CELLULAR, MOLECULAR, AND BIOMEDICAL SCIENCES

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

Amiel, Eyal; Assistant Professor, Department of Medical Laboratory and Radiation Sciences; PHD, Dartmouth College
Anathy, Vikas; Assistant 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
Bonney, Elizabeth; Professor, Department of Obstetrics and Gynecology; MD, Stanford University
Botten, Jason; Assistant 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
Budd, Ralph; Professor, Department of Medicine-Immunobiology; MD, Weill Cornell Medical College
Buskiewicz, Iwona A.; Assistant Professor, Department of Pathology and Laboratory Medicine; PHD, University of Witten
Carr, Frances; Professor, Department of Pharmacology; PHD, University of Illinois Chicago
Dabertrand, Fabrice; Assistant Professor, Department of Pharmacology; PHD, University of Bordeaux, France
Deming, Paula; Associate Professor, Department of Medical Laboratory and Radiation Sciences; PHD, University of North Carolina at Chapel Hill
Diehl, Sean; Assistant Professor, Department of Medicine-Infectious Disease; PHD, University of Vermont
Dostmann, Wolfgang; Professor, Department of Pharmacology; PHD, University of Bremen, MD, University of Munich
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
Everett, 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, Kaley; Assistant Professor, Department of Surgery; MD/PHD, University of Colorado Boulder
Frietze, Seth; Assistant Professor, Department of Medical Laboratory and Radiation Sciences; PHD, Harvard University
Glass, Karen; Associate Professor, Department of Biochemistry; PHD, University of Vermont
Gordon, Jonathan; Assistant Professor, Department of Biochemistry; PHD, University of Western Ontario
Heath, Jessica; Assistant Professor, Department of Pediatrics; Department of Biochemistry; MD, SUNY Stony Brook
Honda, Robert; Associate Professor, Department of Biochemistry; PHD, Ohio State University
Howe, Alan; Associate Professor, Department of Pharmacology; PHD, Northwestern University
Huston, Christopher; Associate Professor, Department of Medicine-Infectious Disease; MD, Cornell University
Irvin, Charles; 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; Professor, Department of Medicine-Endocrinology, Diabetes and Metabolism; PHD, Vanderbilt University
Kelm, Robert; Associate Professor, Department of Medicine-Cardiovascular; PHD, University of Vermont
Kinesy, C. Matthew; Assistant Professor, Department of Medicine-Pulmonary; MD, Albert Einstein College of Medicine, Bronx, NY
Krementsosv, Dimitry; Assistant Professor, Department of Medical Laboratory and Radiation Sciences; PHD, University of Vermont
Landry, Christopher; Professor and Chair, Department of Chemistry; PHD, Harvard University
Li, Dawei; Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, Shanghai Jiao Tong University
Li, Jianing; Assistant Professor, Department of Chemistry; PHD, Columbia University
Lian, Jane; Professor, Department of Biochemistry; PHD, Boston University
Lounsberry, Karen; Professor, Department of Pharmacology; PHD, University of Pennsylvania
Matthews, Dwight; Professor, Department of Chemistry; PHD, Indiana University Bloomington
Morielli, Anthony; Associate Professor, Department of Pharmacology; PHD, University of California at Santa Cruz
Morrical, Scott; Professor, Department of Biochemistry; PHD, University of Wisconsin Madison
Pederson, David; 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 & Biophysics; PHD, University of Vermont
Quenet, Delphine; Assistant Professor, Department of Biochemistry; PHD, University of Strasbourg, France
Radermacher, Michael; Professor, Department of Molecular Physiology and Biophysics; PHD, Technical University of Munich
Rincon, Mercedes; Professor, Department of Medicine-Immunobiology; PHD, Autonomous University of Madrid
Ruiz, Teresa; Professor, Department of Molecular Physiology and Biophysics; PHD, Brandeis University
Seward, David; Assistant Professor, Department of Pathology and Laboratory Medicine; MD, PHD, University of Colorado Anschutz Medical Campus
Shukla, Arti; Associate Professor, Department of Pathology and Laboratory Medicine; PHD, Banaras Hindu University
Shukla, Girja; Associate Professor, Department of Surgery-Oncology; PHD, Lucknow University
Silveira, Jay; Assistant Professor, Department of Biochemistry; PHD, University of Vermont
Spees, Jeffrey; Associate Professor, Department of Medicine-Cardiovascular; PHD, University of California Davis
Stein, Gary; Professor and Chair, Department of Biochemistry; PHD, University of Vermont
Stein, Janet; Professor, Department of Biochemistry; PHD, Princeton University
Stumpf, Jason; Assistant Professor, Department of Molecular Physiology and Biophysics; PHD, University of Colorado
Suratt, Benjamin; Professor, Department of Medicine-Pulmonary; MD, Columbia University
Taatjes, Douglas Joseph; Professor, Department of Pathology and Laboratory Medicine; PHD, University of Basel
Teuscher, Cory; Professor, Department of Medicine-Immunobiology; PHD, University of New Mexico
Thali, Markus; Professor, Department of Microbiology and Molecular Genetics; PHD, University of Zurich
Tierney, Mary; Associate Professor, Department of Plant Biology; PHD, Michigan State University
Toth, Michael; Associate 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
Van Houten, Judith; Professor, Department of Biology; PHD, University of California Santa Barbara
Vigoreaux, Jim; Professor, Department of Biology; PHD, University of Oklahoma
Ward, Gary; Professor, Department of Microbiology and Molecular Genetics; PHD, University of California San Diego
Wargo, Matthew; Assistant Professor, Department of Microbiology and Molecular Genetics; PHD, Dartmouth College
Warshaw, David; Professor and Chair, 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
Zaidi, Sayyed Kaleem; Associate Professor, Department of Biochemistry, PHD, University of Punjab
Zhao, Feng-Qi; Professor, Department of Animal and Veterinary Sciences, PHD, University of Alberta, Canada

Biochemistry Courses
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 212. Biochemistry of Human Disease. 3 Credits.
Molecular approach to genetic, metabolic, and infectious diseases; recombinant DNA technology and medicine; molecular biology of cancer. Prerequisite: CHEM 042, CHEM 044, or CHEM 141.

BIOC 240. Macromol Struct Prot&Nuc Acid. 3 Credits.
Introduction to structural biology and macromolecular structure with an emphasis on protein-protein and protein-nucleic acids interactions. Prerequisites: BIOL 002 or BCOR 012, and CHEM 142; Junior standing. Cross-listed with: MMG 240. Alternate years.
BIOC 301. General Biochemistry. 0 or 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: CHEM 142 or CHEM 144, or Instructor permission.

BIOC 305. Medical Biochemistry. 3 Credits.
A survey course in human biochemistry, with particular emphasis on medical applications.

BIOC 306. Medical Biochemistry. 3 Credits.
A survey course in human biochemistry, with particular emphasis on medical applications.

BIOC 307. Special Topics in Biochemistry. 1-3 Credits.
Areas of biochemistry not treated in concurrent advanced course offerings.

BIOC 308. Special Topics in Biochemistry. 1-3 Credits.
Areas of biochemistry not treated in current advanced course offerings.

BIOC 309. Laboratory Research Rotations. 3 Credits.
Two sequential research projects in Departmental faculty laboratories, composed of experimental work, an oral presentation, and a written report. First semester.

BIOC 310. Laboratory Research Rotations. 3 Credits.
Two sequential research projects in Departmental faculty laboratories, composed of experimental work, an oral presentation and a written report. Second semester.

BIOC 325. Data Analysis&Presentation I. 2 Credits.
Develop graduate level skills in data analysis, reading, writing, teaching and presenting your own work, and that of others (Part 1 of 2). Prerequisites: Graduate standing; Enrollment in BIOC 301 and CLBI 301. Cross-listed with: MPBP 325.

BIOC 326. Data Analysis&Presentation II. 2 Credits.
Develop graduate level skills in data analysis, reading, writing, teaching and presenting your own work and that of others (Part 2 of 2). Prerequisites: BIOC 301, CLBI 301; Graduate standing. Cross-listed with MPBP 326.

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 352. Protein: Nucleic Acid Interact. 3 Credits.
Structure of DNA and RNA, and the structure and assembly of nucleoprotein complexes will be described using examples from prokaryotes, yeast, viruses, and mammalian cells in culture. Prerequisites: MMG 211 or equivalent, and BIOC 302 or equivalent. Cross-listed with: MMG 352. Alternate years.

BIOC 353. Proteins II: Enzymology. 3 Credits.
General consideration of enzyme nomenclature, purification, assay, kinetics, mechanisms, cofactors, active sites, subunit structure, allosteric and regulatory properties, and control of multienzyme systems. Prerequisite: BIOC 301, or Department permission. Alternate years.

BIOC 354. Nucleic Acids II. 3 Credits.
The study of structure, composition, organization, function, synthesis, and metabolism of nucleic acids and nucleoprotein particles and matrices in eukaryotic organisms. Prerequisite: BIOC 302.

BIOC 370. Physical Biochemistry. 3 Credits.
Protein interaction, solubility and fractionation, electrophoresis, sedimentation, phase rule study, diffusion, viscosity, spectrophotometry, and related topics. Prerequisites: BIOL 302 and CHEM 162, or Department permission.

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 302, or Department permission.

BIOC 381. Seminar. 1 Credit.
A review of recent developments and current literature in the various fields of biochemistry. Prerequisite: Graduate standing.

BIOC 391. Master's Thesis Research. 1-12 Credits.
Credit as arranged.

BIOC 392. Independent Literature Rsch. 1-12 Credits.
Reading and literature research culminating in a paper on a topic of current interest in biochemistry.

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 491. Doctoral Dissertation Research. 1-12 Credits.
Credit as arranged.

BIOC 493. 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 496. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

Cell Biology Courses

Cell Biology Courses

CLBI 295. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Credit as arranged.
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. Cross-listed with: BIOL 301, PBIO 301.

CLBI 381. Seminar. 1 Credit.
One hour.

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 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 491. Doctoral Dissertation Research. 1-12 Credits.
Credit as arranged.

CLBI 492. 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 496. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

Medical Lab Radiation Sci Courses
MLRS 242. Immunology. 3 Credits.
Deals with cells, organs, development, interactions and the functioning (infectious process, immunodeficiency, hypersensitivity reactions, transplantation and tumor immunology) of the innate and the adaptive immune system. Prerequisites: One semester of biochemistry, one semester of organic chemistry.

MLRS 244. Immunology Lab. 1 Credit.
Laboratory experience dealing with cellular and humoral immunity, B cells and T cells, autoimmunity, immunodeficiency. Laboratory covers immunological techniques and applications. Co-requisites: MLRS 242 or MMG 223.

MLRS 281. Applied Molecular Biology. 3 Credits.
Introduces students to the nucleic acid and protein-based molecular diagnostics technology through class presentation, reading, and discussions. Focuses on diagnostic applications for understanding molecular mechanisms of disease. Prerequisite: CHEM 042 or CHEM 141.

MLRS 282. Applied Molecular Biology Lab. 1 Credit.
Laboratory experiences include practical concepts of molecular applications. Introduces basic methods used in DNA and Protein technology including plasmid isolation, polymerase chain reaction, restriction enzyme use, and related assays. Prerequisite: CHEM 042 or CHEM 141. Co-requisite: MLRS 281.

MLRS 381. Special Topics Seminar. 1 Credit.
Pre/co-requisite: Instructor Permission.

MLRS 391. Masters Thesis Research. 1-6 Credits.
Pre/co-requisite: Instructor Permission.

MLRS 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.

MLRS 395. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Pre/co-requisite: Instructor Permission.

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 203. Mamm Cell Cult:Molecular Biol. 0 or 4 Credits.
The basic principles and techniques of mammalian cell culture, as well as cell and mammalian molecular genetics. Prerequisite: BCOR 103 or MMG 104, Permission of Coordinator. Alternate years. Spring.
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. Clinical Microbiology I. 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. 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. QR:Prgrmmg for Bioinformatics. 3 Credits.
Introductory course on computing (including scripting, database, and statistical analysis) for developing bioinformatics applications. Particular emphasis is given to comparative genomics and systems biology scenarios. Prerequisites: STAT 151, STAT 153, or Instructor permission. Cross-listed with: CS 231. Alternate Years. Spring.

MMG 232. QR:Methods in Bioinformatics. 3 Credits.
This course provides a methodological survey of bioinformatics. Particular emphasis is given to algorithms associated with sequential analysis, comparative genomics, structural biology, and systems biology. Prerequisites: STAT 151, STAT 153, or Instructor permission. Cross-listed with: CS 232. Alternate Years. Spring.

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 295. Advanced Special Topics. 1-18 Credits.
Supervised investigations in microbiology or molecular genetics. Prerequisite: Instructor permission. Credit as arranged.

MMG 296. Advanced Special Topics. 1-18 Credits.
Supervised investigations in microbiology or molecular genetics. Prerequisite: Instructor permission. Credit as arranged.

MMG 310. Current Topics in MMG. 2 Credits.
Seminar to focus on specific issues at the forefront of current research in molecular genetics. Meetings will involve student presentation and discussion of research articles. Prerequisite: Permission of Coordinator.

MMG 312. Eukaryotic Molecular Genetics. 3 Credits.
The use of lower eukaryotes, such as the yeasts Saccharomyces cerevisiae and Schizosaccharomyces pombe, as model genetic systems to answer questions of basic biological importance. Prerequisites: Instructor permission; MMG 233 and CLBI 301, or equivalent.

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 330. Emerging Infectious Disease. 3 Credits.
Interdisciplinary approach to understanding the emergence, and re-emergence, of infectious diseases in a rapidly changing global environment. Historical, cultural, environmental and biological perspectives are incorporated into the analysis of emerging bacterial, viral and protozoal pathogens. Prerequisite: Introductory undergraduate course in Microbiology. Course in virology is recommended.

MMG 332. Critical Reading. 1 Credit.
Students will participate in group discussions to critically evaluate and interpret the experimental data from one assigned paper from the scientific literature per week. Prerequisite: Permission of Coordinator. Fall.
MMG 333. Genetics and Genomics. 3 Credits.
Integrated entry into both genome science and modern genetic analysis. Together, genetic and genomic information provide unprecedented insights into biological functions, pathways and systems. Emphasizes skills needed to access, organize and interpret emerging genomic information. Graduate students only. Prerequisite: Graduate enrollment in a program within the biomedical or biological sciences.

MMG 352. Protein: Nucleic Acid Interact. 3 Credits.
Structure of DNA and RNA, and the structure and assembly of nucleoprotein complexes will be described using examples from prokaryotes, yeasts, viruses, and mammalian cells in culture. Prerequisite: MMG 211 or equivalent; AGBI 201 or BIOL 301; BIOL 302 or equivalent. Cross-listed with: BIOL 352. Alternate years. Spring.

MMG 391. Master's Thesis Research. 1-18 Credits.

MMG 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.

MMG 396. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

MMG 491. Doctoral Dissertation Research. 1-18 Credits.

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 302. Human Physiology & Pharm II. 4 Credits.
An integrated examination of the physiology and pharmacology of the endocrine, digestive, renal and respiratory systems in the human body. Pre/co-requisites: CHEM 032 and CHEM 042 or equivalent; two semesters general physics, two semesters calculus, MPBP 301 or Instructor permission. 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 306. Medical Physiology. 8 Credits.
Function in the whole human organism, and at the cellular, tissue, and organ levels, considered biologically and physically. Pre/co-requisite: Permission of Department Chair. May not be taken for credit with MPBP 301 or MPBP 302.

MPBP 308. Biometrics & Applied Statistic. 3 Credits.
The rationale and application of biostatistical methods in the biological, health and life sciences with emphasis on interpreting and reporting results. Prerequisite: STAT 141 or equivalent. Cross-listed with: BIOS 308, STAT 308.

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, BIOL 301, BIOL 302; Instructor permission.

MPBP 323. Biophysical Techniques. 4 Credits.

MPBP 325. Data Analysis & Presentation I. 2 Credits.
Develop graduate level skills in data analysis, reading, writing, teaching and presenting your own work and that of others (Part 1 of 2). Prerequisites: Graduate standing; Enrollment in BIOL 301 and CLBI 301. Cross-listed with: BIOL 325.

MPBP 326. Data Analysis & Presentation II. 2 Credits.
Develop graduate level skills in data analysis, reading, writing, teaching and presenting your own work and that of others (Part 2 of 2). Prerequisites: BIOL 301, CLBI 301; Graduate standing. Cross-listed with: BIOL 326.

MPBP 333. 3D Electron Microscopy & Image Prc. 1 Credit.

MPBP 381. Seminar. 1 Credit.
Presentation and discussion by advanced students, staff, and invited speakers, of current topics in physiology. Prerequisite: Department 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 492. 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 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 and its cells. Focus on both peripheral and central nervous system. Lectures and laboratory (gross and microscopic anatomy). Prerequisite: Instructor permission.

NSCI 280. Glia: Not Just Neuron Glue!. 3 Credits.
Interdisciplinary course in which students engage in a focused, indepth 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 302. Neuroscience. 4 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 306. Techniques in Neurobiology. 3 Credits.
Discussion of techniques used to study the nervous system. Experience with light, fluorescence, electron microscopy; microsurgical procedures; electrophysiological stimulating, recording techniques; neuronal tracing techniques. Prerequisite: Permission of the Instructor.

NSCI 320. Developmental Neurobiology. 3 Credits.
Provides fundamental knowledge of cell-to-cell interactions necessary for proper development and organization of the nervous system. Topics include pattern formation, neuronal differentiation, axon guidance, and target interactions. Prerequisite: Permission of the Instructor. Alternate years.

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 326. Basic Sci-Neurologic Disease. 3 Credits.
In-depth examination of basic mechanisms and clinical aspects of a related subset of neurological disorders, e.g. neurodegenerative disease or disorders of neurotransmission. Disease group changes every year. Prerequisite: Advanced Graduate Students, Neuroscience Faculty and Residents in Neurology, Neurosurgery and Psychology.

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 328. Techniques in Microscopy. 3 Credits.
Topics shall include practical background in microscopy, including brightfield, epifluorescence, confocal, multi-photon, deconvolution, atomic force and electron microscopy. Prerequisite: Instructor permission.

NSCI 329. Topics in Excitable Membranes. 2 Credits.
This course is a graduate course designed to introduce the fundamentals of cellular electrophysiology through independent student reading and faculty-led group discussions of journal articles. Prerequisite: Instructor permission.

NSCI 330. 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. Pre/co-requisite: Instructor permission.

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 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 395. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Instructor permission.
**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: Organic chemistry, background in Biology, or Instructor 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.**

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 295. Advanced Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**Special Topics in Pathology.**

A course providing an introduction to anatomic and clinical pathology, classes and hands-on training in essential pathology translational research techniques and exposure to their clinical laboratory applications. Prerequisites: Instructor approval.

**PATH 295. Advanced Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**PATH 303. Translational Pathology. 3 Credits.**

A course providing an introduction to anatomic and clinical pathology, classes and hands-on training in essential pathology translational research techniques and exposure to their clinical laboratory applications. Prerequisites: Instructor approval.

**PATH 304. Human Molecular Genetics. 3 Credits.**

Advanced survey of hereditary and molecular genetics and genomics in human health and disease. Prerequisite: Graduate standing, or minimum Junior standing and BIOC 212.

**PATH 305. Molecular Mech Environ Disease. 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.

**PATH 306. Pathobiology of Disease. 1 Credit.**

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.

**PATH 325. Genetics for Clinicians. 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.

**PATH 326. Pathology Rotations. 3-9 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.

**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 391. Master's Thesis Research. 1-18 Credits.**

**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 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 396. Advanced Special Topics. 1-18 Credits.
See schedule of courses for specific titles.

PHRM 397. Advanced Pharmacology Research. 1-18 Credits.
Student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded.

PHRM 491. Doctoral Dissertation Research. 1-12 Credits.

PHRM 492. 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 496. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.