

## CELLULAR, MOLECULAR, AND BIOMEDICAL SCIENCES

<http://www.uvm.edu/cmb/>

### OVERVIEW

The Cellular, Molecular and Biomedical Sciences (CMB) program provides personalized training in a graduate-student focused, state-of-the-art research environment. Graduates are highly qualified scientists ready to take on the rigors of scientific careers in academia, industry, and government.

This interdisciplinary program is comprised of highly dedicated research faculty in 16 departments across the UVM campus. This breadth, combined with a collegial atmosphere, provides an ideal environment for studying the molecular, cellular, genetic, biophysical, and biochemical mechanisms that control organismal development and disease.

### DEGREES

Cellular, Molecular and Biomedical Sciences M.S.

Cellular, Molecular and Biomedical Sciences Ph.D.

### FACULTY

**Ali, M. Yusuf;** Assistant Professor, Department of Molecular Biology and Biophysics, PHD, Toyohashi University of Technology

**Amiel, Eyal;** Assistant Professor, Department of Biomedical and Health Sciences; PHD, Dartmouth College

**Anathy, Vikas;** Associate Professor, Department of Pathology and Laboratory Medicine; PHD, Madurai Kamraj University

**Barlow, John;** Associate Professor, Department of Animal and Veterinary Sciences; DVM, University of Illinois Urbana-Champaign; PHD, University of Vermont

**Berger, Christopher Lewis;** Professor, Department of Molecular Physiology and Biophysics; PHD, University of Minnesota Twin Cities

**Bernstein, David;** Assistant Professor, Department of Electrical and Biomedical Engineering; PHD, Boston University

**Bonney, Elizabeth;** Professor, Department of Obstetrics and Gynecology; MD, Stanford University

**Botten, Jason W.;** Professor, Department of Medicine-Pulmonary; PHD, University of New Mexico

**Boyson, Jonathan;** Associate Professor, Department of Surgery; PHD, University of Wisconsin Madison

**Brasino, Danielle;** Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, The University of Colorado at Boulder

**Brasino, Michael;** Assistant Professor, Department of Electrical and Biomedical Engineering; PHD, The University of Colorado at Boulder

**Bruce, Emily;** Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, Cambridge University

**Caporizzo, Matthew;** Assistant Professor, Department of Molecular Physiology and Biophysics; PHD, University of Pennsylvania

**Carr, Frances Eileen;** Professor, Department of Pharmacology; PHD, University of Illinois Chicago

**Celli, Jean;** Professor, Department of Microbiology and Molecular Genetics; PHD, Université Pierre & Marie Curie

**Chatterjee, Nimrat;** Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, Baylor College of Medicine

**Cunniff, Brian;** Assistant Professor, Department of Pathology and Laboratory Medicine; PHD, University of Vermont

**Deming, Paula;** Associate Professor, Department of Biomedical and Health Sciences; PHD, University of North Carolina at Chapel Hill

**Diehl, Sean;** Associate Professor, Department of Microbiology and Molecular Genetics; PHD, University of Vermont

**Doublié, Sylvie;** Professor, Department of Microbiology and Molecular Genetics; PHD, University of North Carolina Chapel Hill

**Erdos, Benedek;** Assistant Professor, Department of Pharmacology; MD, PHD, Semmelweis University, School of Medicine, Budapest, Hungary

**Etter, Andrea;** Assistant Professor, Department of Nutrition and Food Sciences; PHD, Purdue University

**Everse, Stephen;** Associate Professor, Department of Biochemistry; PHD, University of California San Diego

**Francklyn, Christopher;** Professor, Department of Biochemistry; PHD, University of California Santa Barbara

**Freeman, Kalev;** Assistant Professor, Department of Surgery; MD, PHD, University of Colorado Boulder

**Frietze, Seth;** Associate Professor, Department of Biomedical and Health Sciences; PHD, Harvard University

**Glass, Karen;** Associate Professor, Department of Pharmacology; PHD, University of Vermont

**Gordon, Jonathan;** Assistant Professor, Department of Biochemistry; PHD, University of Western Ontario

**Green, John Thomas;** Professor, Department of Psychological Science; PHD, Temple University

**Harraz, Osama F.;** Assistant Professor, Department of Pharmacology; PHD, University of Calgary

**Heath, Jessica;** Associate Professor, Department of Pediatrics; Department of Biochemistry; MD, SUNY Stony Brook

**Herrera, Gerald M.;** Assistant Professor, Department of Pharmacology; PHD, University of Vermont

**Hondal, Robert;** Professor, Department of Biochemistry; PHD, Ohio State University

**Howe, Alan K.;** Professor, Department of Pharmacology; PHD, Northwestern University

**Huston, Christopher;** Professor, Department of Medicine-Infectious Disease; MD, Cornell University

**Janssen-Heininger, Yvonne M.W.;** Professor, Department of Pathology and Laboratory Medicine; PHD, Maastricht University, The Netherlands

**Jetton, Thomas Lawrence;** Professor, Department of Medicine-Endocrinology; PHD, Vanderbilt University

**Kelm, Robert;** Associate Professor, Department of Medicine-Cardiovascular; PHD, University of Vermont

**Kinsey, C. Matthew;** Assistant Professor, Department of Medicine-Pulmonary, MD, Albert Einstein College of Medicine, Bronx, NY; MPH Harvard School of Public Health

**Klug, Nicholas;** Assistant Professor, Department of Pharmacology; PHD, University of California, Davis

**Knodler, Leigh;** Associate Professor, Department of Microbiology and Molecular Genetics; PHD, University of New South Wales

**Krementsov, Dimitry N.;** Assistant Professor, Department of Biomedical and Health Sciences, PHD, University of Vermont

**Landry, Christopher C.;** Professor, Department of Chemistry; PHD, Harvard University

**Lee, Benjamin;** Associate Professor, Department of Pediatrics; MD, Case Western Reserve University

**Lounsbury, Karen M.;** Professor, Department of Pharmacology; PHD, University of Pennsylvania

**Ma, Wen;** Assistant Professor, Department of Physics; PhD, University of Illinois at Urbana-Champaign

**Majumdar, Dev;** Assistant Professor, Department of Surgery; PHD, University of California Los Angeles

**Martorelli Di Genova, Bruno;** Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, Federal University of Sao Paulo

**Morelli, Kathryn;** Assistant Professor, Department of Neurological Sciences; PhD, The Jackson Laboratory & University of Maine

**Mughal, Amreen;** Assistant Professor, Department of Pharmacology; PHD, North Dakota State University

**Nallasamy, Shanmugasundaram;** Assistant Professor, Department of Obstetrics, Gynecology, and Reproductive Sciences; DVM, Tamil Nadu Veterinary and Animal Sciences University, India; PHD, University of Illinois at Urbana-Champaign

**Nelson, Mark;** Professor, Department of Pharmacology; PHD, Washington University in St Louis

**Poynter, Matthew;** Professor, Department of Medicine-Pulmonary; PHD, University of Utah

**Previs, Michael;** Assistant Professor, Department of Molecular Physiology and Biophysics; PHD, University of Vermont

**Quénet, Delphine;** Assistant Professor, Department of Biochemistry, PHD; University of Strasbourg, France

**Roberts, Steven;** Associate Professor, Department of Microbiology and Molecular Genetics; PHD, University of North Carolina

**Salogiannis, John;** Assistant Professor, Department of Molecular Physiology and Biophysics; PHD, Harvard University

**Seward, David;** Assistant Professor, Department of Pathology and Laboratory Medicine; MD, PHD, University of Colorado Anschutz Medical Campus

**Silveira, Jay R.;** Assistant Professor, Department of Biochemistry; PHD, University of Vermont

**Skinner, R. Chris;** Assistant Professor, Department of Nutrition and Food Science; PHD, West Virginia University

**Spees, Jeffrey;** Professor, Department of Medicine-Cardiovascular; PHD, University of California Davis

**Stafford, James;** Assistant Professor, Department of Neurological Sciences; PHD, Oregon Health and Science University

**Stein, Gary;** Professor, Department of Biochemistry; PHD, University of Vermont

**Stein, Janet;** Professor, Department of Biochemistry; PHD, Princeton University

**Stumpff, Jason K.;** Associate Professor, Department of Molecular Physiology and Biophysics; PHD, University of Colorado

**Symeonides, Menelaos;** Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, University of Vermont

**Taatjes, Douglas Joseph;** Professor, Department of Pathology and Laboratory Medicine; PHD, University of Basel

**Thali, Markus Josef;** Professor, Department of Microbiology and Molecular Genetics; PHD, University of Zurich

**Tierney, Mary Lauretta;** Associate Professor, Department of Plant Biology; PHD, Michigan State University

**Todd, Travis;** Research Assistant Professor, Department of Psychological Science, PHD, University of Vermont

**Toth, Michael;** Professor, Department of Medicine-Cardiovascular; PHD, University of Maryland Baltimore

**Trybus, Kathleen;** Professor, Department of Molecular Physiology and Biophysics; PHD, University of Chicago

**van der Vliet, Albert;** Professor, Department of Pathology and Laboratory Medicine; PHD, University of Amsterdam

**Ward, Gary;** Professor, Department of Microbiology and Molecular Genetics; PHD, University of California San Diego

**Wargo, Matthew;** Associate Professor, Department of Microbiology and Molecular Genetics; PHD, Dartmouth College

**Warshaw, David;** Professor, Department of Molecular Physiology and Biophysics; PHD, University of Vermont

**Weiss, Daniel;** Professor, Department of Medicine-Pulmonary; MD, PHD, Mount Sinai School of Medicine

**Wellman, George;** Professor, Department of Pharmacology; PHD, University of Vermont

### Biochemistry Courses

#### **BIOC 5990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

#### **BIOC 6001. General Biochemistry I. 3 Credits.**

Survey for science majors. Chemistry, structure, metabolism, and function of proteins, carbohydrates, lipids; enzymes, bioenergetics and respiratory processes. Prerequisite: CHEM 2585 or Instructor permission.

#### **BIOC 6002. General Biochemistry II. 3 Credits.**

Survey for science majors. Amino acids, nucleic acids, protein synthesis, cellular and physiological control mechanisms. Prerequisite: BIOC 6001 or Instructor permission.

#### **BIOC 6072. Cancer Biology. 3 Credits.**

Overview of cancer biology for health science students. Foundation for cancer research. Lecture format; interdisciplinary viewpoint; outside lectures. Prerequisite: BIOC 6001 or Department permission.

#### **BIOC 6391. Master's Thesis Research. 1-12 Credits.**

Research for the Master's Thesis.

**BIOC 6990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**BIOC 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**BIOC 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**BIOC 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**BIOC 7001. Critical Reading and Analysis. 2 Credits.**

Acquire a working knowledge of some highly impactful studies conducted in the field of biochemistry. By carefully reading and reviewing a series of classic and contemporary scientific papers, gain a greater appreciation for some of the conceptual and technical innovations in experimentation that provided answers to vexing problems or created entirely new fields of inquiry. Prerequisite: BIOC 6001.

**BIOC 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**BIOC 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**BIOC 7991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**BIOC 7995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**Cell Biology Courses****CLBI 5990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CLBI 6010. Cell Biology. 3 Credits.**

Advanced survey of cell organelles, their composition, origin, and the relationship between their structure and function. Emphasis on recent literature and current controversies. Prerequisites: CHEM 2585; Biology Graduate student; or Instructor permission.

**CLBI 6020. Science Communication. 2 Credits.**

Develop effective oral and written communication skills for a range of audiences from academia to industry, organizations, news, policymakers, and the general public.

**CLBI 6080. Seminar. 1 Credit.**

One hour.

**CLBI 6391. Master's Thesis Research. 1-18 Credits.**

Research for the Master's Thesis.

**CLBI 6990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CLBI 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**CLBI 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**CLBI 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**CLBI 7010. Critical Reading & Analysis. 2 Credits.**

Runs concurrently with CLBI 6010 and utilizes primary literature and an active, discussion-based approach to provide intensive study in the logic, critical thinking, and experimental design & interpretation. Co-requisite: CLBI 6010.

**CLBI 7020. Biomedical Data Analysis. 2 Credits.**

Introduction to qualitative, quantitative and statistical analysis for cell, molecular, and biomedical sciences. The practical philosophy underlying data presentation and interpretation will be emphasized via problem solving in and outside of class time.

**CLBI 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**CLBI 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CLBI 7991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**CLBI 7995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**Microbiology Molecular Genetics Courses****MMG 5210. Gr Medical Microbiology. 3 Credits.**

Addresses the clinical importance of infectious diseases with emphasis on the appropriate collection, handling and identification of clinically relevant bacteria. Disease states, modes of transmission, prevention and antibiotic susceptibility testing will also be discussed. Credit not awarded for both MMG 5210 and MMG 3210.

Prerequisite: Undergraduate course in microbiology recommended.

**MMG 5220. Gr Medical Micro w/lab. 0 or 4 Credits.**

Comprehensive study of human pathogenic bacteria and their disease states in humans. Laboratory sessions provide practical experience in handling and identifying these pathogens. Credit not awarded for both MMG 5220 and MMG 3220. Prerequisite: Undergraduate course in microbiology recommended.

**MMG 5230. Immunology Concepts. 3 Credits.**

Introduces the vast array of defenses that can be deployed by mammalian hosts to protect against infections. Explores how this powerful system can contribute to disease, but also be leveraged in vaccines and cancer immunotherapy. Covers innate and adaptive immunity and analyze the immune system in health and disease. Credit not awarded for both MMG 5230 and MMG 3230. Prerequisite: Recommended one semester of biochemistry and/or one semester of cell biology.

**MMG 5270. Advanced Cancer Genetics. 3 Credits.**

Focuses on genetic mechanisms that either protect us from cancer or increase our vulnerability to cancer. Discusses genetic methods that are being used to discover genes that influence cancer risk or may prove useful in diagnostics or cancer therapy. Credit not awarded for both MMG 5270 and MMG 3270. Prerequisites: An introductory courses in genetics and cell biology is recommended.

**MMG 5310. Bioinformatics & Data Analysis. 3 Credits.**

Designed to provide a broad overview of bioinformatics, emphasizing accessing and interpreting biological sequence data (DNA, RNA, protein) from various databases. Covers the following topics: data mining, DNA sequence alignment, genetic variation, next-generation sequencing (NGS), and transcriptomics. Highlights a direct, hands-on experience. Credit not awarded for both MMG 5310 and MMG 3310. Prerequisite: Instructor permission.

**MMG 5320. Advanced Bioinformatics. 3 Credits.**

Students will learn and execute each step in the bioinformatic workflow by processing a publicly available genomics dataset. By the end of the course, students will have accessed, processed, analyzed, visualized, and interpreted an NGS dataset of their choosing. Credit not awarded for both MMG 5320 and MMG 3320. Prerequisite: Instructor permission.

**MMG 5990. Special Topics. 1-18 Credits.**

Supervised investigations in microbiology or molecular genetics. Prerequisite: Instructor permission. Credit as arranged.

**MMG 5994. Teaching Assistantship. 1-3 Credits.**

Student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

**MMG 6110. Adv Bacterial Genetics. 3 Credits.**

Covers bacterial genetics and the biology of bacteria at an advanced level through a combination of lectures, primary literature discussions, and team-based learning exercises. Prerequisite: A foundational understanding of microbiology, genetics, molecular biology and biochemistry is assumed.

**MMG 6200. Cellular Microbiology. 4 Credits.**

Utilizes primary literature to explore the cellular and molecular basis of microbial pathogenesis caused by viruses, pathogenic bacteria and protozoan parasites.

**MMG 6330. Adv Genetics and Genomics. 3 Credits.**

Covers the topics of gene structure, expression, epigenetics and inheritance. These basics will form the foundation of discussions on functional genomics and genome engineering. Current approaches and methodologies to address scientific questions related to these topics will be emphasized. Consequently, recent reviews and primary research literature will be the main texts used in the course. Prerequisites: Understanding of basic genetics, molecular biology, and biochemistry concepts is assumed.

**MMG 6391. Master's Thesis Research. 1-18 Credits.**

Research for the Master's Thesis.

**MMG 6890. Graduate Teaching Practicum. 3 Credits.**

Required practicum for all Microbiology and Molecular Genetics Master's Students. Students will be exposed to and mentored in the fundamentals of undergraduate teaching and learning in the laboratory setting.

**MMG 6990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**MMG 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**MMG 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**MMG 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**MMG 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**MMG 7991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion. Prerequisite: Instructor permission.

**MMG 7995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion. Prerequisite: Instructor permission.

**Molecular Physiology Biophysics Courses****MPBP 6010. Human Physiology & Pharm I. 4 Credits.**

An integrated examination of the physiology and pharmacology of the peripheral nervous, muscle and cardiovascular systems in the human body. Pre/co-requisites: CHEM 1450, CHEM 1580 or equivalent; two semesters general physics; two semesters calculus. May not be taken for credit with MPBP 6060.

**MPBP 6100. Molecular Control of the Cell. 3 Credits.**

Examines the fundamental molecular mechanisms that control dynamic cellular processes. Advanced topics in cell biology will be explored from the single molecule to the whole tissue level with an emphasis on the coordination of complex molecular systems. Prerequisites: MPBP 6010, BIOC 6001, BIOC 6002; Instructor permission.

**MPBP 6300. Biomedical Grantsmanship. 2 Credits.**

Introduces Graduate students in the biomedical life sciences to process of writing competitive research proposals for funding from federal and private agencies such as the National Institutes of Health (NIH).

**MPBP 6391. Master's Thesis Research. 1-18 Credits.**

Research for the Master's Thesis.

**MPBP 6810. Seminar. 1 Credit.**

Presentation and discussion by advanced students, staff, and invited speakers, of current topics in physiology. Prerequisite: Department permission.

**MPBP 6900. Medical Master's Capstone. 1-2 Credits.**

Advances fundamental knowledge in Biochemistry, Pharmacology, and Physiology by addressing therapeutic applications. Students will choose and research current clinical problems and will communicate new molecular strategies through formal presentations. Prerequisites: BIOC 6001, MPBP 6010; Medical Science Graduate student; or Instructor permission.

**MPBP 6990. Special Topics. 1-18 Credits.**

Topics of interest to Graduate students beyond the scope of existing courses.

**MPBP 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**MPBP 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**MPBP 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**Neuroscience Courses****NSCI 5220. Advanced Cellular Neurophysiol. 3 Credits.**

Discusses in detail, on both the cellular and molecular level, the physiological properties of cells within the nervous system. Focuses not only on the specific details of neuronal physiology, but also on the scientist, hypothesis, and experimental paradigm that validated the foundational ideas and concepts of this field. Credit not awarded for both NSCI 5220 and NSCI 3220.

**NSCI 5230. Neurochemistry. 3 Credits.**

Biochemistry of the nervous system. Topics include ion channels, synaptic function, neurotransmitters and neuropeptides, signal transduction, and hormones in brain function. Prerequisite: Instructor permission.

**NSCI 5300. Gr Comparative Neurobiology. 3 Credits.**

Many biological adaptations involve unique sensory and/or motor system skills that enable successful prey detection, predator avoidance, or mate location. Explores ways in which the nervous systems of a wide variety of animals are uniquely adapted for their survival challenges. Credit not awarded for both NSCI 5300 and NSCI 3230.

**NSCI 5990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**NSCI 6010. Intr Functional Neuroimaging 2. 3 Credits.**

Part One will offer lecture-based technical background on in vivo brain-imaging techniques (e.g.MRI, PET; MEG; EEG; TMS). Part Two will focus on hands-on fMRI data processing including data collection at UVMMC research MRI unit and in-class analysis instruction. Pre/Co-requisites: Basic statistics and/or introductory physics helpful.

**NSCI 6020. Neuroscience. 3 Credits.**

Functional anatomy of the human nervous system. Lectures and laboratory providing learning experience with dissected specimens, gross and microscopic anatomy. Incorporates clinical information from physician-scientists. Prerequisite: Physical Therapy Graduate student or Instructor permission.

**NSCI 6030. Human Gross and Microanatomy. 3 Credits.**

Combination of gross anatomy, histology, embryology, physiology and medical imaging to present an integrated overview of the human body. Emphasis on peripheral nervous system including autonomic nervous system and cranial nerves. Cadaver dissection laboratory combined with lecture and/or content modules and research and teaching presentations. Pre/Co-requisites: Six credits coursework, plus two credits lab in biology, general chemistry, organic chemistry and physics; Neuroscience Graduate student or Instructor permission.

**NSCI 6071. Medical Neuroscience Part 1. 2-6 Credits.**

Explores the nervous system through integrative study of behavior, cellular and systems neurobiology, neuroanatomy, neuroethics, neuropharmacology, neurophysiology, pathophysiology, and psychopathology. Several instructional methods support learning in this course, including lecture, online independent study modules, laboratory sessions, team-based learning and case and problem based discussions. Prerequisites: Neuroscience Graduate student; Instructor permission.

**NSCI 6072. Medical Neuroscience Part 2. 2-6 Credits.**

Explores the nervous system through integrative study of behavior, cellular and systems neurobiology, neuroanatomy, neuroethics, neuropharmacology, neurophysiology, pathophysiology, and psychopathology. Several instructional methods support learning in this course, including lecture, online independent study modules, laboratory sessions, team-based learning and case and problem based discussions. Prerequisites: Neuroscience Graduate student; Instructor permission.

**NSCI 6270. Resp Conduct in Biomed Rsch. 1 Credit.**

Topics in Scientific Integrity surrounding responsible conduct and practices in biomedical research. Prerequisites: Advanced Graduate students, postdoctoral fellows and assistant professors in the biological or biomedical sciences.

**NSCI 6391. Master's Thesis Research. 1-18 Credits.**

Research for the Master's Thesis.

**NSCI 6820. Seminar in Neuroscience. 1 Credit.**

Research presentations and critical review of the literature in various areas of anatomical and neurobiological sciences.

**NSCI 6990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles. Prerequisite: Instructor permission.

**NSCI 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**NSCI 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**NSCI 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**NSCI 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**NSCI 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**NSCI 7991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**NSCI 7995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**Pathology Courses****PATH 6000. Biomedical Research Design. 1 Credit.**

Covers the anatomy of research: what it is made of; and the physiology of research: how it works. Introduces techniques and strategies of research design, implementation, and interpretation. Provides basic tools needed to understand how research in pathology is conducted.

**PATH 6070. Molecular Pathology. 3 Credits.**

Covers mechanisms of disease, molecular biology and genetics, diagnostic molecular pathology, as well as principles, tools and applications in research of molecular pathogenesis. Prerequisite: PATH 6000.

**PATH 6080. Pathology Journal Club. 1 Credit.**

Develops ability to read and present findings communicated in peer-reviewed research articles at the level necessary to formulate and plan independent research. Co-requisites: PATH 6000, PATH 6030; or Instructor permission.

**PATH 6090. Pathology Grand Rounds. 1 Credit.**

Develops ability to prepare and deliver research presentations/Grand Rounds, and to participate in Grand Rounds discussion by critically reading related literature. Builds on the reading skills developed in PATH 6080. Prerequisites: PATH 6000, PATH 6030, PATH 6080; or Instructor permission.

**PATH 6100. Genomic Med & Cytogenetics. 2 Credits.**

Covers the basic concepts of genomic medicine and cytogenetics and their clinical applications, procedures and techniques of molecular and cytogenetic testing, and management of a clinical laboratory. Focuses on diagnostic molecular and cytogenetic testing applicable to malignancies, constitutional disorders, and pharmacogenomics. Prerequisite: PATH 6300 or Instructor permission; experience in either clinical or anatomic pathology required.

**PATH 6250. Genetics for Clinicians. 3 Credits.**

Provides an overview of contemporary human genetics and genomics with application to clinical practice. Cross-listed with: GRNS 6250.

**PATH 6280. Techniques in Microscopy. 3 Credits.**

Introduces many of the microscopy systems and techniques available in the Microscopy Imaging Center core facility in the Larner College of Medicine at UVM.

**PATH 6300. Pathology Rotations. 3-9 Credits.**

Laboratory practicum for Pathology Master's students. Engages students in clinical and anatomic pathology laboratory rotations under supervision of attending physicians and senior residents in the University of Vermont Medical Center Pathology Department.

**PATH 6310. Pathology Clinical Practice. 1 Credit.**

An opportunity to become familiar with how pathologists work in a team with other clinicians to solve difficult problems in clinical practice. Prerequisite: PATH 6000.

**PATH 6391. Master's Thesis Research. 1-18 Credits.**

Research for the Master's Thesis.

**PATH 6990. Special Topics. 1-18 Credits.**

Special Topics in Pathology. Prerequisites: Immunology desirable; Department permission.

**PATH 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**PATH 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**PATH 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**Pharmacology Courses****PHRM 5400. Molecules & Medicine. 3 Credits.**

This course conveys an understanding about drug design and the molecular mechanisms by which drugs act in the body. It highlights the importance of medicinal chemistry as it overlaps with the disciplines of Chemistry, Biochemistry, Microbiology, Cell Biology, and Pharmacology. Prerequisites: Organic Chemistry, Biology; permission.

**PHRM 5720. Gr Toxicology. 3 Credits.**

Provides an understanding of the chemical, biochemical and physiological factors that determine the pathological effects of chemicals in living systems. Credit not awarded for both PHRM 5720 and PHRM 3720. Prerequisite: Introductory Biology or Organic Chemistry.

**PHRM 5900. Gr Adv Pharmacology Topics. 3 Credits.**

Focuses on basic pharmacological principles, drug interactions with receptors, membranes, synapses, neurotransmitters, macromolecules, ion channels, the cytoskeleton, and membrane pumps. Recent studies of the molecular and cellular mechanisms of drug action are discussed, and state-of-the-art techniques for pharmacological analysis of various cellular target molecules are described. Credit not awarded for both PHRM 5900 and PHRM 3900. Prerequisite: Introductory Biology or Biochemistry or Instructor permission.

**PHRM 6010. Applied Systems Pharmacology. 3 Credits.**

A systems approach to basic and applied pharmacology, including pharmacokinetic and pharmacodynamic principles, drug receptors and mechanisms, and clinically relevant adverse effects. Develops skills in diagnostic reasoning and evidence-based medicine. Prerequisite: Graduate student or Instructor permission.

**PHRM 6020. Pharmacological Techniques. 1-4 Credits.**

Experiments conducted under supervision in the areas of drug metabolism, modes of drug action, physicochemical properties of drugs, bioassay, and toxicology. Thesis Master's students limited to three credits.

**PHRM 6050. Milestones in Pharmacology. 2 Credits.**

A critical readings class where students read and present landmark pharmacology papers and link them to modern experiments and clinical applications. Co-requisite: PHRM 3010 or Graduate student.

**PHRM 6060. Medical Cell Biology. 3 Credits.**

Explores the structure and function of eukaryotic cells in multicellular organisms with a special emphasis on the human model. Appropriate for graduate students who have a strong background in biology and chemistry and students with an interest in pursuing health-related fields. Prerequisite: Graduate student, AMP student, or Instructor permission.

**PHRM 6080. Integrative Physiol. & Pharm.. 3 Credits.**

Intended for students pursuing careers in basic scientific research or health-related fields, designed to combine general physiological principles with examples of disease-based pathophysiology and targeted pharmacological approaches. Case studies will emphasize the impact of these processes on human function. Pre/Co-requisites: Two semesters of Chemistry, two semesters of Physics, a background in Biology/Physiology or Health Sciences.

**PHRM 6391. Master's Thesis Research. 1-18 Credits.**

Research for the Master's Thesis.

**PHRM 6730. Readings in Pharmacology. 2 Credits.**

Intensive directed reading in one area of Pharmacology. Pharmacology students must choose a topic outside thesis research area. Term paper and seminar on selected topic required. Prerequisite: Instructor permission.

**PHRM 6810. Seminar. 1 Credit.**

Current developments in Pharmacology are presented for discussion by students. Prerequisite: Instructor permission.

**PHRM 6900. Medical Master's Capstone. 1-2 Credits.**

Students advance their fundamental knowledge in Biochemistry, Pharmacology, and Physiology by addressing therapeutic applications in a discussion format. Students will choose and research current clinical problems and will communicate new molecular strategies through formal presentations. Prerequisites: BIOC 6001, MPBP 6010; Medical Science Graduate student; or Instructor permission.

**PHRM 6990. Special Topics. 1-18 Credits.**

See schedule of courses for specific titles.

**PHRM 6991. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**PHRM 6993. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**PHRM 6995. Graduate Independent Research. 1-18 Credits.**

Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**PHRM 7491. Doctoral Dissertation Research. 1-18 Credits.**

Research for the Doctoral Dissertation.

**PHRM 7990. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.