

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. (<http://catalogue.uvm.edu/graduate/cellularmolecularbiomedical/cellularmolecularandbiomedicalsciencesms/>)
- Cellular, Molecular and Biomedical Sciences Ph.D. (<http://catalogue.uvm.edu/graduate/cellularmolecularbiomedical/cellularmolecularandbiomedicalsciencesphd/>)

FACULTY

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

Ballif, Bryan; Professor, Department of Biology; PHD, Harvard 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

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

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

Bouchard, Beth; Assistant Professor, Department of Biochemistry; PHD, University of Vermont

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

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

Budd, Ralph Charles; Professor, Department of Medicine-Immunobiology; MD, Weill Cornell Medical College

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

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

Double, 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

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

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

Irvin, Charles G.; Professor, Department of Medicine-Pulmonary; PHD, University of Wisconsin-Madison

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

Kraft, Jana; Associate Professor, Department of Animal and Veterinary Sciences; PHD, Friedrich-Schiller-University of Jena

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, Andrea J.; Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, University of Wisconsin-Madison

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

Li, Jianing; Associate Professor, Department of Chemistry; PHD, Columbia University

Lian, Jane; Professor, Department of Biochemistry; PHD, Boston University

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

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

McKay, Stephanie; Associate Professor, Department of Animal and Veterinary Sciences; PHD, University of Alberta

Morielli, Anthony D.; Associate Professor, Department of Pharmacology; PHD, University of California Santa Cruz

Morrill, Scott Walker; Professor, Department of Biochemistry; PHD, University of Wisconsin-Madison

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

Ou, Yangguang; Assistant Professor, Department of Chemistry; PHD, University of Pittsburgh

Pederson, David Scott; Professor, Department of Microbiology and Molecular Genetics; PHD, University of Rochester

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

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

Schneebeli, Severin; Associate Professor, Department of Chemistry; PHD, Columbia University

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

Shukla, Arti; Professor, Department of Pathology and Laboratory Medicine; PHD, Banares Hindu University

Shukla, Girja Shanker; Associate Professor, Department of Surgery-Oncology; PHD, Lucknow University

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

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

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

Testroet, Eric; Assistant Professor, Department of Animal and Veterinary Science; PHD, Iowa State University

Teuscher, Cory; Professor, Department of Medicine-Immunobiology; PHD, University of New Mexico

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

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

Vanegas, Juan; Assistant Professor, Department of Physics; PHD, University of California Davis

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 201. Fundamentals of Biochemistry. 3 Credits.

Provides a broad introduction to the field of biochemistry.

Students will explore the molecular basis and chemical principles of biochemistry pertinent to living systems. This course is taught by LCOM faculty and emphasizes the relevance of biochemistry to health, disease, physiology and medicine. Prerequisites: CHEM 026, CHEM 042, CHEM 048, CHEM 142, or equivalent; BIOL 002, BCOR 012, BCOR 103, or equivalent.

BIOC 205. Biochemistry I. 3 Credits.

Introduction to chemistry and structure of biological macromolecules; examination of mechanisms of chemical processes in biological systems including enzyme catalysis, biosynthesis, regulation, and information transfer. Prerequisite: CHEM 048 or CHEM 142 or CHEM 144. Cross-listed with: CHEM 205 and MMG 205.

BIOC 206. Biochemistry II. 3 Credits.

Continuation of Biochemistry I. Biochemistry of nucleic acids; nucleic acid based processes, such as replication and transcription; cellular information transfer, genomics, and proteomics. Prerequisite: BIOC 205, CHEM 205, or MMG 205. Cross-listed with: CHEM 206, MMG 206.

BIOC 207. Biochemistry Lab. 3 Credits.

Introduction to biochemical tools, including spectrometry, chromatography, and electrophoresis; natural and recombinant enzyme isolation; assays of DNA-modifying enzymes; computer-based structure/function exercises. Prerequisite: BIOC 205, CHEM 205, or MMG 205. Cross-listed with: CHEM 207, MMG 207.

BIOC 275. Adv Biochem of Human Disease. 3 Credits.

The course takes a deep dive into five distinct areas of biochemistry related to a disease or group of diseases primarily through group learning. Key biochemical principles are reviewed and extended. Additionally students will read and discuss a primary literature article with each area. Prerequisites: NSF 183, BIOC 201, or BIOC 205.

BIOC 301. General Biochemistry. 3 Credits.

Survey for science majors. Chemistry, structure, metabolism, and function of proteins, carbohydrates, lipids; enzymes, bioenergetics and respiratory processes. Prerequisite: CHEM 142 or CHEM 144, or Instructor permission.

BIOC 302. General Biochemistry. 3 Credits.

Survey for science majors. Amino acids, nucleic acids, protein synthesis, cellular and physiological control mechanisms. Prerequisite: BIOC 301, or Instructor permission.

BIOC 351. Proteins I: Structure&Function. 3 Credits.

Special Topics: Introduction to concepts in protein structure and chemistry as well as exploration of ideas in a "hands on" fashion using computational resources. Prerequisite: BIOC 301, or Department permission. Alternate years.

BIOC 372. Cancer Biology. 3 Credits.

Overview of cancer biology for health science students. Foundation for cancer research. Lecture format; interdisciplinary viewpoint; outside lectures. Prerequisite: BIOC 301, or Department permission.

BIOC 390. 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 391. Master's Thesis Research. 1-12 Credits.

Credit as arranged.

BIOC 393. 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 395. Special Topics. 1-12 Credits.**BIOC 396. Advanced Special Topics. 1-12 Credits.****BIOC 397. Independent Graduate 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 490. 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 491. Doctoral Dissertation Research. 1-12 Credits.

Credit as arranged.

BIOC 492. Independent Graduate 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 496. Advanced Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

Cell Biology Courses**CLBI 301. 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. Prerequisite: CHEM 142; Graduate standing in Biology or Instructor permission.

CLBI 381. Seminar. 1 Credit.

One hour.

CLBI 390. 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 391. Master's Thesis Research. 1-12 Credits.

Credit as arranged.

CLBI 392. 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 393. Independent Graduate 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 394. Science Communication. 3 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 395. Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles. Credit as arranged.

CLBI 396. Advanced Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles. Credit as arranged.

CLBI 401. Critical Reading & Analysis. 2 Credits.

Runs concurrently with CLBI 301 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 301.

CLBI 402. 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. Prerequisite: Doctoral student or Instructor permission.

CLBI 490. 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 491. Doctoral Dissertation Research. 1-12 Credits.

Credit as arranged.

CLBI 494. Independent Graduate 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 496. Advanced Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

Microbiology Molecular Genetics Courses**MMG 201. Molecular Cloning Lab. 4 Credits.**

Intensive advanced laboratory course in the fundamentals of recombinant DNA technology through the isolation and characterization of a unique gene. Prerequisite: MMG 104 or BIOC 207 or Instructor permission. Fall.

MMG 205. Biochemistry I. 3 Credits.

Introduction to chemistry and structure of biological macromolecules; examination of mechanisms of chemical processes in biological systems, including enzyme catalysis, biosynthesis, regulation, and information transfer. Prerequisite: CHEM 048 or CHEM 142 or CHEM 144. Cross-listed with: BIOC 205, CHEM 205. Fall.

MMG 206. Biochemistry II. 3 Credits.

Continuation of Biochemistry I. Biochemistry of nucleic acids; nucleic acid based processes, such as replication and transcription; cellular information transfer, genomics, and proteomics. Prerequisite: MMG 205. Cross-listed with: BIOC 206, CHEM 206. Spring.

MMG 207. Biochemistry Lab. 3 Credits.

Introduction to biochemical tools, including spectrometry, chromatography, and electrophoresis; natural and recombinant enzyme isolation; assays of DNA-modifying enzymes; computer-based structure/function exercises. Prerequisite: BIOC 205 or CHEM 205 or MMG 205. Cross-listed with: BIOC 207, CHEM 207.

MMG 211. Prokaryotic Molecular Genetics. 3 Credits.

The organization, replication, and expression of genes in prokaryotes, focusing on the genetics of *Escherichia coli* and its viruses. Prerequisite: Introductory microbiology, biochemistry, genetics, and/or cell biology courses. Fall.

MMG 220. Environmental Microbiology. 3 Credits.

The activities of microorganisms, primarily bacteria, in air, soil, and water. Prerequisites: MMG 101 and Organic Chemistry Alternate years.

MMG 222. Advanced Medical Microbiology. 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. Alternate years. Spring. Prerequisites: MMG 065 or MMG 101 or equivalent or Instructor permission.

MMG 223. Immunology. 3 Credits.

Analysis of the immune response with respect to structure and function of immunoglobulins and the T-cell receptor, tolerance, innate and adaptive immunity, the Major Histocompatibility Complex, hypersensitivity states, transplantation, cancer, and AIDS. Prerequisite: Instructor permission. Alternate years, Spring.

MMG 225. Eukaryotic Virology. 3 Credits.

An in-depth analysis of eukaryotic virus-mammalian cell interactions emphasizing mechanisms by which viruses modulate gene expression in infected cells. Prerequisite: MMG 101 or MMG 104 or equivalent. Alternate years. Fall.

MMG 231. Bioinformatics&Data Anlysis. 3 Credits.

Methodological survey of bioinformatics in the -omics era, focusing on genomics data of medically relevant microbes. Topics include data mining, metagenomics, phylogenetics, and comparative genomics. Mix of lecture and hands-on interaction utilizing analysis tools on the Vermont Advanced Computing Core. Prerequisite: Instructor permission.

MMG 232. QR: Advanced Bioinformatics. 3 Credits.

Advanced data processing and genome assembly analysis, data integration, and machine learning. Python, R, and Linux-scripting are used to assemble genomes, integrate large data sets, and build complex biological models. Topics include genomics, meta-data management, and multi-omics analyses at systems biology levels. Alternate Years. Spring. Prerequisites: MMG 104 or BCOR 101; MMG 231, or Instructor permission.

MMG 233. Genetics and Genomics. 3 Credits.

Integrated entry into both genome science and modern genetic analysis. Students will develop skills needed to access, organize and interpret emerging genomic information. Fall. Prerequisite: Junior/Senior/Graduate standing in biological or computational sciences.

MMG 320. 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. Alternate years. Spring.

MMG 391. Master's Thesis Research. 1-18 Credits.**MMG 393. Graduate Teaching Practicum. 3 Credits.**

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

MMG 394. Independent Graduate 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 395. 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 396. Advanced Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

MMG 490. 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 491. Doctoral Dissertation Research. 1-18 Credits.**MMG 494. Independent Graduate 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 496. Advanced Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

Molecular Physiology Biophysics Courses**MPBP 301. 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 032 and CHEM 042 or equivalent, two semesters general physics, and two semesters calculus. May not be taken for credit with MPBP 306.

MPBP 303. Critical Reading. 1 Credit.

Critical reading of the current literature, team taught by the faculty in the Dept. of Molecular Physiology & Biophysics, giving broad exposure to the expertise present in the department.

MPBP 310. 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 301, BIOC 301, BIOC 302; Instructor permission.

MPBP 330. 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 381. Seminar. 1 Credit.

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

MPBP 390. Medical Master's Capstone. 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: Graduate Student standing in the Medical Science program; BIOC 301, MPBP 301, or Instructor permission.

MPBP 391. Master's Thesis Research. 1-18 Credits.**MPBP 392. 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 395. Advanced Special Topics. 1-18 Credits.

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

MPBP 491. Doctoral Dissertation Research. 1-18 Credits.**MPBP 496. Advanced Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

Neuroscience Courses**NSCI 222. Cellular Neurophysiology. 3 Credits.**

Fundamentals of cellular neurophysiology through lecture, independent student reading and faculty-led group discussions of journal articles. Prerequisites: NSCI 110 or, NSCI 111 and NSCI 112, or Instructor Permission.

NSCI 225. Human Neuroanatomy. 0 or 3 Credits.

Functional anatomy of the human nervous system on both the microscopic and macroscopic scales. Focuses on the structures of the peripheral nervous system, spinal cord, and brain, and how they work together to achieve behavior. Lectures and a required laboratory (gross and microscopic anatomy). Prerequisite: NSCI 111.

NSCI 230. Comparative Neurobiology. 3 Credits.

Examination of the cellular mechanisms that underlie selective motor and sensory abilities, and unique behaviors that have evolved in various species. Discussion and student presentations. Prerequisite: ASCI 141 or BIOL 106 or NSCI 111 or PSYS 115 or Instructor permission.

NSCI 280. Glia: Not Just Neuron Glue. 3 Credits.

Interdisciplinary course in which students engage in a focused, in-depth exploration of how glial cells contribute to neurological and psychiatric disorders. Prerequisites: NSCI 111; Course director approval. Pre/Co-requisites: NSCI 111; Course Director permission.

NSCI 300. Intro Functional Neuroimaging. 3 Credits.

Functional neuroimaging may be the most exciting recent development in cognitive neuroscience. Students will learn about neuroimaging, and work in small groups to develop experiments, acquire and analyze functional MRI data an MRI scanner.

NSCI 301. Intro Functional Neuroimaging. 3 Credits.

Part 1 will offer lecture-based technical background on in vivo brain-imaging techniques (e.g.MRI, PET; MEG; EEG; TMS). Part 2 will focus on hands-on fMRI data processing including data collection at UVMMC research MRI unit and in-class analysis instruction. Prerequisites: Graduate standing or Senior standing with Instructor permission. Pre/Co-requisites: Basic statistics and/or introductory physics helpful.

NSCI 302. 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 major or Instructor permission.

NSCI 303. 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: Graduate standing; Neuroscience Graduate Program or others with Instructor permission; six credits coursework, plus two credits lab in biology, general chemistry, organic chemistry and Physics.

NSCI 323. 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: Permission of the Instructor.

NSCI 327. 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 381. Seminar in Neuroscience. 1 Credit.

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

NSCI 382. Seminar in Neuroscience. 1 Credit.

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

NSCI 390. 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 391. Master's Thesis Research. 1-18 Credits.**NSCI 392. 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 394. Independent Graduate 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 395. Advanced Special Topics. 1-18 Credits.

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

NSCI 490. 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 491. Doctoral Dissertation Research. 1-18 Credits.**NSCI 494. Independent Graduate 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 496. Advanced Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

Pathology Courses**PATH 300. 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 307. 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 300.

PATH 308. 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 300, PATH 303, or Instructor permission.

PATH 309. 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 308. Prerequisites: PATH 300, PATH 303, PATH 308, or Instructor permission.

PATH 310. Clinical Genomic Medicine. 1 Credit.

Covers the basic concepts of genomic medicine and its clinical application, procedures and techniques of clinical molecular testing, and management of a clinical molecular laboratory; focuses on diagnostic molecular testing on solid tumors, hematopathology, constitutional disorders, and pharmacogenomics. Prerequisite: PATH 330 or Instructor permission; experience in either clinical or anatomic pathology required.

PATH 325. Genetics for Clinicians. 3 Credits.

Provides an overview of contemporary human genetics and genomics with application to clinical practice. Prerequisite: Graduate standing. Cross-listed with: GRNS 325.

PATH 328. 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 330. 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 331. 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. Prerequisites: PATH 300.

PATH 390. 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 391. Master's Thesis Research. 1-18 Credits.**PATH 392. 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 394. Independent Graduate 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.

PATH 395. Advanced Special Topics. 1-18 Credits.

Special Topics in Pathology. Prerequisites: Graduate Students, Department Permission Immunology (MMG 223) desirable. Alternate year course with PATH 305.

Pharmacology Courses**PHRM 200. Medical Cannabis. 3 Credits.**

An introduction to the pharmacology underlying recreational and medicinal uses of Cannabis. Focuses on Cannabis taxonomy, chemistry of cannabinoids, physiological effects, and emerging therapeutic applications. Discusses historical, political and socio-economic influences on medical marijuana legislation. Prerequisite: BCOR 103, NSCI 110, NSCI 111 or PHRM 201, or Instructor permission.

PHRM 201. Introduction to Pharmacology. 3 Credits.

This course will focus on biochemical and physiological actions of prototype drugs used in the treatment and prevention of human diseases. Prerequisite: Introductory courses in Biology and Organic Chemistry.

PHRM 240. 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: Intro to Organic Chemistry, Intro to Biology; Permission.

PHRM 272. Toxicology. 3 Credits.

This course is intended to provide an understanding of the chemical, biochemical and physiological factors that determine the pathological effects of chemicals in living systems. Prerequisites: Organic chemistry, background in Biology, or Instructor permission.

PHRM 290. Topics Molecular&Cell Pharm. 3 Credits.

Focuses on basic principles, drug interactions with receptors, membranes, synapses, neurotransmitters, macromoles, cytoskeleton, ion channels and pumps, and mechanisms of drug resistance. Prerequisite: Introductory course in organic chemistry, background in physiology or health sciences.

PHRM 301. Medical Pharmacology. 6 Credits.

All topics for a conventional course in pharmacology for medical students or health science students. General pharmacokinetic and pharmacodynamic principles, treatment rationales and adverse effects.

PHRM 302. 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 masters students limited to three credits.

PHRM 305. 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-requisites: PHRM 201 or Graduate standing.

PHRM 308. 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, and a background in biology/physiology or health sciences.

PHRM 372. Special Topics. 1-3 Credits.

Topics of current interest and importance in pharmacology are considered in depth through presentations by staff, students, and visiting scientists. Prerequisite: Instructor Permission. Credit variable.

PHRM 373. 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 381. Seminar. 1 Credit.

Current developments in pharmacology are presented for discussion by students. Prerequisite: Instructor Permission.

PHRM 390. Medical Master's Capstone. 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: Graduate Student standing in Medical Science program; BIOC 301, MPBP 301, or Instructor permission.

PHRM 391. Master's Thesis Research. 1-12 Credits.**PHRM 392. 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 393. 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 394. Independent Graduate 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 396. Advanced Special Topics. 1-18 Credits.

See schedule of courses for specific titles.

PHRM 491. Doctoral Dissertation Research. 1-12 Credits.**PHRM 496. Advanced Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.