biochemical toxicology. Specific topics include oxidation-reduction reactions, Phase I and II xenobiotic metabolism and mechanisms of cellular toxicity. Also, this course focuses on pharmacology. General principles of pharmacology, drug transport and absorption, drug metabolism, neuropharmacology, immunopharmacology and pharmacokinetics are discussed.

**EVHS 402. Fundamentals of Environmental Health Sciences: Risk Assessment. 3 Units.**

This course presents an overview of the scientific approaches used to determine whether environmental agents are potentially dangerous to people. In this course, criteria utilized for establishing exposure limits is presented. A variety of assays which can be employed to assess the impact of environmental exposure on normal and genetically susceptible individuals are studied. These include: numerous animal tests, short term toxicity and mutagenicity tests, functional assays, molecular techniques to delineate mechanisms of action, epidemiology studies and controlled clinical trials. Recommended preparation: EVHS 429.

**EVHS 435. Environmental Health Law and Policy. 3 Units.**

This course will introduce students to environmental law and policy, with a focus on federal environmental law. The goal of the course is to enable students to understand the distinctive characteristics of a regulatory agency, where scientific insights must be channeled through the paths set out by law. Students will consider how federal statutes are implemented through agency regulations, and the role of courts in overseeing the regulatory process. Substantive statutes we will consider include the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, the regulation of hazardous wastes and the cleanup of contaminated sites, and a range of federal statutes regulating chemical manufacturing/ use and the workplace. The course includes an overview of the common law concepts of torts and nuisance. Prereq: EVHS 429 or permission of instructor.

**EVHS 506. Independent Study in Environmental Health Sciences. 1 - 6 Unit.**

**EVHS 651. Master's Thesis Research. 1 - 9 Unit.**

**EVHS 701. Dissertation Ph.D.. 1 - 9 Unit.**

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

**Epidemiology and Biostatistics**

The Department of Epidemiology and Biostatistics (http://epbiwww.case.edu) draws on the core disciplines of Epidemiology, Biostatistics, and Public Health to help support students in developing the knowledge, skills and competencies needed to assume positions of leadership with the ultimate goal of advancing the public's health. Through challenging coursework and both independent and collaborative research opportunities, 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 influence the nature and impacts of population health determinants.

The Department of Epidemiology and Biostatistics offers the following degrees:
- Doctor of Philosophy (PhD)
- Masters (MS)
- Master of Public Health (MPH)

Faculty and Research

Department faculty are nationally recognized and have more than $9.5 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 Veteran Administration. The department has offices in two locations at the university, (Wood Building and Wolestein 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 (including Medicare, Medicaid, and Vital Statistics databases) are stored on the servers and are used for faculty and student research and educational projects.

Masters Programs

Master of Science in Biostatistics

Statistics is the science of data and a discipline that provides tools for making decisions under conditions of uncertainty. Biostatistics addresses all aspects of statistics that arise from medical and health-related sciences, and is an essential component of most medical, biological, and health care. The study of biostatistics includes design and analysis of both experimental studies, such as clinical trials, and observational studies; the theory of probability and statistic; mathematical and statistical modeling; and knowledge of the methodology used to evaluate the properties of statistical procedures. It also includes a competency in computing, which encompasses programming, statistical software use, and database management. Modern Biostatistics is a dynamic field of study and an integral part of medical and public health research. Those who earn the MS in Biostatistics are equipped for careers in government, industry and academic research centers or to enter doctoral programs in biostatistics.

There are three tracks or majors: Biostatistics, Genomics and Bioinformatics and Health Care Analytics.

The mission of the Masters Program in Biostatistics is to enroll and train outstanding students in the core discipline of biostatistics. The faculty and students in this program are committed to teaching and learning the theory, methodology and application of the essential and modern statistical methods used in the biomedical and related sciences.

Courses required in this program include data management and statistical programming, applied biostatistics methods, epidemiology and biostatistics consulting. Biostatistics Track: Statistical Theory, Longitudinal Data Analysis, Data Meaning with either Machine Learning or Multivariate Analytics. Genomics and Bioinformatics Track: Genetic Epidemiology, Bioinformatics, Genome Sequencing, Advanced Methods in Genomic Analysis. Health Care Analytics: Large Healthcare Databases and Electronic Health Records and two of the following: Longitudinal Data Analysis, Observational Studies, Clinical Trials, Machine Learning and Data Mining, Comparative and Cost Effectiveness Analysis.

Plentiful research opportunities exist within the department and numerous research centers across the university, and extend to the adjoining University Hospitals, to the nearby Cleveland Clinic, to Cleveland’s MetroHealth Medical Center, and to similar entities across the United States and internationally.

Concurrently, students will master the rigorous scientific and analytic methods necessary to be at the forefront of efforts to not only describe, but effectively evaluate and improve the population’s health, and contribute to both the society and the biostatistics profession. Student- and faculty-led seminars provide an ongoing mechanism for keeping abreast of current literature and identifying important areas of research and collaborative opportunities. The Department operates within a strong interdisciplinary framework involving faculty within the department, the school of medicine, and across the entire university, as well as leaders in health care institutions and health oriented organizations and agencies throughout the wider community.

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 19-credit core curriculum, plus a 9 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 defend their internship practicum project.

Master of Public Health (MPH)

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Cleveland, Ohio 44106-4945
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216.368.2286 - fax drabousky@case.edu

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, bioethics, management and other fields, as well as students holding undergraduate degrees.

The CWRU MPH Program has a two-year curriculum requiring 42 credit hours. Twenty-one credits are accumulated in seven core required
courses, representing the fundamental domains of public health: biostatistics, epidemiology, environmental health sciences, health services administration, public health history and social and behavioral sciences. Students receive nine credits for three courses in the major of their choice, three credits for one elective course, and nine credits for the “Culminating Experience,” a 3 credit public health field practicum and a 6 credit capstone project. 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.

Requirements: Course List

Core required courses (21 credits)

- MPH 403 Research & Evaluation Methods 3
- 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
- MPH 483 Introduction to Epidemiology for Public Health Practice 3

Culminating Experience

- MPH 652 Public Health Capstone Experience 6
- MPH 650 Public Health Practicum 3

Complete 9 credits within chosen major 2

Elective 3

Total Units 42

1 Students in the Population Health Research major should strongly consider taking MPH 431 Statistical Methods I in place of MPH 405.

2 Choices for major are Population Health Research, Global Health, Health Policy & Administration, or Health Promotion and Disease Prevention.

MPH Sample Plan of Study (full-time):

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<th>First Year</th>
<th>Units</th>
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<tr>
<td>History and Philosophy of Public Health (MPHP 406)</td>
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<tr>
<td>Introduction to Health Behavior (MPHP 411)</td>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td>Introduction to Epidemiology for Public Health Practice (MPHP 483)</td>
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<tr>
<td>Statistical Methods in Public Health (MPHP 405)</td>
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<td>Introduction to Environmental Health (MPHP 429)</td>
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<tr>
<td>Public Health Management and Policy (MPHP 439)</td>
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<td>Major course 3</td>
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<tr>
<td>Elective course</td>
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<tr>
<td>Public Health Practicum (MPHP 650) (Public Health Capstone Experience)</td>
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</table>

Public Health Capstone Experience (MPHP 652) (Public Health Capstone Experience)

Year Total: 12 6

Total Units in Sequence: 39

Majors

Currently, four different majors (a.k.a. tracks) are offered by the CWRU MPH Program: Population Health Research, Global Health, Health Policy & Administration, and Health Promotion & Disease Prevention. Each major 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 major area to expand and apply the knowledge of the subject. Individual emphasis will differ from student to student within each major.

MPH students can also choose to expand the emphasis and depth of their program of study by electing to do a double major plan of study. For the double major, the student chooses two areas (two majors) of equal emphasis and takes 3 courses in each area (this requires the student to take a minimum of 45 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 major plan of study should also work closely with an advisor to ensure optimal course selection and foster the evolution of a successful Capstone project.

Population Health Research Major

Coordinator - Mendel Singer, PhD

Learning Objectives:

- Working knowledge of epidemiologic principles, terminology, and tools
- Working knowledge of the primary analytic methods employed in both prospective and retrospective studies relating to population health
- Understand the most common study designs used in public health and/or clinical research
- Gain familiarity with some of the key advanced concepts in one of the subspecialties of population health (e.g. epidemiology, health services research, outcomes research.

Select three of the following courses one of which must be a methods course:

- MPH 491 Epidemiology: Case-Control Study Design and Analysis 3
- MPH 421 Health Economics and Strategy 3
- MPH 432 Statistical Methods II 3
- MPH 450 Clinical Trials and Intervention Studies 3
- MPH 458 Statistical Methods for Clinical Trials 3
- MPH 460 Introduction to Health Services Research 3
- EPBI 465 Design and Measurement in Population Health Sciences 3
- MPH 467 Comparative and Cost Effectiveness Research 1
- MPH 484 Global Health Epidemiology 1 - 3
- EPBI 414 Introduction to Statistical Computing 3
- EPBI 451 Principles of Genetic Epidemiology 3
- EPBI 452 Statistical Methods for Genetic Epidemiology 3
Global Health Major
Coordinator - Daniel Tisch, PhD, MPH

Learning Objectives:

- Develop a global perspective on health and diseases
- Learn to design, execute, analyze, and evaluate global health research or projects
- Acquire skills to understanding and communicate meaningfully with colleagues from distant fields of global health
- Learn to integrate multiple objectives in global health across academic and applied disciplines
- Understand ethical and regulatory issues for global health research

Select two out of the following three courses as required major courses:

- INTH 401 Fundamentals of Global Health
- MPHP 447 Global Health: Outbreak Investigation in Real-Time
- MPHP 484 Global Health Epidemiology

Select remaining major course from below:

- MPHP 467 Comparative and Cost Effectiveness Research
- MPHP 508 Ethics, Law, and Epidemiology
- MPHP 510 Health Disparities
- ANTH 461 Urban Health
- ANTH 480 Medical Anthropology and Global Health I
- ANTH 481 Medical Anthropology and Global Health II
- ANTH 511 Seminar in Anthropology and Global Health: Topics
- LAWS 4101 International Law
- LAWS 5123 International Trade Law and Policy
- MGMT 460 Managing in a Global Economy

Health Promotion & Disease Prevention Major
Coordinator - Erika Trapl, PhD

Learning Objectives:

- Describe models and theories of health behavior as they relate to health promotion and disease prevention
- Identify multi-factorial causes of health behavior and disease
- Demonstrate knowledge and skills necessary to support behavior change
- Apply principles and practice of effective health communication
- Describe development, implementation, and evaluation of programs that promote healthy lifestyle and behaviors

Required major course:

- MPHP 433 Community Interventions and Program Evaluation

Select remaining major courses from the list below:

- MPHP 413 Health Education, Communication, and Advocacy
- EPBI 423 Dissemination and Implementation Science for Health Promotion
- 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 508 Ethics, Law, and Epidemiology
- MPHP 510 Health Disparities
- ANTH 461 Urban Health
public’s health. The Department operates within a strong interdisciplinary framework involving faculty within the department, the school of medicine, and across the entire university, as well as leaders in health care institutions and health oriented organizations and agencies throughout the wider community.

Student- and faculty-led seminars provide an ongoing mechanism for keeping abreast of current literature and identifying important areas of research and collaborative opportunities. Students are considered junior colleagues of the faculty who will develop the capacity to work independently in a supportive environment. The Department operates within a strong interdisciplinary framework involving faculty within the department, the school of medicine, and across the entire university, as well as leaders in health care institutions and health oriented organizations and agencies throughout the wider community.

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.

All incoming PhD students take a required 36-credit core curriculum, which includes a 24-credit common core, 12-credit concentration core, and 6-credits of electives from one of five areas of concentration: Genetic Epidemiology and Bioinformatics, Global Health Epidemiology, Health Behavior and Prevention Science, Health Care Organizations, Outcomes and Policy, and Modern Biostatistics (see descriptions below).

On completion of all core requirements, students take a qualifying examination that leads to advancement to candidacy. When ready to embark upon the Doctoral dissertation, the student must choose a research advisor to have the major responsibility for facilitating, guiding, and advising the student in his or her research.

Curriculum

The Doctor of Philosophy degree in the Department of Epidemiology and Biostatistics comprises the following components:

- Basic Core Curriculum (24 credits) or Statistical Alternative Core (24 credits)
- Specialization/Concentration Core Curriculum (12 credits)
- Concentration Approved Electives (9 credits)
- Seminar Requirements (501 & 502, 503, 504, or 505)
- Passing the Qualifying Exam
- Portfolio Presentation
- Dissertation (18 credits)

Core Curriculum

The basic core curriculum is designed to provide PhD students with a strong foundation in epidemiology and biostatistics and related areas - the fields that comprise population health sciences - and the methodological and analytic training to conduct a rigorous, high quality dissertation in the student’s selected specialization or concentration.

Specialization/Concentrations

The PhD coursework requirement also consists of concentrated studies within one of four substantive areas offered within the department: Genetic Epidemiology and Bioinformatics, Global Health Epidemiology, Health Behavior and Prevention Science, and Health Care Organizations, Outcomes and Policy and Modern Biostatistics.

Most PhD students will specify a concentration when they apply to the program; those who do so will have better chance of acceptance. Students who do not directly specify a concentration when applying for admission to the program, must do so by no later than the end of the second semester (for full-time students) or 18 credit hours of core coursework, and meet all the requirements of the chosen concentration. Applying to a concentration after matriculation OR changing concentrations after initial admission does not guarantee acceptance into the concentration. Some concentrations may have additional prerequisites beyond those required for entrance into the PhD program (i.e., at least one course in calculus), or additional coursework requirements (i.e., applied research experience).

Electives

Electives are chosen in conjunction with consultation with the student’s academic advisor.

Seminars (0 credits)

Attending research seminars is integral to our graduate program and your 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.

Portfolio Presentation

The purpose of the portfolio presentation is to give the doctoral student, faculty and other doctoral students an opportunity to consider the progress, achievements and goals of the presenting student. However, it is neither an examination nor a formal checklist of activity. The presentation is an opportunity for the presenting student to review her/his study and career goals and for the faculty to offer feedback and advice to the student regarding progress toward her/his goals. One way for the student to think about the portfolio presentation is to imagine that (s)he is being interviewed for an academic or research position. In such a circumstance, the student would explain why (s)he has the background and skills that would qualify her/him for the position.

Generally, the Portfolio Presentation is given after Advancement to Candidacy but prior to the dissertation proposal defense.

Dissertation (18 credits)

After passing the qualifying examination and completing all coursework, the student should choose a dissertation topic and find a faculty member with an appointment in the Department who is willing to be his/her research advisor.

PhD Epidemiology & Biostatistics Sample Plan of Study

Please also see Graduate Studies Academic Requirements for Doctoral Degrees.
First Year

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<tr>
<th>Course</th>
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<td>Epidemiology: Introduction to Theory and Methods (EPBI 490)</td>
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<td>Seminar in Health Care Organization, Outcomes and Policy (EPBI 504)</td>
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<td>Research Ethics in Population Health Sciences (EPBI 445)</td>
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<td>Introduction to Health Services Research (EPBI 460)</td>
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<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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Second Year

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<td>Essence of Structural Equation Modeling (EPBI 438)</td>
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<td>After completing the core courses, students take a comprehensive and a qualifying exam to advance to candidacy.</td>
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Total Units in Sequence: 36

**Statistical Alternative Core:** Students taking the statistical alternative core make the following changes to the basic core curriculum and related schedule of courses:

First Year Fall: Add EPBI 481 Statistical Theory I

Remove EPBI 440 Introduction to Population Health

First Year Spring: Add EPBI 482 Statistical Theory II

Remove EPBI 460 Introduction to Health Services Research

Second Year Fall: Add EPBI 440 Introduction to Population Health

Remove EPBI 436-438 Essence of …. (statistical series)

**Year 3 +** : Complete remaining hours of elective coursework, Portfolio, and 18 hours of Dissertation Research

**Areas of Concentration**

**Genetic Epidemiology and Bioinformatics**

Students enrolled in the Genetic Epidemiology and Bioinformatics Concentration will learn to design and conduct epidemiological studies investigating the genetic and environmental influences on disease. Genetic epidemiology combines genetics, epidemiology, and biostatistics. Bioinformatics involves the use of sophisticated statistical and data mining tools to analyze genomic, epigenomic, and proteomic data.

Special study designs and statistical methods are required to explore genetic influences in epidemiologic studies, and this field continues to evolve as molecular and computational technology evolves. Furthermore, studies have moved beyond associations strictly between trait and DNA sequence, and now incorporate gene-environment interaction, RNA/gene expression, copy number variants, epigenetics, and proteomics. Thus, today’s genetic epidemiologists must be able to take multidisciplinary approaches to the evaluation of genetics in disease pathogenesis.

Researchers in many diverse areas are interested in incorporating genetics into their studies of disease pathogenesis, so this field is in demand. Currently the area is moving towards the development of predictive models incorporating genetic polymorphisms, so this field is central to translational and personalized medicine. After finishing training in this concentration, students may become collaborators with other basic and clinical scientists who are interested in examining genetic effects on their respective phenotypes, may become methodologists and develop new statistical/bioinformatic approaches appropriate for obtaining genetic information, or may lead their own research related to the genetics of specific complex traits.

**Global Health Epidemiology**

The World Health Organization (WHO) and the US Institute of Medicine (IOM) defines Global Health as “health problems, issues, and concerns that transcend national boundaries, may be influenced by circumstances or experiences in other countries, and are best addressed by cooperative actions and solutions”. We believe that, at its core, Global Health (and more broadly, population health sciences) is built upon the disciplines of epidemiology and biostatistics. The unifying theme of this concentration is the relatedness of health across diverse geographic areas and communities and the application of epidemiology in the context of related disciplines to define, quantify, and address health determinants, measurements, and trends.
CWRU is a recognized leader in Global Health research and education. Academic opportunities in the field of Global Health are extensive and have been formally organized through the CWRU Framework for Global Health with nine departments, five schools and The Center for Global Health and Diseases at CWRU. Recognizing that Global Health is not limited to international settings or “developing countries”, the concentration also recognizes neglected diseases and vulnerable populations within the USA that transcend cultural boundaries.

The spirit of this concentration is advanced, innovative training to invite and strengthen the brightest new researchers in the field of global health. To accomplish this to the highest degree possible, we take advantage of our own connections within the University and our deep resources in Global Health professionals. Since the focus of this concentration is the development of research impact in a global perspective of health, prior or current experience in cultural settings from which these populations arise is strongly encouraged.

Health Behavior and Prevention Science
Health behavior and prevention research involves the systematic study of factors that modify behaviors related to disease risk and health promotion. This involves the development and testing of intervention programs designed to change behavior and reduce the onset and impact of various diseases, and programs designed to improve quality of life. Students enrolled in a concentration in Health Behavior and Prevention Science (HBPS) will train and conduct research on the psychological, social and ecological influences of health-related behaviors linked to the prevention of chronic disease, focusing not only on individual-level health and health behavior change, but more broadly to include multi-level, socio-ecological influences from interpersonal relationships and families, to organizations (school, work, religion), neighborhoods and communities, and policy.

Research opportunities for HBPS students are plentiful across campus, both with EPBI faculty and through established research centers within the university, such as the Prevention Research Center for Healthy Neighborhoods, Center for Reducing Health Disparities, Practice-Based Research Networks, Swetland Center for Environmental Health, Case Comprehensive Cancer Center (Prevention and Control Program), and the Center on Urban Poverty and Community Development.

The Prevention Research Center for Healthy Neighborhoods, through its Training and Mentoring and Research Development Cores, have built-in opportunities for students to become part of research teams, attend seminars, brown-bag discussions and participate in collaborative exchanges with community research partners.

Health Care Organization, Outcomes, and Policy
Students in the Health Care Organization, Outcomes, and Policy concentration will be prepared to design and carry out research in alternative models for the organization and delivery of care; quality, cost-effectiveness and comparative effectiveness of care; disparities in receipt or outcomes of care; translation of evidence-based practice into guidelines and evaluation of their real-world applications; and health policy analysis and implementation. Students in this concentration will acquire a solid grounding in the conduct of rigorous multidisciplinary studies applying quantitative, qualitative and mixed methods, and specialized competencies in key areas, viz., large database analysis; cost-effectiveness and comparative effectiveness analysis; health economics; health policy and management; and other advanced methods such as hierarchical linear modeling; structural equation modeling; instrumental variable analysis; analysis of weighted survey data; and spatial analysis of data.

There is a nationally recognized need for researchers prepared to lead or collaborate on the types of studies students in this concentration would be prepared to conduct. Placements of past graduates of our department who focused their studies in this area indicate that a variety of employment opportunities exist in academia, industry, and government. This concentration is closely related to research in comparative effectiveness, disparities, and health care quality, all three of which reflect national funding priorities. For example, over one billion in federal research dollars has recently been devoted to the funding of comparative effectiveness research.

Modern Biostatistics
Modern biostatistics is the science of designing experiments, analyzing and interpreting data from both experimental and observational studies, and making predictions. Appropriate planning and designing of a study is critical to ensure the quality and relevancy of its data to a scientific enquiry. Sound statistical analyses require consideration of multiple and perhaps previously unconsidered factors, knowledge and skills in modern statistics, computation and relevant sciences. Data mining and modern statistical learning techniques are important for knowledge discovery from large or massive data.

Modern biostatistics addresses all aspects of statistics that arise from medical and health-related sciences, including challenges in nanomedicine, microarray experiments, next generation sequencing, preclinical and clinical trials, complex health policies, biomedical engineering and other new/emerging areas. It involves the application and development of statistical methods for the advancement of medical science, health care and related areas. Thus, modern biostatistical scientists develop new statistical methods, play a key role in the effective communication of quantitative information, collaborate with medical scientists in disease prevention and treatments, and contribute to the rational formulation of health policies and interventions.

The concentration in modern biostatistics provides both theoretical and practical biostatistical training integrated with the core requirements in epidemiology and health sciences, facilitated by the involvement of faculty in cutting-edge biomedical and health research across the medical school and university. This concentration aims to develop students as modern biostatisticians with knowledge of the determinants of population health and/or another scientific area of applications (of the student’s choice), as well as in statistical theory, methods and computing which naturally have applications beyond a particular substantive area. This program provides unique biostatistical training designed to prepare students for today’s rewarding careers in academia, government, and industry. Modern biostatisticians are highly sought after in the job market.
EPBI Courses

EPBI 400. Statistics As Integral to the Scientific Method. 3 Units.
Modern statistical thinking and methods and how they are integral to the scientific method. Designing studies (statistical planning), analyzing data, interpreting results, and presenting statistical material effectively and truthfully, often via graphics far more informative and truthful than those still commonly appearing in scientific publications. Mathematically, only ordinary algebra is needed to understand the key statistical concepts and models. Extensive use of R (via RStudio), an open-source (free) system that runs under Windows, Mac OS, and Linux, and is now a standard environment used widely throughout the scientific world. All R programs used in the lectures are provided to students, so they can modify them to conduct their own analyses. However, this course does not focus on the technical details underlying those computations. Almost all student work is based on using R to apply the methods to real/realistic problems in their own research areas and then develop and give oral presentations. This includes learning that sticks. Grading is P/NP; auditing is allowed (if space available). May not be used to satisfy course requirements in MS or PhD programs in the Department of Epidemiology and Biostatistics.

EPBI 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 EPBI 411 and MPHP 411. Prereq: Enrollment limited to MPH students (Plan A or Plan B) and EPBI students or consent.

EPBI 414. Introduction to Statistical Computing. 3 Units.
This course introduces the use of computers in epidemiologic investigations and biostatistical applications. Topics covered include the use of the Internet to access and obtain publicly available databases, database and spreadsheet concepts, and developing a sound approach to analysis planning and implementation. The majority of the course will focus on instruction in the use of SAS software for advanced database management and manipulation and basic statistical analyses, with parallel applications in R to exploit its features. Primary emphasis is on developing the knowledge and familiarity required for running these particular programs in connection with data collection, analysis, and presentation of results in clinical studies. Students will be required to complete assignments using personal computers using Windows operating systems and/or computer systems maintained by the department. Students should expect weekly assignments to reinforce lecture concepts. Knowledge of basic statistics is beneficial, as this course does not teach inferential statistical analysis in detail; but it is not vital to learning the material in this course.

EPBI 415. Statistical Computing and Data Analytics. 3 Units.
Statistical computing is an essential part of modern statistical training. 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 EPBI 481,or EPBI 431, or by permission. Experience with at least one programing language is required: R/Splus, Matlab, C/C++, Fortran, JAVA, or Python. Prereq: STAT 312, STAT 325, STAT 425, STAT 345, STAT 445, EPBI 431 or EPBI 481.

EPBI 423. Dissemination and Implementation Science for Health Promotion. 3 Units.
This graduate-level course introduces concepts, skills, and methods for systematically disseminating and implementing evidence-based interventions for population health promotion. The course includes a focus on developing partnerships and transdisciplinary research teams, applying theories and frameworks to guide dissemination and implementation (D & I) science, examining research methods and designs appropriate for conducting D & I research at different and multiple levels of intervention (e.g., clinical, community, policy), and exploring channels for effectively communicating evidence to inform decision-making and practice in diverse contexts. Recommended Preparation: EPBI 411 or grad. level behavioral theory equivalent; EPBI 490 or MPHP 483 or grad. level research methods equivalent.

EPBI 430. Design and Analysis of High-Dimensional Data. 3 Units.
High-dimensional, high-throughput data are often encountered in the fields of genomics, proteomics, systems biology and bioinformatics. Through this course, students will learn how to design high-throughput studies and analyze the high-dimensional genomic data necessary for precision medicine when the number of measures far exceeds the number of subjects ("high-dimensional data"). Topics include (but are not limited to) design of high-throughput studies, sample size estimation, power analysis, low-level preprocessing of microarrays, basic exploratory genomics and proteomics data analyses, multiple comparison (p>>n problem), supervised and unsupervised learning methods. These statistical methods will be applied to gene and protein expression data, and next generation sequencing data. The course will use an interdisciplinary approach that combine statistics, computer science, molecular biology, and genomics. While this particular course will focus mostly on statistical methods for designing and analyzing molecular studies, those who take it will come from a wide variety of disciplines. Therefore, relevant multivariate methods and molecular biology will be reviewed. Recommended Preparation: At least one advanced undergraduate or graduate statistical course experience.

EPBI 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, EPBI 431 and MPHP 431.
EPBI 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, EPBI 432, CRSP432 and MPH 432. Prereq: EPBI 431 or equivalent.

EPBI 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: EPBI 490, EPBI 431, or MPH 405. Offered as EPBI 433 and MPH 433.

EPBI 434. Community Engaged Research: Principles, Methods and Applications. 3 Units.
Community-engaged research is a partnership approach to research that equitably involves community members, organization representatives, and academic researchers in all aspects of the research process. This course is designed to provide an overview of community-based participatory research (CBPR) and will familiarize students with the core principles, concepts and methods as it applies to health-related outcomes. Using a class format that includes lectures, discussion, case studies, small group exercises and fieldwork projects, we will examine and discuss key methodological considerations in each phase of the research process from partnering with communities to planning for research, data gathering, and dissemination of results. Examples of applications in both public health and clinical settings will be highlighted.

EPBI 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: EPBI 432.

EPBI 436. Essence of Multilevel Statistical Modeling, Including Repeated Measures Analysis. 1 Unit.
A brief introduction to statistical models to handle studies having observational units (cases) at multiple levels (hierarchies). In particular, cases are often nested within groups, such as distinct communities, healthcare centers, or schools. Because the cases are not independent, ordinary statistical models (EPBI 432) are not appropriate. In addition, some research questions suggest case-level analyses; others suggest group-level analyses. Longitudinal and other repeated measures analyses can be formed by taking the measurements to be nested within independent cases. Methods include the basic "summary measure" approach and mixed linear model methods, such as random coefficient regression models. Examples and wise use of software (R and SAS) are stressed in order to develop a strong conceptual understanding of the models. This course joins EPBI 437 and 438 as the three-step "essence" series in advanced statistical methods required for the PhD in Population Health Science. Prereq: EPBI 432 or requisites not met permission.

EPBI 437. Essence of Classical Multivariate Analysis. 1 Unit.
A brief introduction to classical multivariate analysis methods: data visualization, two-group discriminant analysis via Hotelling's test, principal components and exploratory factor analysis, cluster analysis. Examples and wise use of software R are stressed in order to develop a strong conceptual understanding of the methods. This course joins EPBI 436 and 438 as the three-step "essence" series in advanced statistical methods required for the PhD in Population Health Science. Prereq: EPBI 432 or requisites not met permission.

EPBI 438. Essence of Structural Equation Modeling. 1 Unit.
Brief introduction to classic "linear structural relations" (LISREL) formulation of structural equation models: Building them to address specific research aims. Fitting and assessing the goodness of the fit. Prudent interpretations. Examples and wise use of software are stressed in order to develop a strong conceptual understanding. This course joins EPBI 436 and 437 as the three-step "essence" series in advanced statistical methods required for the PhD in Population Health Science. Prereq: EPBI 432 or requisites not met permission.

EPBI 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.

EPBI 444. Communicating in Population Health Science Research. 2 Units.
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: EPBI 431 and EPBI 490. Coreq: EPBI 432.

EPBI 445. Research Ethics in Population Health Sciences. 0 Units.
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 EPBI 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.
EPBI 447. Global Health: Outbreak Investigation in Real-Time. 3 Units.
This course provides a trans-cultural, trans-disciplinary, multimedia learning experience by analyzing historical and real-time data from the annual dengue endemics and sporadic epidemics in Puerto Rico and Brazil. A rigorous problem-centered training in the epidemiology, prevention, treatment, and control of infectious diseases using real-time and historical surveillance data of endemic and epidemic Dengue in Bahia, Brazil. This is an advanced epidemiology course in which core material will be primarily taught through reading assignments, class discussion, group projects, and class presentations. The course will utilize the online web-based communication and learning technology to create a single classroom between the CWRU and international partners with unique and complementary skills. In addition to joint classroom lectures across sites, student groups will also perform smaller-scale videoconference meetings for assigned group projects, thus creating strong international connections for the students, faculty, and our institutions. Note: Due to the complexities of time zones for this international course, the course will begin at 8:00a.m. until the U.S.A. adjusts clocks for Daylight Savings Time (unlike Brazil). Therefore, classes after the second week of March will begin at 9:00a.m. Offered as: EPBI 447, INTH 447, and MPH 447. Prereq: EPBI 490.

EPBI 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: EPBI 431 or consent of instructor. Offered as EPBI 450 and MPH 450.

EPBI 451. Principles of Genetic Epidemiology. 3 Units.
A survey of the basic principles, concepts and methods of the discipline of genetic epidemiology, which focuses on the role of genetic factors in human disease and their interaction with environmental and cultural factors. Many important human disorders appear to exhibit a genetic component; hence the integrated approaches of genetic epidemiology bring together epidemiologic and human genetic perspectives in order to answer critical questions about human disease. Methods of inference based upon data from individuals, pairs of relatives, and pedigrees will be considered. Offered as EPBI 451, GENE 451, and MPH 451. Prereq: EPBI/MPHP 431 and EPBI/MPHP 450 or MPH 450.

EPBI 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: EPBI 431 and EPBI 451.

EPBI 453. Categorical Data Analysis. 3 Units.
Descriptive and inferential methods for categorical data with applications: bivariate data; models for binary and multinomial response variables, with emphasis on logit models; loglinear models for multivariate data; model fitting using the maximum likelihood approach; model selection and diagnostics; and sample size and power considerations. Topics in repeated response data as time allows. Recommended preparation: EPBI 441.

EPBI 454. Population Genetics for Genetic Epidemiology. 3 Units.
Introduce concepts and classical results of mathematical population genetics, with emphasis on the influence of evolutionary forces and population history on contemporary human genetic variation. Survey empirical population variation and their implication for mapping complex traits. How to simulate population sequence data using coalescence models will also be emphasized.

EPBI 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: EPBI 451 and EPBI 452.

EPBI 458. Statistical Methods for Clinical Trials. 3 Units.
This course will focus on special statistical methods and philosophical issues in the design and analysis of clinical trials. The emphasis will be on practically important issues that are typically not covered in standard biostatistics courses. Topics will include: randomization techniques, intent-to-treat analysis, analysis of compliance data, equivalency testing, surrogate endpoints, multiple comparisons, sequential testing, and Bayesian methods. Offered as EPBI 458 and MPH 458. Prereq: EPBI 432 or MPH 432.

EPBI 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: EPBI 432.

EPBI 460. Introduction to Health Services Research. 3 Units.
This survey course provides an introduction to the field of Health Services Research and an overview of key health services research concepts and methods, including conceptual frameworks and models; outcomes research; risk adjustment; disparities in health care; policy/health care systems; cost and cost-effectiveness; quality of life, process improvement; patient satisfaction; patient safety; health economics; statistical modeling techniques; and qualitative research methods. Offered as EPBI 460 and MPH 460.

EPBI 461. Health Services Research Methods. 3 Units.
This is a course in research methods focusing on practical issues in the conduct of health services research studies. Topics include: an overview of health services research; ethics in health services research; proposal writing and funding; the relationship between theory and research; formulating research questions; specifying study design and study objectives; conceptualizing and defining variables; validity and reliability of measures; scale construction; operationalizing health research relevant variables using observation, self and other report, and secondary analysis; formatting questionnaires; developing analysis plans; choosing data collection methods; sampling techniques and sample size; carrying out studies; preparing data for analysis; and reporting of findings.
EPBI 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 EBPI 464, MPHP 464.

EPBI 465. 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: EPBI 440, EPBI 431, EPBI 490, EPBI 432, EPBI 460, EPBI 444 and EPBI 445.

EPBI 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, EPBI 466, SOCI 466, NURS 466 and BETH 466. Prereq: Graduate student status or instructor consent.

EPBI 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 EPBI 467 and MPHP 467.

EPBI 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 EPBI 468, MPHP 468, NURS 468.

EPBI 480. Introduction to Statistical Theory. 3 Units.
Theoretical introduction to probability and deep understanding of key concepts of statistical inference. Topics will be covered are: basic probability theory, conditional probability, Bayes theorem, random variables, discrete and continuous distributions (Bernoulli, binomial, hypergeometric, Poisson, negative binomial, normal, gamma and beta distribution), expectation, variance, moments, moment generating functions, the central limit theorem, maximum likelihood methods, unbiased estimators, sufficient statistics, EM algorithm, sample and sampling distribution, point and interval estimation, hypothesis testing and basic asymptotic theory. Prereq: MATH 122, MATH 124 or MATH 126.

EPBI 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 EPBI 481. Prereq: MATH 122 or MATH 223 or Coreq: EPBI 431.

EPBI 482. Theoretical Statistics II. 3 Units.
Point estimation: maximum likelihood, moment estimators. Methods of evaluating estimators including mean squared error, consistency, "best" unbiased and sufficient. 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 EPBI 482. Prereq: STAT 345 or STAT 445 or EPBI 481.
EPBI 483. Causal Inference. 3 Units.
This course covers concepts and methods for causal inference in health research. The ideas and approaches introduced in this course take us beyond standard statistical methods such as regression analysis, and have applications in both observational and randomized studies. Specific topics include potential outcomes, causal diagrams, confounding, propensity scores, instrumental variables, treatment noncompliance, mediation analysis, sensitivity analysis, and structural equation models. Prereq: EPBI/MPHP/BIOL 432 or equivalent.

EPBI 484. Global Health Epidemiology. 1 - 3 Unit.
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 EPBI 484, INTH 484, and MPHP 484.

EPBI 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 EPBI 490 and MPHP 490. Prereq or Coreq: EPBI 431 or requisites not met permission.

EPBI 494. Infectious Disease Epidemiology. 3 Units.
This course focuses on tuberculosis (TB) and HIV epidemiology, including perspectives on these diseases in the US and globally. It is a follow-up to EPBI/MPHP 484: Global Health Epidemiology, but these courses do not necessarily need to be taken in sequence. This is an advanced course, focusing on methods and approaches in epidemiology and public health. Offered as EPBI 494, INTH 494 and MPHP 494. Prereq: EPBI 490.

EPBI 499. Independent Study. 1 - 18 Unit.

EPBI 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 EPBI 500.

EPBI 501. Research Seminar. 0 Units.
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.

EPBI 502. Seminar in Genetic Epidemiology and Bioinformatics. 0 Units.
Presentation of original research or recent journal publications by faculty and students.

EPBI 503. Seminar in Biostatistics. 0 Units.
Presentation of original research or recent journal publications by faculty and students in the area of Biostatistics.

EPBI 504. Seminar in Health Care Organization, Outcomes and Policy. 0 Units.
This seminar is designed to enhance the professional development of students in the Health Care Organization, Outcomes and Policy concentration of the Department of Epidemiology and Biostatistics and provide them with practical information, experiences and guidance to foster their academic success. Students will 1) develop the ability to critically appraise the health services research literature; 2) gain experience in organizing and delivering oral presentations based on published literature and their own research endeavors; 3) be exposed to role models and receive coaching on career development through lecture and discussion involving experienced faculty from within and outside the division; 4) receive didactic training and hands-on experience with career-related tasks and skills such as grant writing and proposal evaluation, article review, and effective participation in professional meetings; and hear faculty from within and outside the department describe their research. The specific content of the seminar for any given semester will be determined jointly by HCOOP students and faculty. Enrollment is limited to students in the HCOOP division of the Department of Epidemiology and Biostatistics.
EPBI 505. Seminar in Global Health Epidemiology. 0 Units.
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.

EPBI 506. Seminar in Health Behavior and Prevention Research. 0 Units.
This seminar is designed to enhance the academic and professional development of students in the Health Behavior & Prevention Research (HB&PR) concentration in the Department of Epidemiology and Biostatistics. The seminar is comprised of a journal club style in which current and classic research literature in health behavior and prevention research is critically evaluated. Also, talks are given by students, faculty, and invited guests. These activities give students the opportunity to improve their ability to: 1) critically evaluate research literature in HB&PR; 2) lead effectively a discussion of a research article; and 3) organize and deliver oral presentations based on published literature and their own research endeavors. Some sessions are devoted to didactic training and hands-on experience with career-related tasks and skills such as grant writing, proposal evaluation, and manuscript review. The specific content of the seminar for any given semester will be determined jointly by the students and faculty in HB&PR. Enrollment is required of all PhD students in the HB&PR concentration of the Department of Epidemiology and Biostatistics; however is open to all interested students.

EPBI 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, EPBI 510, MPH 510, NURS 510, and SASS 510.

EPBI 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: EPBI 414 or equivalent; EPBI 431 or EPBI 460 and EPBI 461 (for HSR students).

EPBI 550. Meta-Analysis & Evidence Synthesis. 2 - 3 Units.
Systematic reviews use reproducible methods to systematically search the literature an 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. 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. Offered as CRSP 550 and EPBI 550. Prereq: CRSP 401, EPBI 431, MPH 405, NURS 532 or Requisites Not Met permission.

EPBI 601. Master's Project Research. 1 - 18 Unit.
EPBI 602. Practicum. 1 - 3 Unit.
This course focuses on the skills needed to become an effective statistical consultant. The course objectives are: to learn the role of the consulting statistician and the accompanying responsibilities and ethical considerations, to develop the ability to interact with clients and elicit the information required to provide consulting expertise, to learn general strategies for approaching consulting problems that can be applied to a wide range of problems in medical areas, and to develop expertise in areas needed by the consulting biostatistician. These include database architecture, data quality control, record keeping for potential audits, statistical techniques, and report generation.

EPBI 651. Thesis M.S.. 1 - 18 Unit.
EPBI 701. Dissertation Ph.D.. 1 - 9 Unit.
Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

MPHP Courses

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 403. Research & Evaluation Methods. 3 Units.
This course is designed to provide an overview of research and evaluation methods for first-year MPH students. Through lecture, discussion and application exercises, students are introduced to the principles and processes of research and evaluation methods in public health, including formulation of research questions, aims and hypotheses and evaluation goals and objectives; literature review; development/selection of conceptual and theoretical models; quantitative, qualitative and evaluation project management; and application of ethical principles and protection of human subjects in public health research and evaluation.

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 EPBI 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 MPH 413 and MPHP 413.

MPHP 421. Health Economics and Strategy. 3 Units.
This course has evolved from a theory-oriented emphasis to a course that utilizes economic principles to explore such issues as health care pricing, anti-trust enforcement and hospital mergers, choices in adoption of managed care contracts by physician groups, and the like. Instruction style and in-class group project focus on making strategic decisions. The course is directed for a general audience, not just for students and concentration in health systems management. Offered as ECON 421, HSMC 421, and MPHP 421.

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, EPBI 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, EPBI 432, CRSP432 and MPHP 432. Prereq: 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 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: EPBI 490, EPBI 431, or MPHP 405. Offered as EPBI 433 and MPHP 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 447. Global Health: Outbreak Investigation in Real-Time. 3 Units.
This course provides a trans-cultural, trans-disciplinary, multimedia learning experience by analyzing historical and real-time data from the annual dengue endemics and sporadic epidemics in Puerto Rico and Brazil. A rigorous problem-centered training in the epidemiology, prevention, treatment, and control of infectious diseases using real-time and historical surveillance data of endemic and epidemic Dengue in Bahia, Brazil. This is an advanced epidemiology course in which core material will be primarily taught through reading assignments, class discussion, group projects, and class presentations. The course will utilize the online web-based communication and learning technology to create a single classroom between the CWRU and international partners with unique and complementary skills. In addition to joint classroom lectures across sites, student groups will also perform smaller-scale videoconference meetings for assigned group projects, thus creating strong international connections for the students, faculty, and our institutions. Note: Due to the complexities of time zones for this international course, the course will begin at 8:00a.m. until the U.S.A. adjusts clocks for Daylight Savings Time (unlike Brazil). Therefore, classes after the second week of March will begin at 9:00a.m. Offered as: EPBI 447, INTH 447, and MPHP 447.

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: EPBI 431 or consent of instructor. Offered as EPBI 450 and MPHP 450.

MPHP 451. Principles of Genetic Epidemiology. 3 Units.
A survey of the basic principles, concepts and methods of the discipline of genetic epidemiology, which focuses on the role of genetic factors in human disease and their interaction with environmental and cultural factors. Many important human disorders appear to exhibit a genetic component; hence the integrated approaches of genetic epidemiology bring together epidemiologic and human genetic perspectives in order to answer critical questions about human disease. Methods of inference based upon data from individuals, pairs of relatives, and pedigrees will be considered. Offered as EPBI 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 458. Statistical Methods for Clinical Trials. 3 Units.
This course will focus on special statistical methods and philosophical issues in the design and analysis of clinical trials. The emphasis will be on practically important issues that are typically not covered in standard biostatistics courses. Topics will include: randomization techniques, intent-to-treat analysis, analysis of compliance data, equivalency testing, surrogate endpoints, multiple comparisons, sequential testing, and Bayesian methods. Offered as EPBI 458 and MPHP 458.

MPHP 460. Introduction to Health Services Research. 3 Units.
This survey course provides an introduction to the field of Health Services Research and an overview of key health services research concepts and methods, including conceptual frameworks and models; outcomes research; risk adjustment; disparities in health care; policy/health care systems; cost and cost-effectiveness; quality of life, process improvement; patient satisfaction; patient safety; health economics; statistical modeling techniques; and qualitative research methods. Offered as EPBI 460 and MPHP 460.

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 EPBI 464, 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, EPBI 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 EPBI 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 EPBI 468, MPHP 468, NURS 468.

MPHP 472. Leadership and Advocacy in Urban Community Health. 3 Units.
Teams of medical and MPH students will work with the Children's Defense Fund and Cleveland neighborhood and nonprofit organizations using principles of community organization to articulate shared stories and hopes for the health and well-being of community where both the students and the organizations live and serve. While the course begins with dialogue, it will end with specific activities (performed by the students and community together) to improve community health, and a logic model for evaluating and expanding those activities. As reflection is a critical skill for leadership, the experiences in community organizing and advocacy will be counterposed with reflection on learning and will include independent reading and writing and small group discussions. Readings about leadership, advocacy and community health (particularly in cities) will include diverse perspectives and genre including work from Lao Tzu, Gandhi, Martin Luther King Jr., Shakespeare, Saul Alinsky and others. Prereq: Enrolled in MPH or JD program.

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: EPBI 515.

MPHP 479. Teaching Population Health and Community Assessment. 3 Units.
This course allows students to function in a teaching and leadership role in population health education and conduct of a multilevel community assessment of underserved neighborhoods in Cleveland. During the course, students will function as facilitators of small groups (8 to 9 students) of first year medical students during the Population Health block of their medical curriculum. Community assessment, also known as the "Extensive Care Unit" project will include 1) semi-structured interviews with Key Community Contacts; 2) an environmental scan of the assigned neighborhood; 3) analysis of publicly available data; and 4) analysis of youth risk behavior survey data. All data analysis will be mentored by course faculty. In addition, students will be involved with facilitation of a pandemic influenza tabletop exercise. Students will participate in an intensive training prior to facilitation responsibilities; and each week will both debrief the community assessment sessions and plan for the next weekly session.

MPHP 480. Health Systems Management in Primary Care. 1 Unit.
Goal - To develop a deeper understanding of components of the health system that influence and provide shape to the environment in which health care is delivered and about the implementation of systems-based strategies that foster better processes and/or outcomes of health care delivery.

MPHP 481. A Primer of Dental Public Health. 3 Units.
This course introduces students to principles and issues in dental public health. In addition to the principles, students will learn about contemporary issues impacting dental public health, oral epidemiology, dental health care systems, and oral health promotion. To facilitate the understanding of oral health promotion, students will gain a basic understanding of the common oral diseases. Prereq: MPHP 306 or MPHP 406 and MPHP 490 or EPBI 490.
MPHP 482. Qualitative and Mixed Methods in Public Health. 3 Units.
The purpose of this course is three-fold: 1) to provide students with an understanding of the fundamentals of qualitative and mixed methods, including the history and philosophy of these methods, 2) to provide students with an understanding of and skill set associated with the use of qualitative and mixed methods in public health research, and 3) to provide students with an introduction to local professionals engaged in qualitative and mixed methods public health research. Prerequisites include MPHP 405 and 483 (or equivalents) and current status as an MPH student. Prereq: MPHP 405, MPHP 483 and current MPHP student.

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 Unit.
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 EPBI 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 EPBI 490 and MPHP 490. Prereq or Coreq: EPBI 431 or requisites not met permission.

MPHP 491. Epidemiology: Case-Control Study Design and Analysis. 3 Units.
This course builds upon EPBI 490 with a comprehensive study of the concepts, principles, and methods of epidemiologic research. The course content specifically focuses on the case-control study design and provides a framework for the design, analysis, and interpretation of case-control studies. Rigorous problem-centered training includes exposure measurement, subject selection, validity, reliability, sample size and power, effect modification, confounding, bias, risk assessment, matching, and logistic regression. Individual and group data projects will be analyzed using SAS statistical software. Prereq: EPBI/MPHP 490.

MPHP 492. Epidemiology: Cohort Study Design and Analysis. 3 Units.
This course provides a comprehensive introduction to the cohort study. Particular emphasis is placed on cohort study design and cohort data analysis. The course will cover the conceptual framework underlying cohort studies, planning and conducting a cohort study, basic concepts of time, exposure and outcome, and methods in the analysis of longitudinally collected data. Analytic methods covered in the class include, but are not limited to: analysis of age, period, and cohort effects, analysis of incidence rates, analysis of repeated measures, and analysis of time-to-event data. Students will have the opportunity to conduct analysis of data obtained from an actual cohort study using a statistical package of their choice. Prereq: EPBI 431 and EPBI 490 or equivalent.

MPHP 494. Infectious Disease Epidemiology. 3 Units.
This course focuses on tuberculosis (TB) and HIV epidemiology, including perspectives on these diseases in the US and globally. It is a follow-up to EPBI/MPHP 484: Global Health Epidemiology, but these courses do not necessarily need to be taken in sequence. This is an advanced course, focusing on methods and approaches in epidemiology and public health. Offered as EPBI 494, INTH 494 and MPHP 494. Prereq: EPBI 490.

MPHP 499. Independent Study. 1 - 18 Unit.

MPHP 506. The Future of Public Health. 0 - 3 Units.
This seminar course is meant to provide an orientation to the Master of Public Health (MPH) Program at Case Western Reserve University's (CWRU) School of Medicine, essential topics related to the future of public health as a professional field, and local public health efforts in the broader campus and Cleveland communities. This seminar is designed for first year MPH students. Prereq: MPHP Plan A or Plan B student status.

MPHP 507. Building a Public Health Project. 0 Units.
This course is designed to walk students through the process of creating a Capstone Project, form "idea to field." Specific topics to be covered include: identifying a project, creating a project plan, how to effectively work in the community, program design, evaluation, ethical issues in community research, creating an analytic plan, survey design, and writing results. Major class projects include completing an IRB application or completing a grant application for your own project. The last two weeks of class center around attending and discussing the Capstone Presentations of graduating students. Prereq: MPHP Plan A or Plan B student status.
MPHP 508. Ethics, Law, and Epidemiology. 3 Units.
This course is designed to provide epidemiology students with basic knowledge about the ethical and legal principles underlying epidemiological research. This is not a public health law class. Issue papers are assigned on a weekly basis. Each issue paper requires that the student analyze the situation depicted and apply the principles learned. Some issue papers may require that the student draft a proposed rule, a portion of legislation, or a document such as an informed consent form. Other exercises may require that students critique an existing agency rule or legislation. Prereq: EPBI 490 and EPBI 491 or equivalent.

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, EPBI 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 650. Public Health Practicum. 1 - 3 Unit.
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.

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 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.
MPHP 656. Dual Degree Field Capstone III. 3 Units.
The Public Health Capstone Project 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, mentored, and evaluated public health scholarly project. This course is designed to be taken by advanced level students. It consists of a 288 hour field based Capstone experience and participation in 12 hours of professional development opportunities. The overall goal of this course is designed to move students beyond the walls and constraints of the classroom, to understand the political, economic, social, and organizational contexts within which public health and social work activities are conducted. It is also designed to provide graduate level dual degree students with field related opportunities to begin to develop advanced level competencies in the eight abilities by helping students apply knowledge of social work theory, skills, values and ethics acquired in the classroom in an agency setting. These collective experiences provide students with a forum to continue to develop and hone social work skills, integrate and operationalize the values and ethics inherent in professional practice, and confront social injustice as self-reflective, competent developing practitioners. (EPAS Program Objective M6 and EPAS Content Area 4.7) Offered as SASS 656 and MPHP 656 Prereq: MPHP 655.

MPHP 657. Dual Degree Field Capstone IV. 3 Units.
The Public Health Capstone Project 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, mentored, and evaluated public health scholarly project. This course is designed to be taken by advanced level students. It consists of a 288 hour field based Capstone experience and participation in 12 hours of professional development opportunities. The overall goal of this course is designed to move students beyond the walls and constraints of the classroom, to understand the political, economic, social, and organizational contexts within which public health and social work activities are conducted. It is also designed to provide graduate level dual degree students with field related opportunities to begin to develop advanced level competencies in the eight abilities by helping students apply knowledge of social work theory, skills, values and ethics acquired in the classroom in an agency setting. Offered as MPHP 657 and SASS 657.

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
Anne M. Duli, MPA, Associate Director, Research Administration and Finance

The Case Comprehensive Cancer Center (Case CCC) is one of only 41 National Cancer Institute-designated Comprehensive Cancer Centers in the country. The Case CCC integrates the cancer research activities of the largest medical collaborative in Ohio, Case Western Reserve University (CWRU), University Hospitals Case Medical Center and Cleveland Clinic - under a single leadership structure. Our researchers dedicate themselves to improving cancer outcomes through basic studies into signaling pathways giving rise to cancer and its generic and epigenetic causes, pursuing novel therapeutic targets, and analyzing lifestyle interventions to prevent cancer and detect it earlier.

The Case CCC has over 360 collaborating scientists and physicians who have successfully competed for over $119 million in annual funding. These investigators are organized into eight interdisciplinary scientific programs and have access to 15 Scientific Core Facilities. A unified clinical research effort consisting of 12 multidisciplinary clinical disease teams develop and prioritize clinical trials among the partner institutions.

Located in Cleveland, Ohio, the Case CCC serves a population with higher than average cancer rates. Research programs extend to CWRU affiliates MetroHealth Medical Center (the region’s county hospital) and Louis Stokes Veterans Affairs Hospital and to 13 community medical centers operated by University Hospitals and Cleveland Clinic.

As a consortium cancer center, Case CCC has become a powerful example of the potential generated by complementary institutions coming together for the benefit of research and discovery, patient treatments and community impact. Through its partners, Cancer Center programs extend throughout Northeast Ohio to offer residents access to cancer care through participation in community outreach, cancer prevention, cancer survivorship initiatives and a robust clinical trials operational effort coordinated across academic medical centers and community sites.

Center for Clinical Investigation

Phone: 216.368.3286
http://cci.case.edu/cci/index.php/Main_Page
Pamela Davis, MD, PhD, Director
James Spilsbury, PhD, Academic Development Core Director
Nathan Morris, PhD, Statistical Sciences Core Director
Guo-Qiang Zhang, PhD, Medical Informatics Division Chief

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 60 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 Foundation, and MetroHealth System . The CCI has supported hundreds of clinical research and epidemiology projects, including local and national multicenter, longitudinal studies.
The CCI has three cores that work together to provide fully integrated research support to all investigators: Academic Development Core, Division of Medical Informatics, and Statistical Sciences Core.

The Academic Development Core manages the Master’s Degree Program in Clinical Research (http://casemed.case.edu/CRSP) (Clinical Research Scholars Program - see "Clinical Research MS" tab above) as well as a newly created 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 Division of Medical Informatics is primarily charged with developing informatics solutions to many of the barriers clinical investigators face in efficiently processing, storing and sharing research data; and with providing informatics tools and infrastructure for the CCI and the larger research community. In order to meet these goals, the Division of Medical Informatics develops data standards for research database development and data management that aim to maximize the value (accuracy, completeness, availability, security) of research data, develops technological solutions and tools in support of the other CCI cores, develops tools and systems to facilitate understanding of research data (including data dictionaries, data sharing tools, and repositories for biological data) and conducts research in new methodologies for clinical research informatics, clinical and health informatics, comparative effectiveness research, information discovery, data integration, data mining, and translational research. The Division of Medical Informatics staff consists of research programmers and systems analysts with not only a wide range of technical expertise, but with experience using semantic web technology in support of clinical research.

The Statistical Sciences Core provides data management and statistical support on 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, 2 MS biostatisticians, and 1 data manager, each with several years of collaborative experience in an academic medical center. Statistical software packages that are supported by the CCI Statistical Sciences Core include SAS, SPSS, R/S-Plus, JMP, NCSS PASS, Minitab, and Stata.

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

Center for Medical Education
Phone: 216.368.6986
Megan McNamara, MD, Director, CAML

The Center for Medical Education, established in 2010, is currently being reorganized to better align with the needs of learners across the educational continuum – from students to residents to graduate students to faculty. The Center for Medical Education (CMEd) 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 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.

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

Center for Proteomics and Bioinformatics
Phone: 216.368.0291
http://proteomics.case.edu/default.aspx
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, Ph.D, with over $80 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 bioinformatics services including 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/.

Proteomics entails the in-depth structural analysis of individual proteins in human and animal cells. In studying proteins and their changes, bioinformatics enables researchers to take an integrated -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.

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 technologies to understand the function and interactions of macromolecular complexes.

The CPB has three divisions: Proteomics and Genomics, Bioinformatics, and Macromolecular Structure.

**Proteomics and Genomics Division**

The mission of the Division of Proteomics and Genomics is to support research in protein and gene expression analysis, protein and gene modifications, and protein interactions in a wide variety of biological contexts. The division also develops new tools in Proteomics and Genomics research. This includes multiple Proteomics Cores to support these activities.

**Bioinformatics Division**

The mission of the Division of Bioinformatics is to support interdisciplinary research and training in many areas of bioinformatics including analysis of DNA and protein sequences, protein interaction networks, linkage and association studies for simple and complex traits, and gene and protein expression profiles. This includes a Bioinformatics Core that provides research support for these activities.

**Macromolecular Structure Division**

The mission of the Division of Macromolecular Structure is to support interdisciplinary research in new methods of structure determination, the combination of computational and experimental structural biology approaches, and developing and maintaining infrastructure for macromolecular structure determination. The Division will work closely and coordinate their activities with faculty and Departments in the University who use structural information to understand function as well as other Centers that provide leadership in Structural Biology and Biophysics.

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: http://proteomics.case.edu/index.html or e-mail: proteomics@case.edu.

### Center for Psychoanalytic Child Development

The Center for Psychoanalytic Child Development is to be led by a child psychoanalyst affiliated with the Hanna Perkins Center for Child Development, located in Shaker Heights, Ohio. The Center’s goals include the development of courses, practica, and supervisory experiences appropriate for medical students, residents, and fellows.

### The Center for RNA Molecular Biology

Phone: 216.368.1852

http://www.case.edu/med/macenter/home.htm

Timothy W. Nilsen, PhD, Director

The Center for RNA Molecular Biology 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 RNA Center is currently composed of 8 primary faculty members and 10 secondary members.

The RNA Center contains the largest concentration of RNA molecular biologists in the nation. Collectively, the faculty of the RNA Center cover nearly every aspect of RNA research. Current research in the Center focuses on several of these 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, and University Hospitals System. 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. In addition, a comprehensive laboratory manual on RNA technology has been co-authored by the Center’s director, Dr. Nilsen.

### 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 (CWS) 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 in 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: 216.778.4993
John R. Sedor, MD, co-director
Tyler Miller, MD, co-director
Donald E. Hricik, MD, co-director
Walter Boron, MD, PhD, co-director

Kidney disease is the ninth leading cause of death according to the Centers for Disease Control data. Health care costs for approximately 500,000 patients, who are being treated with dialysis [artificial kidney machine] or who received a kidney transplant, consumed almost 1% of the federal budget in 2008. Up to 26 million U.S. residents have evidence of serious kidney disease

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 and the Department of Physiology and other clinical and basic departments. Research interests of the faculty include glomerular development and disease, epithelial cell biology and ion transport, tubular physiology, genetic epidemiology, health services research, renal transplantation, health disparities research and clinical trials. Research faculty applies cellular, molecular biological, genetic, genomic and epidemiological methods to in vitro models, animal models and/or patients. Many projects by Center investigators use health data, culled from robust 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: 216.368.3614
http://www.ncrm.us/
Stanton L. Gerson, MD, Director
Jeremy Rich, MD, PhD, Co-Director
Mariesa Malinowski, Executive Director

The Center for Regenerative Medicine 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.

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

The Clinical Research program is designed for individuals with an existing degree in medicine, dentistry, nursing, or an allied science such as pharmacy or biomedical engineering. Moreover, a track has also been established for medical students interested in obtaining dual MD/MS degree. The program seeks individuals committed to a career in clinical investigation in an academic or related environment. The program consists of a total of 36 credits: 27 credit hours of coursework, 9 credit hours of mentored research and a formal oral thesis defense. The curriculum offers both focus and flexibility. Focus is provided through a core curriculum (13 credit hours) highlighting clinical research methods, the ethical conduct of research, and a seminar series that introduces the skills necessary for scholarly success. 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 (14 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.

CRSP Curriculum

36 credit hours are required for completion of this Master of Science in Clinical Research degree.

Core Courses and Thesis Requirement

| CRSP 401 | Introduction to Clinical Research Summer Series | 3 |
| CRSP 402 | Study Design and Epidemiologic Methods | 3 |
| CRSP 412 | Communication in Clinical Research - Grant Writing | 1 |
NURS 630 Advanced Statistics: Linear Models 3  
CRSP 413 Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media 1  
CRSP 603 Research Ethics and Regulation 2  
CRSP 651 Clinical Research Scholars Thesis 9  
Total Units 22  

Recommended Courses  
CRSP 406 Introduction to R Programming 2  
CRSP 407 Logistic Regression and Survival Analysis 3  
CRSP 500 Design and Analysis of Observational Studies 3  
Total Units 8  

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 include but are not limited to:  
CRSP 410 Independent Study in Clinical Research 1 - 3  
CRSP 501 Team Science - Working in Interdisciplinary Research Teams 1  
CRSP 502 Leadership Skills for Clinical Research Teams 2  
CRSP 503 Innovation and Entrepreneurship 1  
CRSP 504 Managing Research Records - A System’s Approach 2 - 3  
CRSP 505 Investigating Social Determinants of Health 2 - 3  
CRSP 510 Health Disparities 3  
EPBI 411 Introduction to Health Behavior 3  
EPBI 450 Clinical Trials and Intervention Studies 3  
EPBI 458 Statistical Methods for Clinical Trials 3  
EPBI 467 Comparative and Cost Effectiveness Research 1  

MS Clinical Research, Plan of Study  
Prep Year Units Summer  
CRSP Program starts in the Summer  
Term of First Year  
Year Total:  
First Year Units Fall Spring Summer  
Elective 2-3  
Study Design and Epidemiologic Methods (CRSP 402) 3  
Communication in Clinical Research - Grant Writing (CRSP 412) 1  
Advanced Statistics: Linear Models (NURS 630) 3  

Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media (CRSP 413) 1  
Design and Analysis of Observational Studies (CRSP 500) 3  
Elective 3  
Introduction to Clinical Research Summer Series (CRSP 401) 3  
Introduction to R Programming (CRSP 406) 2  
Year Total: 9-10 7 5  
Second Year Units Fall Spring Summer  
Research Ethics and Regulation (CRSP 603) 2  
Clinical Research Scholars Thesis (CRSP 651) 3  
Elective 3  
Clinical Research Scholars Thesis (CRSP 651) 3  
Year Total: 8 3 3  
Total Units in Sequence: 35-36  

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) 6  
CMED 401 Intro to Clinical Research and Scientific Writing 3  or CRSP 401 Introduction to Clinical Research Summer Series  
CMED 402 Statistical Science for Medical Research 3  
CMED 403 Introduction to Clinical Epidemiology 3  or CRSP 402 Study Design and Epidemiologic Methods  
CMED 404 Clinical Research Seminars (*) 1  or CRSP 412 Communication in Clinical Research - Grant Writing  
CMED 405 Clinical Research Seminars (*) 1  or CRSP 413 Communication in Clinical Research - Oral Presentation, Posters, and the Mass Media  
CMED 450 Clinical Trials 3  or EPBI 450 Clinical Trials and Intervention Studies  
CMED 458 Statistical Modeling with Applications in Clinical Research 3  or EPBI 458 Statistical Methods for Clinical Trials  
CMED 500 Scientific Integrity in Biomedical Research 0-1
or IBMS 500  On Being a Professional Scientist: The Responsible Conduct of Research

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMED 601</td>
<td>Clinical Research Project</td>
<td>18</td>
</tr>
<tr>
<td>IBIS 600</td>
<td>Exam in Biomedical Investigation</td>
<td>0</td>
</tr>
</tbody>
</table>

Program Advisors: Dr. Dennis Stacey (College students) and Dr. William Merrick (University students).

Registration permits for all CMED courses can be obtained from Dr. Ticknor’s office.

**Certificate in Global Health**

Ronald Blanton, MD  216.368.4814

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 Anthropology, Bioethics, Biology, Biostatistics/Epidemiology, Mathematics, Medicine, Nursing, Engineering) 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 301/401 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>
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</thead>
<tbody>
<tr>
<td>INTH 301</td>
<td>Fundamentals of Global Health</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 215</td>
<td>Health, Culture, and Disease: An Introduction to Medical Anthropology</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 359</td>
<td>Introduction to International Health</td>
<td>3</td>
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</table>

And one elective selected from list of approved electives in the Anthropology Department

*Graduate:*

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
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<td>INTH 401</td>
<td>Fundamentals of Global Health</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 459</td>
<td>Introduction to International Health</td>
<td>3</td>
</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

**Bioethics**

<table>
<thead>
<tr>
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<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>BETH 414</td>
<td>International Health Research Ethics</td>
<td>3</td>
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</tbody>
</table>

And complete one elective selected from list of approved electives in the Bioethics Department

**Epidemiology/Biostatistics**

<table>
<thead>
<tr>
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<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>EPBI 484</td>
<td>Global Health Epidemiology</td>
<td>1-3</td>
</tr>
<tr>
<td>EPBI 494</td>
<td>Infectious Disease Epidemiology</td>
<td>3</td>
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</tbody>
</table>

And complete an epidemiology research project with global perspective (may be substituted with other course work).

**Math/Applied Math specialization:**

<table>
<thead>
<tr>
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<th>Title</th>
<th>Credits</th>
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<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>
<td>3</td>
</tr>
<tr>
<td>EPBI/ANAT/BIOL 431</td>
<td>Statistical Methods I (A basic course in Epidemiology or Biostatistics)</td>
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</tr>
<tr>
<td>or EPBI 490</td>
<td>Epidemiology: Introduction to Theory and Methods</td>
<td>3</td>
</tr>
<tr>
<td>MATH 449</td>
<td>Dynamical Models for Biology and Medicine</td>
<td>3</td>
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<tr>
<td>or EECS 397/600</td>
<td>Special Topics</td>
<td>3</td>
</tr>
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</table>

Complete a heal related modeling project with global perspective (may be substituted with other course work).

**Contact:** Daniel Guraliere (david.guralie@case.edu), 216.368.2857

**Medicine**

<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>
</tbody>
</table>

Compete 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>
<td>3</td>
</tr>
</tbody>
</table>

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>
<td>3</td>
</tr>
<tr>
<td>NURS 394</td>
<td>Global Health Seminar</td>
<td>3</td>
</tr>
<tr>
<td>EPBI 484</td>
<td>Global Health Epidemiology ((Choose either one or another approved Epidemiology course))</td>
<td>1-3</td>
</tr>
</tbody>
</table>

or EPBI 494 | Infectious Disease Epidemiology

Contact: Janet McGrath (janet.mcgrath@case.edu), 216.368.2287
The Scholar's focus of oncology research provides additional guidance for a clinical investigator. A mentoring committee comprised of faculty in each Scholar is co-mentored by both a basic or behavioral scientist and methodological components of clinical and translational oncology.

Each Scholar is selected for their background and highly individualized advanced training in both clinical and translational cancer research. Eligible candidates are physicians (MD, DO or MD/PhD) with a fundamental cancer research discoveries into medical care of cancer patients. 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 IBMS 500 On Being a Professional Scientist: The 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 Course (1 hr/semester); and one elective (1-3). Additional courses include:

- Prevention, Aging and Cancer Genetics and Clinical Trials
- Stem Cell Biology and Hematopoietic Malignancy Clinical Trials
- Mechanism Based Therapeutics and 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. 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 formal didactic program includes a course in responsible conduct IBMS 500 On Being a Professional Scientist: The 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 Course (1 hr/semester); and one elective (1-3). Additional courses include:

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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 issued by the Center for Clinical Investigation. 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 Center for Clinical Investigation. Individuals who want to participate in the program will complete an 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 Center for Clinical Investigation, 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:

| CRSP 401 | Introduction to Clinical Research Summer Series | 3 |
| CRSP 402 | Study Design and Epidemiologic Methods | 3 |
| NURS 630 | Advanced Statistics: Linear Models | 3 |
| CRSP 603 | Research Ethics and Regulation | 2 |

Exit Standards: Students who complete all required coursework will submit a checklist to the Center for Clinical Investigation notifying the Center for Clinical Investigation’s Education Administrator/Manager that all coursework is completed. This administrator will verify with the registrar’s office that all requirements have been met and will then issue a certificate to the enrollee, documenting completion of the program.

Systems Biology and Bioinformatics MS and PhD Programs

216.368.2601

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 4 tracks (http://bioinformatics.case.edu/tracks.html):

- Translational Bioinformatics - Equips students to apply recent advances in genomics and proteomics to solve clinical problems in a cost-effective manner
- Clinical Research Informatics - Prepares students to analyze large clinical data repositories to derive new knowledge pertaining to health and disease
- Molecular and Computational Biology - Provides students the cutting edge tools to tackle a variety of biological problems using computational approaches
- Applied Health Informatics - Students learn methods and technology to translate data to information to knowledge in the healthcare ecosystem.

Students can choose 1 of the 4 tracks for both the M.S. and Ph.D. programs.

The SYBB participating departments and centers include:

- Biology
- Biomedical Engineering
- Center for Proteomics and Bioinformatics
- Electrical Engineering and Computer Science
- Epidemiology and Biostatistics
- Genetics and Genome Sciences
- Mathematics
- 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 three Fundamental Core Competencies and equip them for their particular thesis research discipline. Each trainee will be guided in a 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.

Fundamental Core Competencies

- Genes and proteins
- Bioinformatics and Computational Biology
- Quantitative Analysis and Modeling
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. Additional required courses for the Clinical Research Informatics and Applied Health Informatics tracks are SYBB 421 and SYBB 422 Clinical Informatics at the Bedside and the Bench Parts I and II. 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. Additional required courses for the Clinical Research Informatics and Applied Health Informatics tracks are SYBB 421 and SYBB 422 Clinical Informatics at the Bedside and the Bench Parts I and II. 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 Clinical Research Informatics Track

Plan of Study includes required courses as well as electives.

Plan of Study Grid

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
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Data Mining (EECS 435) 3
Year Total: 9

Second Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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Total Units in Sequence: 27

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 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. Additional required courses for the Clinical Research Informatics and Applied Health Informatics tracks are SYBB 421 and SYBB 422 Clinical Informatics at the Bedside and the Bench Parts I and II. At least six additional courses will be required based upon 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 grade graduate courses, 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 or via the Medical Scientist Training Program.

Sample Plan of Study for PhD Degree

Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

Plan of study includes required courses as well as electives. Visit www.bioinformatics.case.edu for information regarding Plan of Study for all SYBB Tracks.

Plan of Study Grid for Translational Bioinformatics Track

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<tr>
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Biomedical Informatics and Systems Biology Journal Club (SYBB 501) 0
Survey of Bioinformatics: Technologies in Bioinformatics (SYBB 411A) 1
### Survey of Bioinformatics: Data Integration in Bioinformatics (SYBB 411B)
1

### Survey of Bioinformatics: Translational Bioinformatics (SYBB 411C)
1

### Survey of Bioinformatics: Programming for Bioinformatics (SYBB 411D)
1

### Principles of Genetic Epidemiology (EPBI 451)
3

### Cell Biology I (CBIO 453)
4

### Systems Biology and Bioinformatics Research (SYBB 601)
1-9

### Current Proteomics (SYBB 555)
3

### Bioinformatics for Systems Biology (SYBB 459)
3

### Structural Biology (BIOL 434)
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

### Year Total:
12-20  10-18  1

### Second Year

#### Units

- **Fall**
- **Spring**

### Statistical Computing and Data Analytics (EPBI 415)
3

### Contemporary Approaches to Drug Discovery (BIOC 528)
3

### Biomedical Informatics and Systems Biology Journal Club (SYBB 501)
0

### Systems Biology and Bioinformatics Research (SYBB 601)
3

### Ethical Issues in Genetics/Genomics (BETH 412)
3

### Seminar in Genetic Epidemiology and Bioinformatics (EPBI 502)
0

### Biomedical Informatics and Systems Biology Journal Club (SYBB 501)
0

### Systems Biology and Bioinformatics Research (SYBB 601)
6

### Year Total:
9  9

### Third Year

#### Units

- **Fall**
- **Spring**

### Dissertation PhD (SYBB 701)
1-9

### Year Total:
1-9  1-9

### Fourth Year

#### Units

- **Fall**
- **Spring**

### Dissertation PhD (SYBB 701)
1-9

### Year Total:
1-9  1-9

### Fifth Year

#### Units

- **Fall**
- **Spring**

### Dissertation PhD (SYBB 701)
1-9

### Year Total:
1-9  1-9

### Total Units in Sequence:
51-115

### Footnotes

* Students admitted into program via BSTP would take BSTP 400 for research rotations; students admitted via 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 Code</th>
<th>Course Name</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>SYBB 459</td>
<td>Bioinformatics for Systems Biology</td>
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<tr>
<td>SYBB 555</td>
<td>Current Proteomics</td>
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<tr>
<td>SYBB 501</td>
<td>Biomedical Informatics and Systems Biology</td>
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<tr>
<td>SYBB 601</td>
<td>Systems Biology and Bioinformatics Research</td>
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<tr>
<td>SYBB 651</td>
<td>Thesis MS (For MS students only)</td>
<td>1-18</td>
</tr>
<tr>
<td>SYBB 701</td>
<td>Dissertation PhD (For PhD students only)</td>
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### Required Core Courses for the Clinical Research Informatics and Applied Health Informatics Tracks of the MS and PhD programs

#### Course List

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<tr>
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<tbody>
<tr>
<td>SYBB 421</td>
<td>Fundamentals of Clinical Information Systems</td>
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<tr>
<td>SYBB 422</td>
<td>Clinical Informatics at the Bedside and the Bench (Part II)</td>
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<tr>
<td>SYBB 501</td>
<td>Biomedical Informatics and Systems Biology</td>
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<tr>
<td>SYBB 601</td>
<td>Systems Biology and Bioinformatics Research</td>
<td>1-18</td>
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<tr>
<td>SYBB 651</td>
<td>Thesis MS (For MS students only)</td>
<td>1-18</td>
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<tr>
<td>SYBB 701</td>
<td>Dissertation PhD (For PhD students only)</td>
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</table>

### Elective Courses for MS and PhD programs

#### Genes and Proteins Courses

#### Course List

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<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
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<tr>
<td>EPBI/GENE/MPHP 451</td>
<td>Principles of Genetic Epidemiology</td>
<td>3</td>
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<tr>
<td>CLBY 555/BIOC 555/PATH 555</td>
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Bioinformatics and Computational Biology Courses

Course List

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<thead>
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<tbody>
<tr>
<td>EPBI 415</td>
<td>Statistical Computing and Data Analytics</td>
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</tr>
<tr>
<td>BIOL/ECCS 419</td>
<td>Applied Probability and Stochastic Processes for Biology</td>
<td>3</td>
</tr>
<tr>
<td>PHRM/PHOL/</td>
<td>Advanced Methods in Structural Biology</td>
<td>1 - 6</td>
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<tr>
<td>CHEM/BIOC 430</td>
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<tr>
<td>EECS 458</td>
<td>Introduction to Bioinformatics</td>
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<tr>
<td>NEUR 478/BIOL</td>
<td>Computational Neuroscience</td>
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<tr>
<td>478/EBME 478</td>
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<tr>
<td>GENE 508</td>
<td>Bioinformatics and Computational Genomics</td>
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<tr>
<td>BIOC 430</td>
<td>Advanced Methods in Structural Biology</td>
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Quantitative Analysis and Modeling

Course List

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<tr>
<td>EPBI 431</td>
<td>Statistical Methods I</td>
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<tr>
<td>EPBI 432</td>
<td>Statistical Methods II</td>
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<tr>
<td>EPBI 480</td>
<td>Introduction to Statistical Theory</td>
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<td>EPBI 481</td>
<td>Theoretical Statistics I</td>
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<tr>
<td>EPBI 482</td>
<td>Theoretical Statistics II</td>
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<tr>
<td>EPBI 460</td>
<td>Introduction to Health Services Research</td>
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</tr>
<tr>
<td>EPBI 515</td>
<td>Secondary Analysis of Large Health Care Data Bases</td>
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<tr>
<td>MHPH 405</td>
<td>Statistical Methods in Public Health</td>
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<tr>
<td>EECS 435</td>
<td>Data Mining</td>
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<tr>
<td>EECS 440</td>
<td>Machine Learning</td>
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<tr>
<td>MATH 441</td>
<td>Mathematical Modeling</td>
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<tr>
<td>EBME 300/MATH 449</td>
<td>Dynamics of Biological Systems: A Quantitative Approach</td>
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<tr>
<td>MIDS 301</td>
<td>Introduction to Information: A Systems and Design Approach</td>
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CMED Courses

CMED 401. Intro to Clinical Research and Scientific Writing. 3 Units.
This seminar brings in numerous experts to cover a variety of essential issues and concepts in clinical research and scientific writing. The overarching goal is for students to produce a short but well-crafted research proposal. Topics for reading and discussion include general principles of research design and proposal development; key concepts and issues in biostatistical science for study planning, data management, analysis, interpretation, and presentation; modern medical library informatics; ethical issues in clinical research and necessary rigmarole; technical writing emphasizing research proposals; designing studies of diagnostic tests; outcomes research and medical decision making; clinical genomics research.

CMED 402. Statistical Science for Medical Research. 3 Units.
A rigorous, practical introduction to core concepts and methods in statistical planning, managing, and analyzing data, and interpreting and communicating biostatistical information. Seminar sessions: discuss readings, work through realistic examples using popular commercial software. Project sessions: individuals in small groups discuss their own examples and receive on-the-spot feedback. Topics: types of data and common distributions; database and statistical software; understanding and describing data with simple statistics and effective tables and graphics; statistical transforms (log, logit) and what they imply, basic inference tests, confidence intervals, and related sample-size analyses involving categorical data (analyzing proportions), ordinal data (analyzing ranks), continuous data (analyzing means), and time-to-event data with censoring. A substantial introduction to statistical modeling unifies seemingly diverse methods to induce a cohesive, flexible, and broad understanding of biostatistics. Medical students enrolled in CRSP must complete CCLCM Introduction to Clinical Research, IBIS 431 and IBIS 490 to satisfy the CRSP 401, 402 and 403 series. Prereq: Must be enrolled in School of Medicine.

CMED 403. Introduction to Clinical Epidemiology. 3 Units.
Using multiple learning modalities, including case-based seminars, computer-based interactive learning, journal club, and readings from texts as well as contemporary clinical literature, students will receive a rigorous introduction to methods of research in clinical epidemiology. Topics to be covered will include human subjects protections; legal and ethical components of clinical research; measures of disease frequency; basics of clinical study design; nature of and analysis of risk factors; cohort study design and analysis; case-control study design and analysis; confounding; interaction; bias; survey research; diagnostic tests; disease screening; design, analysis, and reporting of clinical trials; meta-analysis; decision analysis; cost-effectiveness analysis; and a brief introduction to health services research. Medical students enrolled in CRSP must complete CCLCM Introduction to Clinical Research, IBIS 431, and IBIS 490 to satisfy the CRSP 401, 402, and 403 series. Prereq: Must be enrolled in School of Medicine.

CMED 404. Clinical Research Seminars. 1 Unit.
The Clinical Research Seminars series is intended to give students a broad exposure to issues unique to clinical research as well as career development. Students attend seminars on relevant clinical research topics offered either on the Case or CCF campuses, and will write a short summary of each seminar attended. A total of 12-14 one-hour seminars per semester is required for successful completion of the course. Students are expected to take two semesters. Prereq: Must be enrolled in School of Medicine and consent of CCLCM Office.
CMED 405. Clinical Research Seminars. 1 Unit.
The Clinical Research Seminars series is intended to give students a broad exposure to issues unique to clinical research as well as career development. Students attend seminars on relevant clinical research topics offered either on the Case or CCF campuses, and will write a short summary of each seminar attended. A total of 12-14 one-hour seminars per semester is required for successful completion of the course. Students are expected to take two semesters. Prereq: Must be enrolled in School of Medicine and consent of CCLCM Office.

CMED 406. Introduction to Database Programming Base SAS. 0 Units.
Using the SAS Data Step as a programming language. Creating temporary and permanent SAS datasets, exchanging datasets with other software (e.g. Excel, Jmp, R), checking and manipulating data, sorting and merging, producing reports. Effective programming style. This is not a course in statistical analysis. Prereq: Must be enrolled in the School of Medicine and consent of CCLCM Office.

CMED 407. Basic Research Ethics. 3 Units.
Examine the ethical issues of clinical research involving human subjects. Topics include research versus clinical practice, informed consent, therapeutic misconception, risk reduction, vulnerability and subject selection, recruitment and inducement.

CMED 450. Clinical Trials. 3 Units.
Design, organization and operation of randomized controlled clinical trials and intervention studies. Topics include ethical issues in 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 mistakes. Prereq: Must be enrolled in School of Medicine.

CMED 458. Statistical Modeling with Applications in Clinical Research. 3 Units.
Statistical modeling methods and strategies for analyzing data in clinical research, including randomized and non-randomized clinical trials. Standard Normal-theory, logistic, and Cox proportional hazard regression methods, emphasizing that these tools provide a unified schema to use linear models for continuous and categorical predictors of outcomes that are continuous, binary, or time-to-event with censoring. Repeated measures analysis using summary measures versus modern mixed models. Spline models for non-linear relationships. Extending the logistic model for ordinal outcomes. Propensity analysis. Software: R. Prereq: Must be enrolled in School of Medicine and consent of CCLCM Office.

CMED 460. Foundations of Clinical Medicine. 3 Units.
Students meet weekly to examine, and discuss issues related to their future societal and professional roles as physicians. Topics covered include population health, medical errors and patient safety, cultural competence, health care disparities, quality improvement, pain management, ethical and legal issues in medicine, leadership, and professionalism. Prereq: Must be enrolled in School of Medicine and consent of CCLCM Office.

CMED 499. Independent Study in Clinical Trials. 3 Units.
A survey of the various aspects of clinical trial investigation to provide the student a first-hand perspective on the day-to-day conduct of clinical investigation from the perspective of investigating physicians, clinical trial coordinators, compliance and regulatory officers, and core laboratory personnel. Students will develop a specific plan with the course directors that will total 40-50 hours of discussion and direct participation. Prereq: CMED 460. Must be enrolled in the School of Medicine and consent of CCLCM Office.

CMED 500. Scientific Integrity in Biomedical Research. 0 Units.
This course covers a wide variety of topics in ethics for biomedical researchers including Institutional Review Boards for human and animal experimentation, requirements of the Health Insurance Portability and Accountability Act (HIPAA), informed consent, and de-identification of patient data in research databases. Issues of data ownership, responsibilities of authorship, and conflicts of interest are also discussed. Prereq: Enrolled in School of Medicine. Must have completed 1.5 years.

CMED 601. Clinical Research Project. 9 Units.
Clinical research project leading toward the completion of a type B Masters of Science in Biomedical Investigation - CRSP.

CNCR Courses

CNCR 460. Introduction to Microarrays. 3 Units.
Microarray technology is an exciting new technique that is used to analyze gene expression in a wide variety of organisms. The goal of this course is to give participants a hands-on introduction to this technology. The course is intended for individuals who are preparing to use this technique, including students, fellows, and other investigators. This is a hands-on computer-based course, which will enable participants to conduct meaningful analyses of microarray data. Participants will gain an understanding of the principles underlying microarray technologies, including: theory of sample preparation, sample processing on microarrays, familiarity with the use of Affymetrix Microarray Suite software and generation of data sets. Transferring data among software packages to manipulate data will also be discussed. Importation of data into other software (GeneSpring and DecisionSite) will enable participants to mine the data for higher-order patterns. Participants will learn about the rationale behind the choice of normalization and data filtering strategies, distance metrics, use of appropriate clustering choices such as K-means, Hierarchical, and Self Organizing Maps. Course Offered as BIOC 460, PATH 460, CNCR 460.

CNCR 501. Translational Cancer Research A. 1 Unit.
In this course Case K12 Paul Calabresi Scholars will learn about the steps to receive an IRB approval for their research proposal and clinical trials; how to design and conduct clinical trials-designing a protocol, developing a research question, the purpose of the LOI, funding and budge issues, working with pharmaceutical companies; essential writing skills for successfully submitting a manuscript for publication in a peer reviewed journal. The class will discuss Social Intelligence and the Biology of Leadership by Goleman and Boyatzis; the scholars will learn about the Case Cancer Center Core Facilities services and resources which are available for their research projects. Topics also include the expectations of the K12 CORP program and essential elements for advancing their academic and research career. Recommended preparation: Acceptance to Case K12 Clinical Oncology Career Development Training Program as Paul Calabresi Research Scholar.
CNCR 502. Translational Cancer Research B. 1 Unit.
In this course Case K12 Paul Calabresi Scholars will learn how to manage clinical trials; including staffing, multi or single site, contracting issues, translation and incorporation of laboratory research/correlative science into clinical trials design, getting involved with ECOG. The scholars will learn about mentored and independent funding resources, how to select the appropriate mechanism, and strategies for successful grant submissions and resubmissions. They will learn how to present research and clinical trials progress orally and written to peers/faculty for evaluation my making two PowerPoint presentations: on to the class and their two K12 mentors and a second to the K12 CORP Advisory Committee for written evaluation. Both of these sections will be videotaped and a copy of the tape will be reviewed with the scholar. Each scholar will also provide a written summary of their research to date along with their goals for the next 12 months on April 1. Recommended preparation: Acceptance to Case K12 Clinical Oncology Career Development Training Program as Paul Calabresi Research Scholar.

CNCR 503. Translational Cancer Research C. 1 Unit.
In this course each Case K12 Paul Calabresi Scholar will present a summary of their experience from attending either the ASCO/AACR or ASH Clinical Trial Protocol Writing Workshop; two sessions will cover how to write a research proposal-hypothesis, specific aims, methods, and study design. Each scholar will write a sample research proposal which will be critiqued by the other members of the class; two sessions will cover the organization and analysis of biostatistic data used in research. One of these sessions will be a working session based on the scholar's own data. The scholars will learn about the essential components and issues in developing a successful career in clinical and translational research. Recommended preparation: Acceptance to Case K12 Clinical Oncology Career Development Training Program as Paul Calabresi Research Scholars.

CNCR 504. Translational Cancer Research D. 1 Unit.
In this course Case K12 Paul Calabresi Scholars will discuss an article on essential components of leadership in an academic and clinical setting; how to advance their clinical research career to the level that they can present at the ASCO national conference; learn how to present research and clinical trials progress orally and written to peers/ faculty for evaluation by making two PowerPoint presentations: one to the class and their two K12 mentors and a second to the K12 CORP Advisory Committee for written evaluation. Both of these sessions will be videotaped and a copy of the tape will be reviewed with the scholar. Each scholar will also provide a written summary of their research and date along with their goals for the next 12 months on April 1. Recommended preparation: Acceptance to Case K12 Clinical Oncology Career Development Training Program as Paul Calabresi Research Scholar.

CRSP Courses
CRSP 401. Introduction to Clinical Research Summer Series. 1 - 3 Unit.
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 the 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 Unit.
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., manuscript, essay, grant proposal, or other written product; examination, etc.). It is expected that there will be at least one contact hour per week for each credit hour requested.

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 K12 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. This objective will be achieved through a combination of didactic sessions, readings, and presentations by the students. 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, EPBI 431 and MPH 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, EPBI 432, CRSP432 and MPH 432. Prereq: 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 Units.
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 EPBI 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, EPBI 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. 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. Offered as CRSP 550 and EPBI 550. Prereq: CRSP 401, EPBI 431, MPHP 405, NURS 532 or Requisites Not Met permission.

CRSP 601. Research Practicum. 1 - 3 Unit.
Research practicum and/or laboratory rotation.

CRSP 603. Research Ethics and Regulation. 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 603.

CRSP 651. Clinical Research Scholars Thesis. 1 - 18 Unit.
CRSP Thesis M.S.

CRSP 701. Dissertation Ph.D.. 1 - 9 Unit.
Ph.D. Dissertation credits. Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

INTH Courses

INTH 301. Fundamentals of Global Health. 3 Units.
This course seeks to integrate the multiple perspectives and objectives in global health by investigating how the disciplines of Biology, Medicine, Anthropology, Nursing, Mathematics, Engineering analyze and approach the same set of international health problems. Students will develop a shared vocabulary with which to understand these various perspectives from within their own discipline. The focus sites will emphasize issues related to the health consequences of development projects, emergency response to a health care crisis and diseases of development in presence of underdevelopment. Offered as INTH 301 and INTH 401. Prereq: Junior or senior.
INTH 401. Fundamentals of Global Health. 3 Units.
This course seeks to integrate the multiple perspectives and objectives in global health by investigating how the disciplines of Biology, Medicine, Anthropology, Nursing, Mathematics, Engineering analyze and approach the same set of international health problems. Students will develop a shared vocabulary with which to understand these various perspectives from within their own discipline. The focus sites will emphasize issues related to the health consequences of development projects, emergency response to a health care crisis and diseases of development in presence of underdevelopment. Offered as INTH 301 and INTH 401. Prereq: Graduate student.

INTH 447. Global Health: Outbreak Investigation in Real-Time. 3 Units.
This course provides a trans-cultural, trans-disciplinary, multimedia learning experience by analyzing historical and real-time data from the annual dengue endemics and sporadic epidemics in Puerto Rico and Brazil. A rigorous problem-centered training in the epidemiology, prevention, treatment, and control of infectious diseases using real-time and historical surveillance data of endemic and epidemic Dengue in Bahia, Brazil. This is an advanced epidemiology course in which core material will be primarily taught through reading assignments, class discussion, group projects, and class presentations. The course will utilize the online web-based communication and learning technology to create a single classroom between the CWRU and international partners with unique and complementary skills. In addition to joint classroom lectures across sites, student groups will also perform smaller-scale videoconference meetings for assigned group projects, thus creating strong international connections for the students, faculty, and our institutions. Note: Due to the complexities of time zones for this international course, the course will begin at 8:00a.m. until the U.S.A. adjusts clocks for Daylight Savings Time (unlike Brazil). Therefore, classes after the second week of March will begin at 9:00a.m. Offered as: EPBI 447, INTH 447, and MPHP 447.

INTH 484. Global Health Epidemiology. 1 - 3 Unit.
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 EPBI 484, INTH 484, and MPHP 484.

INTH 494. Infectious Disease Epidemiology. 3 Units.
This course focuses on tuberculosis (TB) and HIV epidemiology, including perspectives on these diseases in the US and globally. It is a follow-up to EPBI/MPHP 484: Global Health Epidemiology, but these courses do not necessarily need to be taken in sequence. This is an advanced course, focusing on methods and approaches in epidemiology and public health. Offered as EPBI 494, INTH 494 and MPHP 494. Prereq: EPBI 490.

INTH 551. World Health Seminar. 1 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. Additionally we will discuss intellectual property policies on global access to medical innovations. Topics will also include neglected diseases and the interactions between these diseases with HIV and malaria infections. 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.

SYBB Courses

SYBB 311A. Survey of Bioinformatics: Technologies in Bioinformatics. 1 Unit.
SYBB 311/411A is a 5-week course that introduces students to the high-throughput technologies used to collect data for bioinformatics research in the fields of genomics, proteomics, and metabolomics. In particular, we will focus on mass spectrometer-based proteomics, DNA and RNA sequencing, genotyping, protein microarrays, and mass spectrometry-based metabolomics. This is a lecture-based course that relies heavily on out-of-class readings. Graduate students will be expected to write a report and give an oral presentation at the end of the course. SYBB 311/411A is part of the SYBB survey series which is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming skills. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311A, SYBB 311B, and SYBB 411A. Prereq: (BIOL 214 and BIOL 215) or BIOL 250. Coreq: SYBB 311B, SYBB 311C, and SYBB 311D.

SYBB 311B. Survey of Bioinformatics: Data Integration in Bioinformatics. 1 Unit.
SYBB 311/411B is a five week course that surveys the conceptual models and tools used to analyze and interpret data collected by high-throughput technologies, providing an entry point for students new to the field of bioinformatics. The knowledge structures that we will cover include: biomedical ontologies, signaling pathways, and interaction networks. We will also cover tools for genome exploration and analysis. The SYBB survey series is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming skills. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311A, SYBB 311B, SYBB 311C, and SYBB 411D.
SYBB 311C. Survey of Bioinformatics: Translational Bioinformatics. 1 Unit.
SYBB 311/411C is a longitudinal course that introduces students to the latest applications of bioinformatics, with a focus on translational research. Topics include: `omic drug discovery, pharmacogenomics, microbiome analysis, and genomic medicine. The focus of this course is on illustrating how bioinformatic technologies can be paired with data integration tools for various applications in medicine. The course is organized as a weekly journal club, with instructors leading the discussion of recent literature in the field of bioinformatics. Students will be expected to complete readings beforehand; students will also work in teams to write weekly reports reviewing journal articles in the field. The SYBB survey series is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311C, BIOL 311C and SYBB 411C. Prereq: (BIOL 214 and BIOL 215) or BIOL 250. Coreq: SYBB 311A, SYBB 311B, and SYBB 311D.

SYBB 311D. Survey of Bioinformatics: Programming for Bioinformatics. 1 Unit.
SYBB 311D/411D is a 1 credit, 5-week long course that will introduce students to bioinformatics software and programming in the R language; this course is designed for those with little or no prior programming experience. Students will gain hands-on experience working with R packages and functions designed for bioinformatics applications. Programming for Bioinformatics short course focuses on a platform, in this case R-project (rproject.org), and introduces students to basic programming. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311D, BIOL 311D and SYBB 411D. Prereq: (BIOL 214 and BIOL 215) or BIOL 250. Coreq: SYBB 311A, SYBB 311B, and SYBB 311D.

SYBB 319. 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 . Prereq: MATH 224 or MATH 223 and BIOL 300 or BIOL 306 and MATH 201 or MATH 307 or consent of instructor.

SYBB 322. Clinical Informatics at the Bedside and the Bench (Part II). 3 Units.
This course is part of a two semester series that provides student with an overview of the field of clinical informatics and its research applications. SYBB 422 focuses on the use of informatics in public health, epidemiology, and translational bioinformatics; topics include: pharmacosurveillance, comparative effectiveness research, and personalized medicine. Through lectures and in-depth readings of literature in the field, students will learn to approach population-level problems in medicine through the lens of "informatics", the science of information, with a focus on application over theory. Students will be required to use R (or another programming language) for data analysis assignments. Offered as SYBB 322 and SYBB 422. Prereq: SYBB 321.

SYBB 387. Undergraduate Research in Systems Biology. 1 - 3 Unit.
This course provides students research experience in data science, proteomics, bioinformatics, and clinical informatics under the guidance of faculty affiliated with the Systems Biology and Bioinformatics program. Areas of research include production of big data at bench (cellular proteomics, structural proteomics, genomics, and interaction proteomics) and analysis of big data such as computational/statistical biology, bioinformatics tool development and clinical research informatics. A written report must be approved by the sponsor and submitted to the director of the Center for Proteomics and Bioinformatics before credit is granted.

SYBB 388. Undergraduate Research. 1 - 3 Unit.
Guided laboratory research under the sponsorship of a biology faculty member. May be carried out within the biology department or in associated departments. Appropriate forms must be secured in the biology department office. A written report must be approved by the biology sponsor and submitted to the chairman of the biology department before credit is granted. Only 3 credit-hours may count towards the biology majors or minor. Offered as BIOL 388 and SYBB 388.
SYBB 388S. Undergraduate Research - SAGES Capstone. 3 Units.
Guided laboratory research under the sponsorship of a biology faculty member. May be carried out within the biology department or in associated departments. May be taken only one semester during the student's academic career. Appropriate forms must be secured in the biology department office. A written report must be approved by the biology sponsor and submitted to the chairman of the biology department before credit is granted. A public presentation is required. Offered as BIOL 388S and SYBB 388S. Counts as SAGES Senior Capstone.

SYBB 411A. Survey of Bioinformatics: Technologies in Bioinformatics. 1 Unit.
SYBB 311/411A is a 5-week course that introduces students to the high-throughput technologies used to collect data for bioinformatics research in the fields of genomics, proteomics, and metabolomics. In particular, we will focus on mass spectrometer-based proteomics, DNA and RNA sequencing, genotyping, protein microarrays, and mass spectrometry-based metabolomics. This is a lecture-based course that relies heavily on out-of-class readings. Graduate students will be expected to write a report and give an oral presentation at the end of the course. SYBB 311/411A is part of the SYBB survey series which is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming skills. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311A, BIOL 311A and SYBB 411A. Prereq: Graduate Standing or Requisites Not Met Permission.

SYBB 411B. Survey of Bioinformatics: Data Integration in Bioinformatics. 1 Unit.
SYBB 311/411B is a five week course that surveys the conceptual models and tools used to analyze and interpret data collected by high-throughput technologies, providing an entry point for students new to the field of bioinformatics. The knowledge structures that we will cover include: biomedical ontologies, signaling pathways, and interaction networks. We will also cover tools for genome exploration and analysis. The SYBB survey series is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming skills. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311A, BIOL 311B and SYBB 411B. Prereq: Graduate Standing or Requisites Not Met Permission.

SYBB 411C. Survey of Bioinformatics: Translational Bioinformatics. 1 Unit.
SYBB 311/411C is a longitudinal course that introduces students to the latest applications of bioinformatics, with a focus on translational research. Topics include: ’omic drug discovery, pharmacogenomics, microbiome analysis, and genomic medicine. The focus of this course is on illustrating how bioinformatic technologies can be paired with data integration tools for various applications in medicine. The course is organized as a weekly journal club, with instructors leading the discussion of recent literature in the field of bioinformatics. Students will be expected to complete readings beforehand; students will also work in teams to write weekly reports reviewing journal articles in the field. The SYBB survey series is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311C, BIOL 311C and SYBB 411C. Prereq: Graduate Standing or Requisites Not Met Permission.

SYBB 411D. Survey of Bioinformatics: Programming for Bioinformatics. 1 Unit.
SYBB 311/411D is a 1 credit, 5-week long course that will introduce students to bioinformatics software and programming in the R language; this course is designed for those with little or no prior programming experience. Students will gain hands-on experience working with R packages and functions designed for bioinformatics applications. Programming for Bioinformatics short course focuses on a platform, in this case R-project (rproject.org), and introduces students to basic programming in R, what packages are available for their use, and teaches an introductory hands-on experience working with R by walking through the students in analyzing a large-omics dataset. At the end of the class, the students are assessed with a small-scale project, where they analyze a publicly available dataset and produce a short report. The SYBB survey series is composed of the following course sequence: (1) Technologies in Bioinformatics, (2) Data Integration in Bioinformatics, (3) Translational Bioinformatics, and (4) Programming for Bioinformatics. Each standalone section of this course series introduces students to an aspect of a bioinformatics project - from data collection (SYBB 311/411A), to data integration (SYBB 311/411B), to research applications (SYBB 311/411C), with a fourth module (SYBB 311/411D) introducing basic programming. Graduate students have the option of enrolling in all four courses or choosing the individual modules most relevant to their background and goals with the exception of SYBB411D, which must be taken with SYBB411A. Offered as SYBB 311D, BIOL 311D and SYBB 411D. Prereq: Graduate Standing or Requisites Not Met Permission.
SYBB 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.

SYBB 421. Fundamentals of Clinical Information Systems. 3 Units.
Technology has played a significant role in the evolution of medical science and treatment. While we often think about progress in terms of the practical application of, say, imaging to the diagnosis and monitoring of disease, technology is increasingly expected to improve the organization and delivery of healthcare services, too. Information technology plays a key role in the transformation of administrative support systems (finance and administration), clinical information systems (information to support patient care), and decision support systems (managerial decision-making). This introductory graduate course provides the student with the opportunity to gain insight and situational experience with clinical information systems (CIS). Often considered synonymous with electronic medical records, the “art” of CIS more fundamentally examines the effective use of data and information technology to assist in the migration away from paper-based systems and improve organizational performance. In this course we examine clinical information systems in the context of (A) operational and strategic information needs, (B) information technology and analytic tools for workflow design, and (C) subsequent implementation of clinical information systems in patient care. Legal and ethical issues are explored. The student learns the process of “plan, design, implement” through hands-on applications to select CIS problems, while at the same time gaining insights and understanding of the impacts placed on patients and health care providers. Offered as EBME 473, IIME 473 and SYBB 421.

SYBB 422. Clinical Informatics at the Bedside and the Bench (Part II). 3 Units.
This course is part of a two semester series that provides student with an overview of the field of clinical informatics and its research applications. SYBB 422 focuses on the use of informatics in public health, epidemiology, and translational bioinformatics; topics include: pharmacovisualization, comparative effectiveness research, and personalized medicine. Through lectures and in-depth readings of literature in the field, students will learn to approach population-level problems in medicine through the lens of “informatics”, the science of information, with a focus on application over theory. Students will be required to use R (or another programming language) for data analysis assignments. Offered as SYBB 322 and SYBB 422. Prereq: SYBB 321.

SYBB 437. Laboratory Course in Proteomics. 3 Units.
SYBB 437 is designed to train students, postdoctoral fellows, and senior investigators in advanced methods in quantitative proteomics in the context of investigating the effects of pH on protein expression in the model organism E-coli. This intensive laboratory class is a 3-credit laboratory course and will be offered for a scheduled three hours time block once each week. In this course, we will cover topics in proteomics including protein sample preparation, total protein quantification, gel based separation and quantification methods, quantitative high throughput mass spectrometry and data analysis methods for examining these high throughput data. Students enrolled in SYBB 437 will be expected to turn in weekly lab reports summarizing their findings on each of the lab topics and will write two project reports at the end of labs 9 and 14 interpreting and summarizing the results obtained.

SYBB 459. Bioinformatics for Systems Biology. 3 Units.

SYBB 472. BioDesign. 3 Units.
Medical device innovations that would have been considered science fiction a decade ago are already producing new standards of patient care. Innovation leading to lower cost of care, minimally invasive procedures and shorter recovery times is equally important to healthcare business leaders, educators, clinicians, and policy-makers. Innovation is a driver of regional economic development and wealth creation in organizational units ranging in size from the start-up to the Fortune 500 companies. In a broader context, the pace of translational research leading to product and service innovation is highly interdisciplinary, thus, new products and services result from team efforts, marked by a systematic, structured approach to bringing new medical technologies to market and impacting patient care. In this course we examine medical technology innovations in the context of (A) addressing unmet clinical needs, (B) the process of inventing new medical devices and instruments, and (C) subsequent implementation of these advances in patient care. In short, the student learns the process of “identify, invent, implement” in the field of BioDesign. Offered as EBME 472, IIME 472 and SYBB 472.
SYBB 501. Biomedical Informatics and Systems Biology Journal Club. 0 Units.
The purpose of this journal club is to provide an opportunity for students to critically discuss a wide variety of informatics and systems biology topics and to present their works in progress. A wide range of informatics and systems theory approaches to conducting biomedical research will be accomplished through the guided selection of articles to be discussed during the club. Potential articles will be chosen from scientific journals including: Nature, Science, BMC Bioinformatics, BMC Systems Biology, the Journal of Bioinformatics and Computational Biology, and the Journal for Biomedical Informatics. During journal presentations, trainees will be expected to lead a discussion of the article that leads to the critical evaluation of the merit of the article and its implication for biomedical informatics and systems biology. The Journal Club will also provide a forum for trainees to present proposed, on-going, and completed research. Trainees will attend and participate in the Journal Club throughout their tenure in the program. The Journal Club will meet twice a month and each trainee will be required to present one journal article and one research in progress presentation yearly. The Journal Club will also include sessions where issues related to the responsible conduct of research are reviewed and extended.

SYBB 502. Clinical Informatics Journal Club. 0 Units.
The Clinical Informatics Journal Club serves as a forum for students to present current research in the field of clinical informatics. Students are required to coregister for SYBB 421 or SYBB 422; weekly lectures in SYBB 421/422 will introduce topics for discussion in the journal club. Coreq: SYBB 421 or SYBB 422

SYBB 535. Independent Study in Biomedical Informatics. 1 - 3 Unit.
For students pursuing MS or PhD degrees in SYBB, this course provides the opportunity for in-depth exposure to a subfield of systems biology and/or biomedical informatics. Degree-seeking students can enroll in this course prior to beginning 601 or 701 research. In conjunction with their proposed research advisor, enrolled students will undertake a self-directed study of a subfield of systems biology and/or biomedical informatics pertinent to their research area. The selected readings may also represent topics not covered by the student's coursework. The student's performance will be evaluated in an end-of-semester presentation or report at their advisor's discretion.

SYBB 555. Current Proteomics. 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 hands-on experience with techniques used in current proteomics. Lectures will cover protein/peptide separation techniques, protein mass spectrometry, bioinformatics tools, and biological applications which include quantitative proteomics, protein modification proteomics, interaction proteomics, structural genomics and structural proteomics. 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 and protein identification using computational tools. The instructors' research topics will also be discussed. Recommended preparation: CBIO 453 and CBIO 455. Offered as PHRM 555 and SYBB 555.

SYBB 600. Special Topics. 1 - 18 Unit.
Offered as EECS 600 and SYBB 600.

SYBB 601. Systems Biology and Bioinformatics Research. 1 - 18 Unit.
(Credit as arranged.)

SYBB 651. Thesis MS. 1 - 18 Unit.
(Credit as arranged.)

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

Department of Genetics and Genome Sciences

Clarice Young (clarice.young@case.edu), Coordinator

The Department of Genetics & Genome Sciences embraces a unified program devoted to outstanding research and teaching in all areas of genetics, with particular emphases on genomics, human genetics and animal models, development, and chromosome structure and function. Faculty conduct internationally recognized research programs in each of these areas. The also are committed to training the next generations of leading genetics researchers. The department has three special programs: the Center for Human Genetics, the Center for Computational Genomics, and the Genomic Medicine Institute (descriptions appear later in this narrative).

Programs offered lead to the PhD, combined MD/PhD degree, or MS with a special emphasis in genetic counseling. In addition to required and elective coursework, students participate in ongoing journal clubs, research seminars and grand rounds. A program of departmental and interdepartmental seminars by outstanding visiting scientists provides regular exposure to a broad range of current research in genetics.

The department accepts direct on-line applications (http://genetics.case.edu/page.php?page_id=126) to the doctoral program by those who have significant prior research experience in genetics and are committed to careers in genetics research. The PhD program also participates in the integrated Biomedical Sciences Training Program (BSTP, please see separate listing in this publication and/or BSTP Web site). Students interested in pursuing the combined MD/PhD program are admitted through the Medical Scientist Training Program (MSTP, please see separate listing in this publication). Those students interested in careers in genetic counseling apply directly to the Genetic Counseling Training Program, via the common Graduate Studies application (http://gradstudies.case.edu).

The Center for Human Genetics is an integral part of the Department of Genetics and consists of both research and clinical laboratories involved in human and clinical genetics. This center supports research and clinical programs focusing on the molecular basis of inherited disease, human genetic disease mapping, and the genetic dissection of complex disease, as well as providing clinical care and training for postdoctoral fellows and genetic counseling students.

The Center for Computational Genomics is an interdisciplinary research and training program involving faculty in the Department of Epidemiology and Biostatistics in the School of Medicine and in the Department of Electrical Engineering and Computer Science in the School of Engineering. The center provides opportunities to combine research in genetics, genomics, epidemiology, biostatistics, computer science, and systems biology.

The Genomic Medicine Institute is a joint program involving the Cleveland Clinic Foundation and Case. Its emphasis involves translating discoveries in basic and clinical research to clinical practice. The mission is to exploit
the discoveries in genomics, epidemiology, ethics, pharmacology, genetics and physiology to revolutionize the practice of medicine.

**MS Genetic Counseling**

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, thesis 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 caring 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 American Board of Genetic Counseling (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 Case 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 through the Center for Human Genetics Diagnostic Laboratory which includes experiences in cytogenetics, molecular genetics, cancer cytogenetics and maternal serum screening. 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 ABGC.

The First Year

The major activities during the first year consist of course work (in plan of study below), clinical observations and defining a research question and preparing a research proposal. Observational clinical rotations begin early in October 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 thesis process, potential topics and are introduced to the faculty’s research areas of interest.

In addition to continuing clinical observational rotations and thesis work, 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 Center for Human Genetics 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 examination.

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 certification examination given by the American Board of Genetic Counseling.

Students continue to work on data collection and analyses for their theses projects, which should result in a publishable document. They meet with the PD periodically to review their progress as well as with their thesis committee and of course, are meeting with their mentor on a more frequent basis. During the fall semester of second year the student 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 graduating in 2012 is as follows:**

**MS Plan of Study**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td>Intensive: Medical Terminology and SOM Block 2 lectures</td>
<td></td>
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<tr>
<td>Advanced Medical Genetics: Clinical Genetics (GENE 525)</td>
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<tr>
<td>Embryology (online course)</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: Molecular &amp; Cytogenetics (GENE 524)</td>
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<tr>
<td>Advanced Medical Genetics: Quantitative Genetics &amp; Genomics (GENE 526)</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>
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<td>Family System Interventions (SASS 517)</td>
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<tr>
<td>Thesis M.S. (GENE 651)</td>
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<td>2</td>
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<tr>
<td>Cancer Genetics (GENE 531)</td>
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<tr>
<td>Clinical Practicum in Genetic Counseling (GENE 532)</td>
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<td>Year Total:</td>
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### 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 (CBIO 453 Cell Biology I/CBIO 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>Second Year</th>
<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Advanced Medical Genetics:</td>
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<tr>
<td>Biochemical Genetics (GENE 527)</td>
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<tr>
<td>or Advanced Medical Genetics:</td>
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<tr>
<td>Quantitative Genetics &amp; Genomics (GENE 526)</td>
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<tr>
<td>Clinical Practicum in Genetic Counseling (GENE 532)</td>
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<tr>
<td>Thesis M.S. (GENE 651)</td>
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<tr>
<td>Ethical and Professional Issues in Genetic Counseling (GENE 530)</td>
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<td>Total Units in Sequence:</td>
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<th>Spring</th>
<th>Summer</th>
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<tr>
<td>Cell Biology I (CBIO 453/455)</td>
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<tr>
<td>Molecular Biology I (CBIO 455)</td>
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<tr>
<td>Complete 3 lab rotations (July 1 to Dec 15)</td>
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<td>Choose Ph.D. mentor (end December)</td>
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<tr>
<td>Research in Genetics (GENE 601)</td>
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<td>Advanced Eukaryotic Genetics I (GENE 500/504)</td>
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<tr>
<td>Ph.D. Comprehensive exam (end of May or early June)</td>
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<tr>
<td>Advanced Eukaryotic Genetics II (GENE 504)</td>
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<tr>
<td>Research in Genetics (GENE 601)</td>
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<th>Second Year</th>
<th>Units</th>
<th>Fall</th>
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<tr>
<td>Grant Writing and Reviewing Skills Workshop (GENE 511)</td>
<td>3</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>
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<tr>
<td>Oral Defense of Thesis Proposal (to be completed by June 1)</td>
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<th>Third Year</th>
<th>Units</th>
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<tr>
<td>Elective</td>
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<tr>
<td>Either semester 1 elective course (Genetics or other)</td>
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<tr>
<td>Dissertation Ph.D. (GENE 701)</td>
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<th>Fourth Year</th>
<th>Units</th>
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<tr>
<td>Dissertation Ph.D. (GENE 701)</td>
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<td>Year Total:</td>
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**Total Units in Sequence:** 72

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

**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, MGM 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, transgenics, 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 508. Bioinformatics and Computational Genomics. 3 Units.
The course is designed to provide an understanding of theory and application of computational methods for molecular biology research. The course will be divided into four primary sections: DNA methods, protein methods, structure analysis (RNA and protein) and phylogenetic analysis. Special emphasis will be placed on the use and development of tools to search and analyze large amounts of sequence data generated as part of the Genome Projects in human, Drosophila and other eukaryotic organisms. The course offers extensive hands-on computational training using UNIX, Web and PC-based software. As such, for every hour of lecture material there will be two corresponding hours of computational laboratory time. In the initial year, enrollment will be limited to five students. Preference will be given to senior-level genetics graduate students or post-doctoral fellows. Recommended preparation: GENE 500 and GENE 504 or permission of instructor.

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 513. Stem Cell Genetics. 3 Units.
This course focuses on fundamental aspects of development with implications for stem cell therapy, tissue engineering, regenerative medicine and postnatal health. The goal of the class is to inform and promote critical thinking and discussion of research topics of medical importance in developmental biology. The themes of the course will include the conditions and factors which promote pluripotency and differentiation, regeneration and repair, epigenetic stability and reprogramming, and prenatal conditions which affect postnatal health. The topics will include early embryonic development and embryonic stem cells, cardiac development and regeneration, bone development and repair, pancreatic development and regeneration, germ line stem cells and conditions affecting postnatal health. The course will be structured around facilitated discussion of the primary literature.

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, microarray, 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; peroxisomal 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 530. Ethical and Professional Issues in Genetic Counseling. 2 Units.
Professional issues inherent in medical genetics and genetic counseling are addressed, including ethical, legal, religious, and cultural concepts. Fundamental principles of ethics are explored in some depth as they relate to genetic issues, such as autonomy and informed consent; use of the NSGC Code of Ethics is emphasized. Genetic counseling roles and responsibilities and aspects of a career as a professional are explored.
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, prediagnosis assessment 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 Unit.
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 Unit.
(Credit as arranged.)

GENE 651. Thesis M.S.. 1 - 9 Unit.
(Credit as arranged.) Master's Thesis Plan A.

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

Molecular Biology and Microbiology

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. 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 in throughout Case School of Medicine. The department also enjoys numerous collaborations with faculty in the Departments of Biochemistry, Neuroscience, and Genetics, the Case Comprehensive Cancer Center, the Visual Sciences Research Center, the Center for AIDS Research, and the Center for RNA Molecular Biology, 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 occurs through the common PhD admissions program, the Biomedical Sciences Training Program (p. 33). In addition, students in the Medical Scientist Training Program (p. 29) (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 provides 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 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 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 entering in 2009 or later must take two of the three following fundamental courses: (CLBY 422 Topics in Cell Biology); (CLBY 526 Cell Biology and Human Disease/MBIO 526 Cell Biology and Human Disease); or (CLBY 488 Yeast Genetics and Cell Biology).

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/schoolofgraduatestudies/academicrequirements).

### First Year

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### Second Year

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<td>5-14</td>
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Total Units in Sequence: 26-62

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 422. Topics in Cell Biology. 3 Units.**

This team-taught seminar course focuses on 3-4 distinct areas of contemporary cell biology. Faculty will present context and overview, but most time will be devoted to a close reading of the literature and discussion by students in a round table format. Recommended preparation: CBIO 453 and CBIO 455.
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. 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 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.

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, 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 and PHOL 466 and PHRM 466.

CLBY 468. Membrane Physiology. 3 Units.
This student-guided discussion/journal course focuses on biological membranes. Topics discussed include thermodynamics and kinetics of membrane transport, oxidative phosphorylation and bioenergetics, electro-physiology of excitable membranes, and whole and single channel electrophysiology, homeostasis and pH regulation, volume and calcium regulation. Offered as CLBY 468 and PHOL 468.

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/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.

CLBY 511. Cell Biology Seminar. 1 Unit.
The Cell Biology Seminar provides a forum for presentation and discussion of contemporary issues in Cell Biology. Students, fellows, local faculty and guest speakers present both research talks and journal clubs.

CLBY 512. Cell Biology Seminar. 1 Unit.
The Cell Biology Seminar provides a forum for presentation and discussion of contemporary issues in Cell Biology. Students, fellows, local faculty and guest speakers present both research talks and journal clubs.

CLBY 519. Molecular Biology of RNA. 3 Units.
Selected topics regarding editing, enzymatic function, splicing, and structure of RNA. Offered as BIOC 519, CLBY 519, and MBO 519.

CLBY 525. Transport and Targeting of Macromolecules in Health and Disease. 3 Units.
PATH 525 is a 3 credit hour advanced course on neurodegenerative disorders intended for PhD and MD/PhD students. Master's and first and second-year medical students with adequate background in cell and molecular biology and the drive to work hard and overcome challenges are welcome. 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 mis-folding 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 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%). 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, MBO 526, MVIR 526.
**CLBY 599. RNA Structure and Function. 3 Units.**
This course will cover fundamental aspects of modern RNA biology with emphasis on the interplay of three dimensional structure of nucleic acids and their function. The main focus of the course is on the recent discoveries that indicate a prominent role of RNA as a major regulator of cellular function. Topics discussed will include an introduction to RNA structure, folding and dynamics, RNA/RNA and RNA-protein interactions, and role of RNA in catalysis of biological reactions in ribosome and the role of other catalytic RNAs in tRNA biogenesis, pre-mRNA splicing, and viral replication. The course also covers the recently discovered RNA regulatory switches, large noncoding regulatory RNAs, and the role of RNA in human diseases and novel, RNA-based therapeutics. Offered as BIOC 599, CLBY 599, and MBIO 599.

**CLBY 601. Special Problems. 1 - 18 Unit.**
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 Unit.**
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 Unit.**
Permits qualified undergraduates to work in a faculty member's laboratory.

**MBIO 413. Advanced Topics in Molecular and Biochemical Research Ethics. 0 Units.**
This course offers continuing education in responsible conduct of research for advanced graduate students. The course will cover the nine federally defined responsible conduct of research (RCR) areas through a combination of lectures, on-line course material and small group discussions. Six 2-hour meetings per semester are planned. Maximum enrollment of 15 students with preference to graduate students in the Department of Molecular Biology and Microbiology, the Department of Biochemistry, and trainees of the Cell and Molecular Biology Training Grant. Offered as: BIOC 413, MBIO 413.

**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, MVIR 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 486. HIV Immunology. 3 Units.
This course will examine the unique immunology of HIV disease. The course content will include the study of HIV pathogenesis, immune control, immune dysfunctions, HIV prevention and immune restoration. Students will be expected to attend lectures and participate in class discussions. A strong emphasis will be placed on reviewing scientific literature. Students will be asked to help organize and to administer an HIV immunology journal club and will be asked to prepare a written proposal in the area of HIV immunology. Offered as PATH 486 and MBIO 486.

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/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.

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 course 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 519. Molecular Biology of RNA. 3 Units.
Selected topics regarding editing, enzymatic function, splicing, and structure of RNA. Offered as BIOC 519, CLBY 519, and MBIO 519.

MBIO 520. Principles of Microbiology. 3 Units.
This course provides lectures and small group discussions of the cellular and molecular mechanisms by which certain bacteria, viruses, and parasites execute normal and pathologic conditions in human hosts. The biology, genetics, and physiological properties of these infectious agents are considered in light of the mechanisms by which they induce pathogenic conditions in their human hosts. The course is intended for graduate students advanced beyond the core curriculum of course work in molecular biology and microbiology areas of specialization. Prereq: CBIO 453 and CBIO 455.

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, 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 599. RNA Structure and Function. 3 Units.
This course will cover fundamental aspects of modern RNA biology with emphasis on the interplay of three dimensional structure of nucleic acids and their function. The main focus of the course is on the recent discoveries that indicate a prominent role of RNA as a major regulator of cellular function. Topics discussed will include an introduction to RNA structure, folding and dynamics, RNA/RNA and RNA-protein interactions, and role of RNA in catalysis of biological reactions in ribosome and the role of other catalytic RNAs in tRNA biogenesis, pre-mRNA splicing, and viral replication. The course also covers the recently discovered RNA regulatory switches, large noncoding regulatory RNAs, and the role of RNA in human diseases and novel, RNA-based therapeutics. Offered as BIOC 599, CLBY 599, and MBIO 599.

MBIO 601. Research in Molecular Biology and Microbiology. 1 - 18 Unit.

MBIO 701. Dissertation Ph.D.. 1 - 9 Unit.
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 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.

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 454 and CBIO 455 and CBIO 456.

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-cell interactions 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, MVIR 526.

MVIR 601. Research. 1 - 18 Unit.
Grade of S/U only.

MVIR 701. Dissertation Ph.D. 1 - 9 Unit.
Grade of S/U only. Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Molecular Medicine Program

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 three laboratory rotations among the laboratories of training faculty, and are exposed to trainer research projects during the Frontiers of Molecular Medicine seminars. The journal club series is taken during the first year. The first year begins mid-July.

During subsequent years, students will devote the majority of their time to thesis research while attending advanced graduate courses, seminars, and journal clubs. 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. Students must take a total of 36 semester hours of courses and maintain a B average.

The qualifying exam will be comprised of preparing and defending a grant application in the NIH/NRSA format. The topic of the grant is the area of
the student’s thesis research in the laboratory of the Research Advisor. 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.

**PhD Program Requirements**

**Coursework**

Students begin in July by first taking 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. The core series concludes with a course in Principles of Clinical and Translational Research and a mentored 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. A minimum of three rotations must be completed during the year.

**Choosing a Thesis Advisor**

After the second semester of the first year, students select an advisor for the 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).

*All required coursework is listed in this plan.

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**Year Total:** 9 9

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<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tr>
<td>Principles of Clinical and Translational Research (MMED 501)</td>
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<tr>
<td>Molecular aspects of the diagnosis, pathology, and treatment of selected human diseases (MMED 521)*</td>
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<td>Dissertation Research (MMED 601)</td>
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<td>Clinical Experience (MMED 612)</td>
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<tr>
<td>Advanced Electives (approved by program director)**</td>
<td>varies</td>
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<tr>
<td>Dissertation Research (MMED 601)</td>
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**Year Total:** 8-16 3-11

**Third Year**

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<tr>
<td>Dissertation Ph.D. (MMED 701)</td>
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<tr>
<td>Advanced Electives (if necessary)**</td>
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<tr>
<td>Dissertation Ph.D. (MMED 701)</td>
<td>1 - 9</td>
<td></td>
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<tr>
<td>Advanced Electives (if necessary)**</td>
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</table>

**Year Total:** 1-9 1-9

**Total Units in Sequence:** 31-63

*Starts in July

**Credits vary

**Recommended, but not required

**Third Year and beyond:** Complete elective coursework so that total graded courses = 24 credits; Research credits switch from MMED 601 to MMED 701 once passed into candidacy. Minimum of 1 credit of 701 is required each regular semester thereafter for a total of 18 credits to graduate. Total of 6 graded credits of advanced electives are required to graduate.

**Courses**

**MMED 400. Research Rotations. 0 Units.**

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 pathophysiology. 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 601. Dissertation Research. 1 - 9 Unit.
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-advise 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 Unit.
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
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, by direct admission to the department 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 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.

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 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. 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)
<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
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<tr>
<td>Cell Biology I (CBIO 453)</td>
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<tr>
<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>Neuroscience Seminars (NEUR 415)</td>
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<td>Research in Neuroscience (NEUR 601)</td>
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<tr>
<td>Principles of Neural Science (NEUR 402)</td>
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<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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<tr>
<td>Begin thesis research</td>
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<tr>
<td>Complete preliminary exam by July 31</td>
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<tr>
<td>Research in Neuroscience (NEUR 601)</td>
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<tr>
<td>Critical Thinking in Neuroscience (NEUR 419)</td>
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<td>Elective courses</td>
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<tr>
<td>Research in Neuroscience (NEUR 601)</td>
<td>1-6</td>
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<tr>
<td>Complete Qualifier Exam by July 31</td>
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<tr>
<td>Form thesis committee</td>
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<tr>
<td>Research</td>
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<td>Prepare individual fellowship application</td>
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<tr>
<td>Dissertation Ph.D. (NEUR 701)</td>
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<tr>
<td>Thesis Committee Meetings every 6 months</td>
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<tr>
<td>Dissertation Ph.D. (NEUR 701)</td>
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<tr>
<td>Advanced Topics in Neuroscience Ethics (NEUR 540)</td>
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<td>Thesis Committee Meetings every 6 months</td>
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<tr>
<td>Thesis committee meetings every 6 months</td>
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Total Units in Sequence: 36-93

* NEUR 540 Advanced Topics in Neuroscience Ethics is offered every other spring semester (beginning 2008), so can be taken in 3rd or 4th year.

### Courses

**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 405. Cellular and Molecular Neurobiology. 3 Units.**
Cell biology of nerve cells, including aspects of synaptic structure physiology and chemistry. The application of molecular biological tools to questions of synaptic function will be addressed. Recommended preparation: BIOL 473. Prereq: 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 424. Sensory Neuroscience. 3 Units.**
How do our brains and those of other animals allow for the acquisition and processing of unique sensory percepts? In what manners might sensory systems interact to enhance perception? Further, what happens to sensory system function in cases of neurological disorders? This course is a topic introduction to sensory neuroscience, a major area of modern neuroscience with connections to neurology, psychology, ethology, and related topics. Topics include visual, auditory, somatosensory, gustatory, and olfactory neuroscience. We will also examine the mechanisms and uses of magnetoreception, electroreception, echolocation, and other 'special' senses. All of the above topics will be covered under the theme of how animals actively sample their sensory environments for information. Prereq: BIOL 402 or BIOL 473 or NEUR 402 or PSCL 403 or Consent of Instructor.

**NEUR 425. Stem Cell Biology and Therapeutics. 3 Units.**
This course is intended to teach current understanding of stem cells as it relates to their characterization, function, and physiologic and pathological states. The course will expose students to the current understanding of various types of stem cells, including embryonic and adult stem cells of various tissues, techniques for their isolation and study. Experimental models and potential biomedical therapeutic applications will be discussed. The course will be taught by the faculty of the “Center for Stem Cell and Regenerative Medicine” who are affiliated with multiple departments of Case Western Reserve University, Cleveland Clinic Foundation and the partnering biomedical companies. Offered as NEUR 425 and PATH 425.
NEUR 427. Neural Development. 3 Units.
Topics include cell commitment, regulation of proliferation and differentiation, cell death and trophic factors, pathfinding by the outgrowing nerve fiber, synapse formation, relationships between center and periphery in development and the role of activity.

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 BIOC 432.

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 and 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 BIOC 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.

NEUR 476. Neurobiology Laboratory. 3 Units.
Introduction to the basic laboratory techniques of neurobiology. Intracellular and extracellular recording techniques, forms of synaptic plasticity, patch clamping, immunohistochemistry and confocal microscopy. During the latter weeks of the course students will be given the opportunity to conduct an independent project. One laboratory and one discussion session per week. Recommended preparation for BIOL 476 and NEUR 476: BIOL 216. Offered as BIOL 376, BIOL 476 and NEUR 476.

NEUR 477. Cellular Biophysics. 4 Units.
This course focuses on a quantitative understanding of cellular processes. It is designed for students who feel comfortable with and are interested in analytical and quantitative approaches to cell biology and cell physiology. Selected topics in cellular biophysics will be covered in depth. Topics include theory of electrical and optical signal processing used in cell physiology, thermodynamics and kinetics of enzyme and transport reactions, single channel kinetics and excitability, mechanotransduction, and transport across polarized cell layers. The format consists of lectures, problem sets, computer simulations, and discussion of original publications. The relevant biological background of topics will be provided appropriate for non-biology science majors. Offered as BIOC 476, NEUR 477, PHOL 476, PHRM 476.
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 482. Drugs, Brain, and Behavior. 3 Units.
This course is concerned with the mechanisms underlying neurochemical signaling and the impact of drugs on those mechanisms. The first half of the course emphasizes the fundamental mechanisms underlying intra- and extracellular communication of neurons and the basic principles of how drugs interact with the nervous system. The second half of the course emphasizes understanding the neural substrates of disorders of the nervous system, and the mechanisms underlying the therapeutic effects of drugs at the cellular and behavioral levels. This course will consist of lectures designed to give the student necessary background for understanding these basic principles and class discussion. The class discussion will include viewing video examples of behavioral effects of disorders of the nervous system, and analysis of research papers. The goal of the class discussions is to enhance the critical thinking skills of the student and expose the student to contemporary research techniques. Offered as BIOL 382, BIOL 482, and NEUR 482.

NEUR 540. Advanced Topics in Neuroscience Ethics. 0 Units.
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 Unit.
NEUR 651. Master's Thesis (M.S.). 1 - 6 Unit.
(Credit as arranged.) Recommended preparation: M.S. candidates only.
NEUR 701. Dissertation Ph.D.. 1 - 9 Unit.
Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Department of Nutrition

Pamela Woodruff (pamela.woodruff@case.edu), Graduate Student Coordinator

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 science degree in nutrition, bachelor of arts degree in nutrition, bachelor of science degree in nutritional biochemistry and metabolism, bachelor of science degree in nutritional biochemistry and metabolism, master of science degree in nutrition, a master of public health/master of science nutrition dual degree program and doctor of philosophy degree. A nutrition minor is available. Graduate certificate programs are available in areas such as maternal and infant nutrition or gerontology. The certifications are in addition to the basic graduate degree.

Human Nutrition (p. 114) | Nutritional Biochemistry and Metabolism (p. 116) | Minors (p. 117)

Undergraduate Degrees (NTRN)

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 course work.

Human Nutrition

Bachelor of Science degree requires:

Required Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>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>
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<tr>
<td>NTRN 342L</td>
<td>Food Science Lab</td>
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</tr>
<tr>
<td>NTRN 343</td>
<td>Dietary Patterns</td>
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</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 397</td>
<td>SAGES Capstone Proposal Seminar</td>
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<td>NTRN 398</td>
<td>SAGES Senior Capstone Experience</td>
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<tr>
<td>Three nutrition electives chosen from:</td>
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<tr>
<td>NTRN 328</td>
<td>Child Nutrition, Development and Health</td>
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<tr>
<td>NTRN 351</td>
<td>Food Service Systems Management</td>
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<tr>
<td>NTRN 360</td>
<td>Guided Study in Nutrition Practice</td>
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</tr>
<tr>
<td>NTRN 361</td>
<td>Energy Dysregulation: From Obesity to Anorexia</td>
<td></td>
</tr>
</tbody>
</table>
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 Nutrition
NTRN 390 Undergraduate Research
NTRN 435 Nutrition during Pregnancy and Lactation
NTRN 436 Pediatric Nutrition
NTRN 437 Evaluation of Nutrition Information for Consumers
NTRN 438 Dietary Supplements
NTRN 440 Nutrition for the Aging and Aged
NTRN 452 Nutritional Biochemistry and Metabolism
NTRN 550A Advanced Community Nutrition or NTRN 528 Introduction to Public Health Nutrition

Additional Required Courses:
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
BIOL 214 Genes, Evolution and Ecology 3
BIOL 216 Development and Physiology 3
BIOL 340 Human Physiology
& BIOL 346 Human Anatomy
BIOL 216L Development and Physiology Lab 1
BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science 4

One of the following:
ANTH 319 Introduction to Statistical Analysis in the Social Sciences 3
EPBI 431 Statistical Methods I
PSCL 282 Quantitative Methods in Psychology
STAT 201 Basic Statistics for Social and Life Sciences

Total Units 60

* Only one of these courses is permitted
400 level Nutrition courses require instructor consent

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 328 Child Nutrition, Development and Health
NTRN 351 Food Service Systems Management
NTRN 360 Guided Study in Nutrition Practice

Bachelor of Science in Nutrition - Human Nutrition Major Example Plan of Study

First Year

<table>
<thead>
<tr>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
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<td>13</td>
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</table>

Principles of Chemistry I (CHEM 105) 3
Nutrition (NTRN 201) 3
SAGES First Seminar 4
Genes, Evolution and Ecology (BIOL 214) 3
Principles of Chemistry II (CHEM 106) 3
Principles of Chemistry Laboratory (CHEM 113) 2
SAGES Breadth Requirements 9
Year Total: 13 14

Second Year

<table>
<thead>
<tr>
<th>Units</th>
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<tr>
<td>Fall</td>
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NTRN Electives 6
Introductory Organic Chemistry I (CHEM 223) 3
SAGES University Seminar 3
Development and Physiology (BIOL 216) 3
Development and Physiology Lab (BIOL 216L) 1
SAGES University Seminar 3
Basic Statistics for Social and Life Sciences (STAT 201) 3
Electives 6
Dietary Patterns (NTRN 343) 3
Year Total: 16 15

**Third Year**

<table>
<thead>
<tr>
<th>Units</th>
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<tbody>
<tr>
<td>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 307)</td>
<td>4</td>
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<td>SAGES Breadth Requirements</td>
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<tr>
<td>Food Science (NTRN 342)</td>
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<td>Food Science Lab (NTRN 342L)</td>
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<td>Nutrition Elective</td>
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<td>Elective</td>
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**Fourth Year**

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<td>Human Nutrition I: Energy, Protein, Minerals (NTRN 363)</td>
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<tr>
<td>Human Nutrition II: Vitamins (NTRN 364)</td>
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<td>Nutrition Elective</td>
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<td>Total Units in Sequence:</td>
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**Nutritional Biochemistry and Metabolism**

**Bachelor of Arts degree requires:**

Required courses:

- NTRN 201 Nutrition 3
- NTRN 342 Food Science 3
- NTRN 342L Food Science Lab 2
- 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
- NTRN 452 Nutritional Biochemistry and Metabolism 3
- One nutrition elective at 300-level (or above with instructor consent) 3

Additional required courses:

- MATH 121 Calculus for Science and Engineering I 4
- MATH 122 Calculus for Science and Engineering II 4
- MATH 124 Calculus II 3
- MATH 223 Calculus for Science and Engineering III 3
- MATH 227 Calculus III 3
- MATH 224 Elementary Differential Equations 3
- MATH 228 Differential Equations 3
- 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
- or CHEM 323 Organic Chemistry I 3
- CHEM 224 Introductory Organic Chemistry II 3
- or CHEM 324 Organic Chemistry II 3
- CHEM 233 Introductory Organic Chemistry Laboratory I 2
- CHEM 234 Introductory Organic Chemistry Laboratory II 2
- BIOL 214 Genes, Evolution and Ecology 3
- BIOL 215 Cells and Proteins 3

**Bachelor of Science degree requires:**

Required courses:

- NTRN 201 Nutrition 3
- NTRN 342 Food Science 3
- NTRN 342L Food Science Lab 2
- 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
- NTRN 452 Nutritional Biochemistry and Metabolism 3
- One nutrition elective at 300-level (or above with instructor consent) 3

Additional required courses:

- MATH 121 Calculus for Science and Engineering I 4
- MATH 122 Calculus for Science and Engineering II 4
- MATH 124 Calculus II 3
- MATH 227 Calculus III 3
- MATH 224 Elementary Differential Equations 3
- MATH 228 Differential Equations 3
- 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
- or CHEM 323 Organic Chemistry I 3
- CHEM 224 Introductory Organic Chemistry II 3
- or CHEM 324 Organic Chemistry II 3
- CHEM 233 Introductory Organic Chemistry Laboratory I 2
- CHEM 234 Introductory Organic Chemistry Laboratory II 2
- BIOL 214 Genes, Evolution and Ecology 3
- BIOL 215 Cells and Proteins 3
BIOL 216  Development and Physiology  3
or BIOL 340  Human Physiology  
& BIOL 346  and Human Anatomy  
BIOL 216L  Development and Physiology Lab  1
PHYS 115  Introductory Physics I  4
or PHYS 121  General Physics I - Mechanics  
or PHYS 123  Physics and Frontiers I - Mechanics  
PHYS 116  Introductory Physics II  4
or PHYS 122  General Physics II - Electricity and Magnetism  
or PHYS 124  Physics and Frontiers II - Electricity and Magnetism  
PHYS 221  Introduction to Modern Physics  3
BIOC 307  Introduction to Biochemistry: From Molecules To Medical Science  4
or BIOC 334  Structural Biology  3
or BIOC 312  Proteins and Enzymes  
or NTRN 454  Isotope Tracer Methodology  

One of the following:

| STAT 201 | Basic Statistics for Social and Life Sciences |
| STAT 243 | Statistical Theory with Application I |
| STAT 312 | Basic Statistics for Engineering and Science |
| STAT 313 | Statistics for Experimenters |

Total Units  86

Bachelor of Arts in Nutrition - Nutritional Biochemistry and Metabolism Major Example Plan of Study

First Year

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<tr>
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<td>Math and Calculus Applications for Life, Managerial, and Social Sci I (MATH 125)</td>
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<td>Nutrition (NTRN 201)</td>
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<tr>
<td>Genes, Evolution and Ecology (BIOL 214)</td>
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<td>SAGES First Seminar</td>
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<td>Principles of Chemistry I (CHEM 105)</td>
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<td>Cells and Proteins (BIOL 215)</td>
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<td>Principles of Chemistry Laboratory (CHEM 113)</td>
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<td>Math and Calculus Applications for Life, Managerial, and Social Sci II (MATH 126)</td>
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<td>Principles of Chemistry II (CHEM 106)</td>
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Second Year

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<tr>
<td>Introductory Organic Chemistry Laboratory I (CHEM 233)</td>
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<td>Introductory Organic Chemistry I (CHEM 223)</td>
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<tr>
<td>Development and Physiology (BIOL 216) &amp; Development and Physiology Lab (BIOL 216L)</td>
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<td>SAGES University Seminar</td>
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<td>Electives</td>
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<td>Introductory Organic Chemistry II (CHEM 224)</td>
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<tr>
<td>Introductory Organic Chemistry Laboratory II (CHEM 234)</td>
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<td>Nutrition Elective</td>
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<td>SAGES University Seminar</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>Introduction to Biochemistry: From Molecules To Medical Science (BIOC 307)</td>
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<tr>
<td>Introductory Physics I (PHYS 115)</td>
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<tr>
<td>Food Science (NTRN 342)</td>
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<td>Food Science Lab (NTRN 342L)</td>
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</tr>
<tr>
<td>SAGES Capstone Proposal Seminar (NTRN 397)</td>
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<tr>
<td>Elective</td>
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<td></td>
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<tr>
<td>Introductory Physics II (PHYS 116)</td>
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Fourth Year

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<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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<td>Human Nutrition I: Energy, Protein, Minerals (NTRN 363)</td>
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<td>Human Nutrition II: Vitamins (NTRN 364)</td>
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<td>Structural Biology (BIOC 334)</td>
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Total Units in Sequence: 114

Minor Programs

The basic sequence for a minor program consists of the following:

Required courses:

<table>
<thead>
<tr>
<th>Units</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>NTRN 201</td>
<td>Nutrition</td>
</tr>
<tr>
<td>NTRN 328</td>
<td>Child Nutrition, Development and Health</td>
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<tr>
<td>NTRN 342</td>
<td>Food Science</td>
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<tr>
<td>NTRN 343</td>
<td>Dietary Patterns</td>
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<td>Three credits selected from:</td>
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<tr>
<td>NTRN 351</td>
<td>Food Service Systems Management</td>
</tr>
<tr>
<td>NTRN 361</td>
<td>Energy Dysregulation: From Obesity to Anorexia</td>
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<tr>
<td>NTRN 363</td>
<td>Human Nutrition I: Energy, Protein, Minerals</td>
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<tr>
<td>NTRN 364</td>
<td>Human Nutrition II: Vitamins</td>
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<tr>
<td>NTRN 365</td>
<td>Nutrition for the Prevention and Management of Disease: Pathophysiology</td>
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<tr>
<td>NTRN 366</td>
<td>Nutrition for the Prevention and Management of Disease: Clinical Applications</td>
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<tr>
<td>NTRN 388</td>
<td>Seminar in Nutrition</td>
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Total Units 15

Didactic Program in Dietetics (DPD)

The following courses must be included in the program.
Required courses:

NTRN 201 Nutrition 3
NTRN 342 Food Science 3
NTRN 342L Food Science Lab 2
NTRN 343 Dietary Patterns 3
NTRN 351 Food Service Systems Management 3
NTRN 360 Guided Study in Nutrition Practice 3
NTRN 363 Human Nutrition I: Energy, Protein, Minerals 3
NTRN 364 Human Nutrition II: Vitamins 3
NTRN 365 Nutrition for the Prevention and Management of Disease: Pathophysiology 4
NTRN 366 Nutrition for the Prevention and Management of Disease: Clinical Applications 3
NTRN 550A Advanced Community Nutrition (or NTRN 528) 3
BIOC 307 Introduction to Biochemistry: From Molecules To Medical Science 4
BIOL 216 Development and Physiology 3
BIOL 343 Microbiology 3
CHEM 223 Introductory Organic Chemistry I 3
ENGL 150 Expository Writing (or SAGES Writing Portfolio) 3
SOCI 101 Introduction to Sociology 3

One of the following: 3-4
- EDUC 304 Educational Psychology
- PSCL 353 Psychology of Learning
- PSCL 357 Cognitive Psychology

One of the following: 3
- ANTH 215 Health, Culture, and Disease: An Introduction to Medical Anthropology
- SOCI 311 Health, Illness, and Social Behavior

One of the following: 3
- ANTH 319 Introduction to Statistical Analysis in the Social Sciences
- EPBI 431 Statistical Methods I
- PSCL 282 Quantitative Methods in Psychology
- STAT 201 Basic Statistics for Social and Life Sciences
- STAT 243 Statistical Theory with Application I
- STAT 312 Basic Statistics for Engineering and Science
- STAT 313 Statistics for Experimenters

Total Units 61-62

Masters Degrees

The Department of Nutrition offers four distinct programs leading to Masters Degrees: (1) MS in Nutrition (2) MS in Public Health Nutrition Internship (3) Coordinated Dietetic Internship/Master's Degree Program and (4) Master of Public Health/Master of Science in Nutrition Dual Degree Program.

MS 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 18 semester hours of nutrition, including six 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, and molecular nutrition. The individual program also may be planned to fulfill the academic requirements for dietetic registration (Didactic Program in Dietetics).

MS in Public Health Nutrition 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 an eight to ten week experience in an out of state 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 or Gerontology. 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).

General Option: Plan of Study

First Year

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<th>Units</th>
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<th>Summer</th>
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<tr>
<td>Introduction to Public Health Nutrition (NTRN 528)</td>
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<tr>
<td>Nutritional Epidemiology (NTRN 529)</td>
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<td>Nutrition for the Aging and Aged (NTRN 440)</td>
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<td>Elective: Any NTRN 400 or 500 level course</td>
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<td>Public Health Nutrition (NTRN 530)</td>
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<td>Public Health Nutrition Field Experience (NTRN 531)</td>
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<td>Elective: Any NTRN 400 or 500 level course</td>
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<tr>
<td>Public Health Nutrition Field Experience (NTRN 531)</td>
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Second Year

<table>
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<tr>
<th>Units</th>
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<tbody>
<tr>
<td>Pediatric Nutrition (NTRN 436)</td>
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<tr>
<td>Public Health Nutrition Field Experience (NTRN 531)</td>
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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.

The MPH/Nutrition dual degree is envisioned with students able to apply for either degree, then later join the other; or apply directly for the joint degree. Both the MPH and MS programs confer degrees through the School of Graduate Studies and as such are subject to Graduate Studies rules and procedures. Both programs are housed in the School of Medicine.

First Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
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<tbody>
<tr>
<td>4</td>
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Second Year

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Third Year

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Total Units in Sequence: 61

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
ment or the Graduate Program Director will assist the student in selecting the appropriate courses for their interests.

**Students in Nutrition must complete:**

<table>
<thead>
<tr>
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**And 9-10 credits or three courses from those listed below:**

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<td>Nutrition during Pregnancy and Lactation</td>
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<td>NTRN 437</td>
<td>Evaluation of Nutrition Information for Consumers</td>
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</tr>
<tr>
<td>NTRN 438</td>
<td>Dietary Supplements</td>
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<td>NTRN 440</td>
<td>Nutrition for the Aging and Aged</td>
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<tr>
<td>NTRN 452</td>
<td>Nutritional Biochemistry and Metabolism</td>
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<tr>
<td>NTRN 454</td>
<td>Isotope Tracer Methodology</td>
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<tr>
<td>NTRN 455</td>
<td>Molecular Nutrition</td>
<td>3</td>
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<tr>
<td>NTRN 460</td>
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<tr>
<td>NTRN 530</td>
<td>Public Health Nutrition</td>
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</tr>
<tr>
<td>NTRN 533</td>
<td>Nutritional Care of Neonate</td>
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</table>

**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.

**Plan of Study**

§ Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)

### First Year

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### Second Year

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### Third Year

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§ Please also see Graduate Studies Academic Requirements for Doctoral Degrees (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements)
Offered as NTRN 359 and NTRN 459. Prereq: NTRN 201 and Junior or
Requirements for developing a Diabetes Self-Management Education
oral medications, and insulin therapy. Patient education and health
use of blood glucose monitoring, physical activity, nutrition counseling,
chronic complications of diabetes and hyperglycemia will be addressed.
In this course, we will explore the diabetes epidemic, its effects on the
service management in depth. Offered as NTRN 351 and NTRN 451.
the application of processing methods and their effect on nutritional quality
and acceptability. Prereq: CHEM 106.
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
NTRN 342L. Food Science Lab. 2 Units.
Apply knowledge of the physical, chemical, and biological aspects of
food and food ingredients to actual experimentation with foods. Acquire
understanding of how food ingredients and their interactions and the
preparation process influence acceptability of the final food product.
Enhance familiarity with safe food handling during preparation and post-
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. Recommended preparation: NTRN 201 or consent.
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 359. 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.
Offered as NTRN 359 and NTRN 459. Prereq: NTRN 201 and Junior or
Senior Status.
NTRN 360. Guided Study in Nutrition Practice. 3 Units.
Methods for the provision of nutrition services to individuals and groups.
Principles of professional practice including ethics, standards, and
regulatory issues. Recommended preparation: NTRN 363 or NTRN 433
or consent. Prereq: NTRN 201 and NTRN 342 or MS in Nutrition or MS in
Public Health Nutrition.
NTRN 361. Energy Dysregulation: 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 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: CHEM 223 and BIOL 216 (3 or 4 cr.
hrs.).
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 371. Special Problems. 1 - 3 Unit.
Independent reading, research, or special projects supervised by a member of the nutrition faculty. Prereq: Junior or senior standing.

NTRN 372. Special Problems. 1 - 3 Unit.
Independent reading, research, or special projects supervised by a member of the nutrition faculty. Prereq: Junior or senior standing.

NTRN 388. Seminar in Nutrition. 1 - 3 Unit.
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: NTRN 201 and NTRN 342.

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 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. Evaluation of Nutrition Information for Consumers. 3 Units.
Reading and appraisal of food and nutrition literature written for the general public, including books, magazines, newsletters. Prereq: Graduate standing and Nutrition or Public Health Nutrition major or consent of instructor.

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. Prereq: NTRN 364 or requisites not met permission.

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 444. 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 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. Isotope Tracer Methodology. 3 Units.
Stable and radioactive isotopes in metabolic research concentrating on the design of in-vitro and in-vivo investigative protocols using mostly stable isotopes and mass spectrometer analysis; critical interpretation of data from the recent literature; and pathway identification and kinetics. Recommended preparation: BIOC 407.

NTRN 455. Molecular Nutrition. 3 Units.
Nutrient control of gene expression in mammalian cells and deregulation of expression of these genes. The molecular basis of nutrition-related diseases, such as diabetes mellitus, PKU, and LDL-receptor deficiency, will be discussed. The application of genetic manipulation to metabolism and nutrition will be evaluated. Recommended preparation: BIOC 407.
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. Offered as NTRN 359 and NTRN 459. 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. Energy Dysregulation: 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 disorders of 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 prerequisites 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. Prereq: Nutrition Major.
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 Unit.
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 601. Special Problems. 1 - 18 Unit.

NTRN 651. Thesis M.S.. 1 - 18 Unit.

NTRN 701. Dissertation Ph.D.. 1 - 9 Unit.
Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Department of Pathology

Christine Kehoe (christine.kehoe@case.edu), Student Affairs

The clinical, research, and educational activities of the Case Department of Pathology are centered at the Case School of Medicine and University Hospitals Case Medical Center (UHCMC). The core components of the department are the Basic Science Pathology Program at Case School of Medicine and the three clinical divisions of Pathology at University Hospitals Health System (UHHS), including the Division of Anatomic Pathology at UHCMC, the Division of Clinical Pathology at UHCMC, and the UHHS Pathology Division of Community Hospitals. In addition, our affiliates include the Cuyahoga County Medical Examiner’s Office, the Pathology Department at the Louis Stokes Veteran's Administration Medical Center, and the Pathology Department at MetroHealth Medical Center. Research laboratories of the department are located in the Wolstein Research Building and Institute of Pathology. Both are situated adjacent to University Hospitals of Cleveland, the primary teaching hospital of the Case School of Medicine and the location of the department’s Pathology Residency Program.

World-class research is conducted in the department in biomaterials biocompatibility, cancer biology, immunology, neuropathology and neurodegenerative disease, outcomes research, and tissue injury and healing. 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. In FY 2011, the department’s annual external research grant support totaled $15,463,639, $13,080,886 of which was from NIH. The CWRU Department of Pathology NIH funding level ranked 12th nationally in FY 2011 and 13th nationally in FY 2012. For information about graduate programs, please see here (http://www.case.edu/med/pathology/training/graduate.html).

Masters Degrees

MS in Pathology (full-time)

The full-time Master’s Program in Pathology is intended for students with a background in the biological or chemical sciences, typically a bachelor’s or baccalaureate degree, who are interested in pursuing advanced coursework in the basis of disease. This coursework may be useful for those interested in pursuing a professional doctoral degree (e.g., MD, DO, DDS, or DMD) or other health professions degree, since the core curriculum and electives include many topics of medical relevance, including histology, gross anatomy, pathology, cancer and immunology. The time of matriculation in the Program is flexible; a typical time to degree is anticipated to be 4 semesters, although completion in approximately 13 months, including 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. The core of the Program is geared toward providing the student a solid basis in cell biology and pathology. This begins with courses in histology and cell & molecular biology (ANAT 412 Histology and Ultrastructure/ANAT 413 General Histology Laboratory and PATH 475 Cell and Molecular Foundations of Pathology) followed by courses in basic pathology and immunology (PATH 510 Basic Pathologic Mechanisms and PATH 416 Fundamental Immunology). After the first year the student can specialize by choosing electives in their area of interest. In the final semester the student will register for 3 credits of PATH 601 Special Problems while writing their paper. An advisor for the paper should be identified by mutual interest during the first year.

Typical Curriculum

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<td>Experimental Pathology Seminar I (PATH 511)</td>
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<tr>
<td>Basic Pathologic Mechanisms (PATH 510)</td>
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<tr>
<td>Fundamental Immunology (PATH 416)</td>
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<td>Experimental Pathology Seminar II (PATH 512)</td>
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<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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<tr>
<td>Cadaver dissection-based human anatomy with histology, neuroanatomy, embryology, and physiology (ANAT 410)</td>
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<tr>
<td>Cell Biology of Neurodegenerative Disorders (PATH 524)</td>
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Attendance optional in summer semester

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 10 9

**Second Year**

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Electives: 6-9

- Current Topics in Cancer (PATH 422)
- Oxidative Stress and Disease Pathogenesis (PATH 430)
- Advanced Immunobiology (PATH 465)
- Immunology of Infectious Diseases (PATH 481)
- Yeast Genetics and Cell Biology (PATH 488)
- Transport and Targeting of Macromolecules in Health and Disease (PATH 522)

Other electives upon approval

- Experimental Pathology Seminar II (PATH 512)

Electives: 6-9

- Cytoskeleton and Disease (PATH 415)
- Current Topics in Vision Research (PATH 432)
- Neurodegenerative Diseases: Pathological, Cell & Molecular Perspectives (PATH 444)
- Introduction to Microarrays (PATH 460)
- Yeast Genetics and Cell Biology (PATH 488)
- Special Topics in Cancer Biology and Clinical Oncology (PATH 521)
- Cell Biology of Neurodegenerative Disorders (PATH 524)
- Special Problems (PATH 601)

Other electives upon approval

Year Total: 7-10 7-10

**Total Units in Sequence:** 52-58

---

**Accelerated Curriculum**

**First Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Summer</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadaver dissection-based human anatomy with histology, neuroanatomy, embryology, and physiology (ANAT 410)</td>
<td></td>
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</tr>
<tr>
<td>Histology and Ultrastructure (ANAT 412)</td>
<td></td>
<td>6</td>
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<tr>
<td>&amp; General Histology Laboratory (ANAT 413)</td>
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</tr>
<tr>
<td>Cell and Molecular Foundations of Pathology (PATH 475)</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>Basic Pathologic Mechanisms (PATH 510)</td>
<td></td>
<td>4</td>
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</tr>
<tr>
<td>Fundamental Immunology (PATH 416)</td>
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<td>4</td>
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</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
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<td>1</td>
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<tr>
<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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<tr>
<td>Special Problems (PATH 601)</td>
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<td>1 - 18</td>
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Year Total: 6 10 11-28

**Second Year**

<table>
<thead>
<tr>
<th>Units</th>
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<tbody>
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<td>Special Problems (PATH 601)</td>
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Year Total: 1-18

**Total Units in Sequence:** 49-100

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**First Year**

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Year Total: 6

**Second Year**

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<th>Summer</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>General Histology Laboratory (ANAT 413)</td>
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<td>2</td>
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</tr>
<tr>
<td>Cell and Molecular Foundations of Pathology (PATH 475)</td>
<td></td>
<td>3</td>
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</tr>
<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Basic Pathologic Mechanisms (PATH 510)</td>
<td></td>
<td>4</td>
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<tr>
<td>Fundamental Immunology (PATH 416)</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Problems (PATH 601)</td>
<td>2</td>
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<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Units in Sequence:</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>

* Students with a significant background in Cell and Molecular Biology may take Path 525 (Transport and targeting of macromolecules in health and disease) or Path 488 (Yeast Genetics and Cell Biology) instead.

**Admission Criteria**

Applicants will be screened by the Pathology Department Admissions Committee. Students will be required to supply a GRE or MCAT score, a transcript, three letters of recommendation and an essay that details the student's interest in the Program. Students will be interviewed on campus via electronic media (i.e. FaceTime or Skype). Although there are no set requirements, successful applicants would be expected to have an MCAT >26, GRE verbal >150 and GRE quantitative > 150, and an undergraduate GPA around 3.0. Applications will be accepted throughout the year with a deadline of June 1st; final decisions for Fall matriculation will be made by July 1st. Prospective students are advised to submit their applications well in advance of the deadline, since the class may fill completely before that date.

**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/. Tuition is currently $1546/credit hour. The total cost of the Program is based on tuition for the credits taken each term. Credits taken in excess of 12 per semester incur no additional cost (e.g. the cost of 12 credits is $18,552, if a student takes 15 credits in a semester the cost will be limited to $18,552).

**MS in Pathology (part-time)**

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 an M.S. degree through Plan A. Required core courses include CBIO 453 Cell Biology I (4 credits), CBIO 455 Molecular Biology I (4 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. CBIO 453 Cell Biology I, CBIO 455 Molecular Biology I and must be taken as graded courses (not P/F).

Plan A requires a minimum of 27 total coursework credits. In addition to the required core courses, the student must take a minimum of 6 credits of PATH 651 Thesis, which involves research in the laboratory of the supervisor (who serves as the M.S. 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 M.S. (Students considering using the M.S. in Pathology as a “stepping stone” to the Ph.D. degree must maintain a GPA of 3.0 or better.) An M.S. thesis must be prepared based on the research, and the student must pass an M.S. 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 varies 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 Dr. James Anderson (james.anderson@case.edu), 216.368.0279, or Dr. Clive Hamlin (clive.hamlin@case.edu), 216.368.0512.

**Students in the Pathology track must complete:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATH 601 Special Problems</td>
<td>18</td>
</tr>
<tr>
<td>PATH 511 or PATH 512 Experimental Pathology Seminar I</td>
<td>1</td>
</tr>
<tr>
<td>IBIS 600 Exam in Biomedical Investigation</td>
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</tbody>
</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</th>
<th>Credits</th>
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<tbody>
<tr>
<td>PATH 410 Aging and the Nervous System</td>
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<tr>
<td>PATH 415 Cytoskeleton and Disease</td>
<td>1</td>
</tr>
<tr>
<td>PATH 416 Fundamental Immunology</td>
<td>4</td>
</tr>
<tr>
<td>PATH 417 Cytokines: Function, Structure, and Signaling</td>
<td>3</td>
</tr>
<tr>
<td>PATH 430 Oxidative Stress and Disease Pathogenesis</td>
<td>1</td>
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<tr>
<td>PATH 432 Current Topics in Vision Research</td>
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<td>PATH 444 Neurodegenerative Diseases: Pathological, Cell. &amp; Molecular Perspectives</td>
<td>3</td>
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<td>PATH 480 Logical Dissection of Biomedical Investigations</td>
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<tr>
<td>PATH 481 Immunology of Infectious Diseases</td>
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### Example Plan of Study of Minimum Coursework:

**First Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD Curriculum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduate course*</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD Curriculum</td>
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<td></td>
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</tr>
<tr>
<td>Special Problems (PATH 601) (optional)</td>
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**Second Year**

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<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Integrated Biological Sciences III (IBIS 403)</td>
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<td>Graduate Course*</td>
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<tr>
<td>MD Curriculum</td>
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<td></td>
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<tr>
<td>Graduate Course*</td>
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<td>Year Total:</td>
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**Third Year**

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<th>Units</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Special Problems (PATH 601)</td>
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<tr>
<td>Special Problems (PATH 601)</td>
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<tr>
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</tr>
<tr>
<td>Exam in Biomedical Investigation (IBIS 600)</td>
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<td>Year Total:</td>
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**Fourth Year**

<table>
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<tbody>
<tr>
<td>MD Curriculum</td>
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<tr>
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**Fifth Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
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<tr>
<td>MD Curriculum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD Curriculum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year Total:</td>
<td></td>
<td></td>
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</tbody>
</table>

**Total Units in Sequence:** 36-46

* 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.

---

### 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>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Biology I (CBIO 453)*</td>
<td>4</td>
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<td></td>
</tr>
<tr>
<td>Molecular Biology I (CBIO 455)*</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Rotation in Biomedical Sciences Training Program (BSTP 400)*</td>
<td>0 - 9</td>
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<td></td>
</tr>
<tr>
<td>Mentor and track chosen</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Basic Pathologic Mechanisms (PATH 510)*</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>Fundamental Immunology (PATH 416)*</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thesis committee chosen; preproposal meeting scheduled</td>
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</tr>
<tr>
<td>Special Problems (PATH 601)</td>
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<tr>
<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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---

**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)
### Immunology Training Program (ITP)

**First Year**

<table>
<thead>
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<th>Units</th>
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<tr>
<td>Molecular Biology I (CBIO 455)</td>
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</tr>
<tr>
<td>Research Rotation in Biomedical Sciences Training Program (BSTP 400)</td>
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</tr>
<tr>
<td>Immunology Journal Club (optional this semester)</td>
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</tr>
<tr>
<td>Mentor and Track chosen</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Basic Pathologic Mechanisms (PATH 510)</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamental Immunology (PATH 416)</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immunology Journal Club (optional this semester)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Thesis commitment chosen; preproposal meeting scheduled</td>
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</tr>
<tr>
<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</td>
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**Year Total:** 8-17 10-18 1

**Second Year**

<table>
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<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
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<tr>
<td>ITP Track Elective</td>
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<tr>
<td>Electives (Core, ITP Track or other)**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Special Problems (PATH 601)</td>
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**Year Total:** 8-17 10-18 1

**Third Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
<td>1</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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</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
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**Year Total:** 8-16 6-16

**Fourth Year**

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<td>Experimental Pathology Seminar I (PATH 511)</td>
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</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
<td>1-9</td>
<td></td>
</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
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<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
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**Year Total:** 2-10 2-10

**Fifth Year**

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<td></td>
</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
<td>1-9</td>
<td></td>
</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
<td>1</td>
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</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)**</td>
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**Year Total:** 2-10 2-10

**Total Units in Sequence:** 45-128

---

Alternate courses for MSTP students: IBIS 401-404. MSTP students in the MCBDTP do not need to take CBIO 453 Cell Biology I, CBIO 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.
Thesis proposal defense and advancement to candidacy must be completed**

Year Total: 8-16 6-16

### Third Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Pathology Seminar I (PATH 511)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Dissertation Ph.D. (PATH 701)***</td>
<td>1-9</td>
<td></td>
</tr>
<tr>
<td>Immunology Journal Club (required this semester)</td>
<td></td>
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</tr>
<tr>
<td>Experimental Pathology Seminar II (PATH 512)</td>
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<tr>
<td>Dissertation Ph.D. (PATH 701)***</td>
<td>1-9</td>
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<td>Immunology Journal Club (required this semester)</td>
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<td>2-10</td>
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### Fourth Year

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<tr>
<th>Units</th>
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<tr>
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<tr>
<td>Dissertation Ph.D. (PATH 701)***</td>
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<td>Immunology Journal Club (required this semester)</td>
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### Fifth Year

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<tr>
<th>Units</th>
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**Total Units in Sequence: 45-128**

* Alternate courses for MSTP students: IBIS 401-404. MSTP students in the ITP do not need to take CBIO 453 Cell Biology I, CBIO 455 Molecular Biology I or PATH 510 Basic Pathologic Mechanisms. PATH 416 Fundamental Immunology is required for MSTP students in the ITP unless they have sufficient prior immunology background as determined by the ITP Chair and curriculum coordinators (e.g. Drs. Harding and Nedrud).

**PATH 520 Basic Cancer Biology and the Interface with Clinical Oncology + PATH 521 Special Topics in Cancer Biology and Clinical Oncology is included as a Track Elective for ITP students.

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### Cancer Biology Training Program (CBTP)

#### First Year

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<td>Basic Pathologic Mechanisms (PATH 510)</td>
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<td>Electives (Core, CBTP track or other)**</td>
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## Fourth Year

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## Fifth Year

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**Total Units in Sequence:** 45-128

* Alternative courses for MSTP students: IBIS 401-404. MSTP students in the CBTP do not need to take CBIO 453 Cell Biology I, CBIO 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 with PATH 601 Special Problems for direct admit students

** PATH 416 Fundamental Immunology is included as a Track Elective for CBTP 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 NRSA 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 indicated 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 215L.
PATH 390. Undergraduate Research in Cancer Biology, Immunology, or Pathology. 1 - 3 Unit.
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 395. Selected Readings in Immunology, Cancer Biology, or Pathology. 1 - 3 Unit.
Relevant readings and literature search on particular immunology, cancer biology or pathology topic(s) chosen by the student and directed by the instructor. Written proposal outlining chosen topic, type of work to be done, a schedule of meetings and format and length of final written report to be prepared prior to registration for credit.

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 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 415. Cytoskeleton and Disease. 1 Unit.
Discussion of recent papers that have added to knowledge of normal cytoskeletal functions and their alterations in disease.

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 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 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 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 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, MVIR 420, PATH 422, and PHRM 420. Prereq: CBIO 453 and CBIO 455.

PATH 425. Stem Cell Biology and Therapeutics. 3 Units.
This course is intended to teach current understanding of stem cells as it relates to their characterization, function, and physiologic and pathological states. The course will expose students to the current understanding of various types of stem cells, including embryonic and adult stem cells of various tissues, techniques for their isolation and study. Experimental models and potential biomedical therapeutic applications will be discussed. The course will be taught by the faculty of the "Center for Stem Cell and Regenerative Medicine" who are affiliated with multiple departments of Case Western Reserve University, Cleveland Clinic Foundation and the partnering biomedical companies. Offered as NEUR 425 and PATH 425.

PATH 430. Oxidative Stress and Disease Pathogenesis. 1 Unit.
Oxidative stress and free radicals are implicated in a number of disease processes including aging, arthritis, emphysema, Alzheimer's disease and cancer. Lecture course with discussion of recent studies concerning the formation and destructive mechanisms of free radicals in the context of various disease processes. Students read assigned papers and discuss these in class.
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 BIOC 432.

PATH 435. Tissue Engineering and Regenerative Medicine. 3 Units.
This course will provide advanced coverage of tissue engineering with a focus on stem cell-based research and therapies. Course topics of note include stem cell biology and its role in development, modeling of stem cell function, controlling stem cell behavior by engineering materials and their microenvironment, stem cells' trophic character, and state-of-the-art stem cell implementation in tissue engineering and other therapeutic strategies. Offered as EBME 425 and PATH 435. Prereq: EBME 325 or equivalent or graduate standing.

PATH 444. Neurodegenerative Diseases: Pathological, Cell. & 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. 3 Units.
This is an advanced graduate level course for students interested in the morphogenesis, structure, function, and maintenance of the skeletal system taught jointly by faculty from Case Western Reserve University (CWRU), Cleveland Clinic Foundation (CCF), and the Northwestern Ohio Universities College of Medicine (NEOUCOM). It will meet twice per week for 90 minutes per session. The format will include an overview of the topic by the responsible faculty, followed by a discussion of important papers on the topic. The students will be expected to discuss the papers for each session and grading will be based on those discussions. The intent of the course is to enable students to understand the important problems in skeletal biology and both classical and modern approaches for solving them.

PATH 460. Introduction to Microarrays. 3 Units.
Microarray technology is an exciting new technique that is used to analyze gene expression in a wide variety of organisms. The goal of this course is to give participants a hands-on introduction to this technology. The course is intended for individuals who are preparing to use this technique, including students, fellows, and other investigators. This is a hands-on computer-based course, which will enable participants to conduct meaningful analyses of microarray data. Participants will gain an understanding of the principles underlying microarray technologies, including: theory of sample preparation, sample processing on microarrays, familiarly with the use of Affymetrix Microarray Suite software and generation of data sets. Transferring data among software packages to manipulate data will also be discussed. Importation of data into other software (GeneSpring and DecisionSite) will enable participants to mine the data for higher-order patterns. Participants will learn about the rationale behind the choice of normalization and data filtering strategies, distance metrics, use of appropriate clustering choices such as K-means, Hierarchical, and Self Organizing Maps. Course Offered as BIOC 460, PATH 460, CNCR 460.

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 486. HIV Immunology. 3 Units.
This course will examine the unique immunology of HIV disease. The course content will include the study of HIV pathogenesis, immune control, immune dysfunctions, HIV prevention and immune restoration. Students will be expected to attend lectures and participate in class discussions. A strong emphasis will be placed on reviewing scientific literature. Students will be asked to help organize and to administer an HIV immunology journal club and will be asked to prepare a written proposal in the area of HIV immunology. Offered as PATH 486 and MBIO 486. Prereq: PATH 416 or permission from the instructor.

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/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.

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 520. Basic Cancer Biology and the Interface with Clinical Oncology. 3 Units.
This is an introductory cancer biology course that is intended to give students a broad and basic overview of Cancer Biology and Clinical Oncology. The course will cover not only fundamental principles of cancer biology, but will also highlight advances in the pathobiology and therapeutics of cancer. Classes will be of lecture and discussion format, with emphasis on critically reading original journal articles. The specific topics presented will include carcinogenesis, oncogenes, tumor suppressor genes, genetic epidemiology, DNA repair, growth factor action/signal transduction, apoptosis, cell cycle control, cell adhesion, angiogenesis, tumor cell heterogeneity, metastasis, chemotherapeutics, photodynamic therapy, gene therapy, signal transduction inhibitor therapy, chemoprevention, and clinical oncology of the breast, prostate, lymphatic tissue, colon and other related malignancies. Course grades will be computed from participation/discussion, presentation and mid-term/final exams. Recommended preparation: CBIO 453 and CBIO 455. Offered as PATH 520 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 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.

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 mis-folding 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. Transport and Targeting of Macromolecules in Health and Disease. 3 Units.
PATH 525 is a 3 credit hour advanced course on neurodegenerative disorders intended for PhD and MD/PhD students. Master’s and first and second-year medical students with adequate background in cell and molecular biology and the drive to work hard and overcome challenges are welcome. 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 mis-folding 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 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%). Offered as PATH 525 and CLBY 525.

PATH 601. Special Problems. 1 - 18 Unit.
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 651. Thesis M.S.. 1 - 18 Unit.

PATH 701. Dissertation Ph.D.. 1 - 9 Unit.
Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Department of Pharmacology

Diane Dowd, PhD, Coordinator

The Department of Pharmacology offers training leading to MS, PhD or MD/PhD degrees for highly qualified post-undergraduate candidates committed to academic 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 clinical 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/neuroparmacology, and drug resistance.

Students who desire the combined MD/PhD degrees are admitted to the Medical Scientist Training Program (MSTP, please see separate listing in this publication). 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 Biomedical Research Building, 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 and mass spectroscopy, 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 during their final semester and sit for a integrative essay question-style examination on the content of the required coursework. A total of 27 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 prescribe 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**

### First Year

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Cell Biology I (CBIO 453)</td>
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<tr>
<td>Molecular Biology I (CBIO 455)</td>
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<tr>
<td>Principles of Pharmacology I: The Molecular Basis of Therapeutics (PHRM 401)</td>
<td>3</td>
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<tr>
<td>Principles of Pharmacology II: The Physiological Basis of Therapeutics (PHRM 402)</td>
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<td>Year Total:</td>
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### Second Year

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<td>PHRM Elective</td>
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<td>Independent Study and Research (PHRM 601)</td>
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<tr>
<td>Pharmacology Seminar Series (PHRM 511)</td>
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<tr>
<td>PHRM Elective</td>
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<tr>
<td>Independent Study and Research (PHRM 601)</td>
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<tr>
<td>Master's Comprehensive Exam (EXAM 600)</td>
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**Total Units in Sequence:** 25-27

**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.

### First Year

<table>
<thead>
<tr>
<th>Units</th>
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<tbody>
<tr>
<td>Integrated Biological Sciences I (IBIS 401)</td>
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</tr>
<tr>
<td>Integrated Biological Sciences II (IBIS 402)</td>
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### Second Year

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<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td>Integrated Biological Sciences III (IBIS 403)</td>
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<td>Principles of Pharmacology I: The Molecular Basis of Therapeutics (PHRM 401)</td>
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<td>Pharmacology Seminar Series (PHRM 511)</td>
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<td></td>
</tr>
<tr>
<td>Principles of Pharmacology II: The Physiological Basis of Therapeutics (PHRM 402)</td>
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<tr>
<td>On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)</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>
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<td></td>
</tr>
<tr>
<td>Exam in Biomedical Investigation (IBIS 600)</td>
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</table>
PhD in Pharmacology

Students seeking the PhD degree are admitted directly into the Department of Pharmacology through the Molecular Therapeutics Training Program, through the Biomedical Sciences Training Program, each of which provides an introduction to many related training areas within the biomedical field during the first year, or through the Medical Scientist Training Program (MSTP).

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 faculty members and 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 course in intensive Pharmacology study, oral presentations and laboratory experience, which cumulates in a comprehensive written exam designed to challenge students to apply key concepts in new context.

After advancing to PhD candidacy by passing the comprehensive written exam, students select one of four advanced tracks in Pharmacology. Choice among the tracks is based on the area of research expertise of the thesis advisor and the student’s interest in specific coursework. The four tracks are: Cancer Therapeutics, Membrane Biology and Pharmacology, Molecular Pharmacology and Cell Regulation, and Translational Therapeutics.

The PhD degree is awarded to students who complete 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. Completion of the PhD degree will also require 36 hours of coursework (24 hours of which are graded) and 18 hours of PHRM 701 Dissertation Ph.D..

Core course requirements for the PhD in Pharmacology

The first year consists of the Core curriculum in Cell Biology and Molecular Biology (CBIO 453 Cell Biology I, CBIO 455 Molecular Biology I) and research rotations, as well as a scientific ethics course (15 credit hours). This is included with the additional 15 formal course credit hours which are required in Pharmacology as listed and then described below.
Advanced Track Elective 2 3
Dissertation Ph.D. (PHRM 701) 1-9
Topics in Cell and Molecular Pharmacology (PHRM 525) 0 - 18
Grant writing workshop
Prelim II Thesis Proposal (by Sept. 30, Yr 3) 2
Year Total: 4-13 4-13 2-20
Total Units in Sequence: 27-80

* Rotation 1 takes place during Summer prior to First Year Fall Semester.

Courses

PHRM 301. Undergraduate Research. 1 - 18 Unit.

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. Most classes will be extensive discussions coupled with student presentations of assigned materials. 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 409. 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.

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 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, 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 and 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, MVIR 420, PATH 422, and PHRM 420. Prereq: CBIO 453 and CBIO 455.

PHRM 430. Advanced Methods in Structural Biology. 1 - 6 Unit.
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. Offered as BIOC 430, CHEM 430, PHOL 430, and PHRM 430.
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 and 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 476. Cellular Biophysics. 4 Units.
This course focuses on a quantitative understanding of cellular processes. It is designed for students who feel comfortable with and are interested in analytical and quantitative approaches to cell biology and cell physiology. Selected topics in cellular biophysics will be covered in depth. Topics include theory of electrical and optical signal processing used in cell physiology, thermodynamics and kinetics of enzyme and transport reactions, single ion channel kinetics and excitability, mechanotransduction, and transport across polarized cell layers. The format consists of lectures, problem sets, computer simulations, and discussion of original publications. The relevant biological background of topics will be provided appropriate for non-biology science majors. Offered as BIOC 476, NEUR 477, PHOL 476, PHRM 476.

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 an introductory cancer biology course that is intended to give students a broad and basic overview of Cancer Biology and Clinical Oncology. The course will cover not only fundamental principles of cancer biology, but will also highlight advances in the pathobiology and therapeutics of cancer. Classes will be of lecture and discussion format, with emphasis on critically reading original journal articles. The specific topics presented will include carcinogenesis, oncogenes, tumor suppressor genes, genetic epidemiology, DNA repair, growth factor action/signal transduction, apoptosis, cell cycle control, cell adhesion, angiogenesis, tumor cell heterogeneity, metastasis, chemotherapy, photodynamic therapy, gene therapy, signal transduction inhibitor therapy, chemoprevention, and clinical oncology of the breast, prostate, lymphatic tissue, colon and other related malignancies. Course grades will be from participation/discussion, presentation and mid-term/final exams. Recommended preparation: CBIO 453 and CBIO 455. Offered as PATH 520 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 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 Unit.
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 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, and PHRM 528.

PHRM 555. Current Proteomics. 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 hands-on experience with techniques used in current proteomics. Lectures will cover protein/peptide separation techniques, protein mass spectrometry, bioinformatics tools, and biological applications which include quantitative proteomics, protein modification proteomics, interaction proteomics, structural genomics and structural proteomics. 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 and protein identification using computational tools. The instructors' research topics will also be discussed. Recommended preparation: CBIO 453 and CBIO 455. 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 Unit.
PHRM 651. Thesis M.S.. 1 - 18 Unit.

PHRM 701. Dissertation Ph.D.. 1 - 9 Unit.
Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

Department of Physiology and Biophysics

Jean Davis (jean.davis@case.edu), Coordinator

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 34, 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.

Masters 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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<thead>
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### MS 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 benefit package. Staff are expected to make up the time they spend in class during the day after hours.

#### First Year

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#### Total Units in Sequence: 20

### 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 course work in modern laboratory methodology and instrumentation.

Students in Physiology and Biotechnology track must complete:

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### 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, by direct admission to the department or via the MSTP program.

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)]

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**Plan of Study for PhD in Structural Biology and Biophysics * **

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**Total Units in Sequence:** 32-64

* 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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**Total Units in Sequence:** 33-65

* After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total
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 PHOL401A or PHOL401B (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 Gibbs-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 PHOL401A or PHOL401B (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 Gibbs-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%).

Courses

PHOL 351. Independent Study. 1 - 6 Unit.
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 402. Physiological Basis for Disease. 4 Units.
Physiological Basis for Disease-- is a graduate-level introductory 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 courses. Select diseases of the endocrine, central nervous, pulmonary, cardiac and renal systems will be covered. The course is 4 credit hours and will be given in the Fall semester of each year. The format will be a combination of lecture and journal paper presentations and discussion. Grading will be based on five short answer/essay examinations given at the end of each section (50%), class participation (30%) and a final presentation (20%).

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, 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, EEC 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 Unit.
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. Offered as BIOC 430, CHEM 430, PHOL 430, and PHRM 430.

PHOL 451. Independent Study. 1 - 18 Unit.
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 and PHOL 466 and PHRM 466.

PHOL 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of 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.

PHOL 468. Membrane Physiology. 3 Units.
This student-guided discussion/journal course focuses on biological membranes. Topics discussed include thermodynamics and kinetics of membrane transport, oxidative phosphorylation and bioenergetics, electro-physiology of excitable membranes, and whole and single channel electrophysiology, homeostasis and pH regulation, volume and calcium regulation. Offered as CLBY 468 and PHOL 468.

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 BIOC 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.
PHOL 476. Cellular Biophysics. 4 Units.
This course focuses on a quantitative understanding of cellular processes. It is designed for students who feel comfortable with and are interested in analytical and quantitative approaches to cell biology and cell physiology. Selected topics in cellular biophysics will be covered in depth. Topics include theory of electrical and optical signal processing used in cell physiology, thermodynamics and kinetics of enzyme and transport reactions, single ion channel kinetics and excitability, mechanotransduction, and transport across polarized cell layers. The format consists of lectures, problem sets, computer simulations, and discussion of original publications. The relevant biological background of topics will be provided appropriate for non-biology science majors. Offered as BIOL 476, NEUR 477, PHOL 476, PHRM 476.

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); Hemorrhagy, Cardiac Hypertrophy and Fibrillation; Respiration Physiology (Gas Transport and Exchange, Control of Breathing, Acid/base regulation, Cor Pulmonaris and Cystic Fibrosis, Sleeping apnea and Emphysema); Renal Physiology (Glomerular Filtration, Tubular Function/transport, Glomerulonephritis, 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, 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 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. 2 Units.
Physiology is the dynamic study of life, describing 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, 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 in turn depends on the interactions among subcellular organelles and countless molecules. 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 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, polycystic kidney disease, etc. Translational Physiology I is a lecture course (1, 2hr lecture/week) taught primarily by clinical faculty. It is the first of a two-part course that follows the topics being simultaneously covered in the Medical Physiology II course. It 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. Coreq: PHOL 482.

PHOL 484. Translational Physiology II. 2 Units.
Physiology is the dynamic study of life, describing 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, 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 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, polycystic kidney disease, etc. Translational Physiology II is a lecture course (1, 2hr lecture/week) taught primarily by clinical faculty. It is the first of a two-part course that follows the topics being simultaneously covered in the Medical Physiology II course. It 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. Coreq: PHOL 482.

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 497A, 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; d. 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 497A 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; d. 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 497A 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 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 513. Structural Journal Club. 1 Unit.
Current topics of interest in structural biology, and protein biophysics. Offered as PHOL 513 and PHRM 513.

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; 1.5hrs/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 522. Special Topics in Cardiac Electrophysiology. 3 Units.
Introduction to current topics in cellular cardiac electrophysiology and cardiac ion channel structure, function, and regulation. The format includes informal lectures as well as student presentations and class discussion of current literature.

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 BIOC 528, PHOL 528, and PHRM 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 - 16 Unit.
Cellular physiology laboratory research activities that are based on faculty and student interests.
PHOL 610. Oxygen and Physiological Function. 3 Units.
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 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 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. 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 attendings 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. Students will observe the medical team involved with management of stroke and vascular neurological problems in the emergency department, the Neuro-critical care unit, step down unit, and hospital floor. They will learn how to approach an acute stroke and will become familiar with identifying which patients may benefit from the interventional procedures. 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. To pass this course, students must pass both Parts I and II of their evaluation. Part I: The attending physician on the service will recommend to the course director whether the student earned a Pass or No Pass grade in the clinical aspect of the course based upon attendance, professional demeanor, active participation, and knowledge of the area. Part II: The student will submit (no later than one week after the end of the course) a 5 page paper (minus the title page, figures, and references) for grading to the course director describing the physiology that underlays one of the clinical cases they observed during the course. Students who do not Pass both parts of the evaluation will receive a grade of No Pass for the course and will be dropped from the Area of Concentration in Clinical Neuroscience program and will not be able to take further course in the PHOL 620 series of courses. Recommended Preparation: Pass National Board Subject Exam in Physiology and Neurophysiology. 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. 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 attendings on an active acute Stroke 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. Students will observe the medical team involved with management of stroke and vascular neurological problems in the emergency department, the Neuro-critical care unit, step down unit, and hospital floor. They will learn how to approach an acute stroke and will become familiar with identifying which patients may benefit from the interventional procedures. 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. To pass this course, students must pass both Parts I and II of their evaluation. Part I: The attending physician on the service will recommend to the course director whether the student earned a Pass or No Pass grade in the clinical aspect of the course based upon attendance, professional demeanor, active participation, and knowledge of the area. Part II: The student will submit (no later than one week after the end of the course) a 5 page paper (minus the title page, figures, and references) for grading to the course director describing the physiology that underlays one of the clinical cases they observed during the course. Students who do not Pass both parts of the evaluation will receive a grade of No Pass for the course and will be dropped from the Area of Concentration in Clinical Neuroscience program and will not be able to take further course in the PHOL 620 series of courses. Recommended Preparation: Pass National Board Subject Exam in Physiology and Neurophysiology. 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. 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 attendings on an active acute Epilepsy 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. The course will: 1. Introduce the student to clinical assessment of adults with new onset seizures. 2. Introduce the student to history-taking of adults with a seizure disorder. 3. Teach the student the principles of managing epilepsy with medications and surgery. 4. Expose the student to some “cutting-edge” technologies applied in epilepsy - PET, SPECT, and invasive EEG. 5. Give the student a clinical approach in the management of epilepsy induced comorbidities (social, psychologic, etc.). 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. To pass this course, students must pass both Parts I and II of their evaluation. Part I: The attending physician on the service will recommend to the course director whether the student earned a Pass or No Pass grade in the clinical aspect of the course based upon attendance, professional demeanor, active participation, and knowledge of the area. Part II: The student will submit (no later than one week after the end of the course) a 5 page paper (minus the title page, figures, and references) for grading to the course director describing the physiology that underlays one of the clinical cases they observed during the course. Students who do not Pass both parts of the evaluation will receive a grade of No Pass for the course and will be dropped from the Area of Concentration in Clinical Neuroscience program and will not be able to take further course in the PHOL620 series of courses. Recommended Preparation: Pass National Board Subject Exam in Physiology and Neurophysiology. 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 and PHOL 498B.

PHOL 651. Thesis M.S.. 1 - 18 Unit.
PHOL 701. Dissertation Ph.D.. 1 - 9 Unit.
Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.

School of Medicine Faculty
Full-Time Faculty

School of Medicine

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John Fredieu, PhD
Asst Professor
Barbara Freeman, PhD
Asst Professor
Ita KaisermanAbramof, PhD
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Scott Simpson, PhD
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Susanne Wish-Baratz, PhD
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Biochemistry
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Bioethics  
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<td>Professor</td>
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<td>Andrei Brateanu, MD</td>
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<td>Karen Broer, PhD</td>
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<td>David Bronson, MD</td>
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Josephine Cialone, MS
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Rachel Colchamiro, BS
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<td>Adj Instructor</td>
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Sudhakar Chandurkar, MD  
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<td>Atul Hulyalkar, MD</td>
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<td>Karen Hummel, MD</td>
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</tr>
</tbody>
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David Hutt, MD  
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<td>Roman Petroff, MD</td>
<td>Clin Instructor</td>
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<td>Latha Pillai, MD</td>
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<td>Steven Schwartz, MD</td>
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<td>Sinziana Seicean, MD, PhD</td>
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<td>James Senft, MD, PhD</td>
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<td>Donna Sexton, MD</td>
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<td>Fariha Shad, MD</td>
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<td>Khanjan Shah, MD</td>
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<td>Eric Shapiro, MD</td>
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<td>Trilok Sharma, MD</td>
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<td>John Sheehan, MD</td>
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<td>Kamal Shemisa, MD</td>
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Clin Instructor
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<td>Irwin Kornbluth, MD</td>
<td>Clin Assist Prof</td>
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<td>Michael Koroly, MD</td>
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<td>Emily Leslie, MA/MS</td>
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<td>Bansari (Bonnie) Patel, MD</td>
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<td>Sherilyn Sage, MD</td>
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<td>Anita Schwandt, MD</td>
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<td>Barbara Shagawat, MD</td>
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