

# MOLECULAR, CELLULAR AND DEVELOPMENTAL BIOLOGY

The undergraduate program in molecular, cellular and developmental biology (MCDB) is directed toward understanding the molecular and cellular mechanisms that provide the basis for biological structure, growth, evolution, embryonic development and genetic inheritance. Undergraduate majors learn about the scientific method, experimental approaches and groundbreaking discoveries that have made modern molecular and cellular biology such an important force in medicine, agriculture and the growing biotechnology industry. They also learn about the diverse tools of modern biology, including recombinant DNA, genomic mapping, transgenic organisms, gene targeting, analysis of mutants, biochemical purification, antibody probes, laser manipulation of living cells, light and electron microscopy, and computer modeling. In addition to academic and laboratory classes, MCDB majors have many opportunities to participate in ongoing research in the department.

Learn how living systems operate at the cellular and molecular levels of organization, their assembly and structure, with heavy emphasis on genetic information and regulation, including embryonic development.

Course code for this program is MCDB.

## Animal Use Policy

Biology is the science of life, and a major in it must include some hands-on experience with living organisms to be complete. Exercises involving the use of living animals or animal tissues are included, therefore, in MCDB laboratory courses. Majors with objections on moral grounds may arrange to limit their participation in these exercises, although their educational experience is compromised by doing so.

Nonmajors may take MCD biology lecture courses without the accompanying laboratories. Laboratory courses in which living vertebrate animals or tissues are used are identified in the course description section of this catalog. For additional information, please contact the department.

## Bachelor's Degree

- Molecular, Cellular and Developmental Biology - Bachelor of Arts (BA) (<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/molecular-cellular-developmental-biology/molecular-cellular-developmental-biology-bachelor-arts-ba/>)

## Minor

- Molecular, Cellular and Developmental Biology - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/molecular-cellular-developmental-biology/molecular-cellular-developmental-biology-minor/>)

## Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Abbott, Lois A.  
Senior Instructor Emerita

Anseth, Kristi S. ([https://experts.colorado.edu/display/fisid\\_103471/](https://experts.colorado.edu/display/fisid_103471/))  
Distinguished Professor; PhD, University of Colorado Boulder

Arnoult, Nausica Christine ([https://experts.colorado.edu/display/fisid\\_164094/](https://experts.colorado.edu/display/fisid_164094/))  
Assistant Professor; PhD, Pierre and Marie Curie University (France)

Betterton, Meredith D. ([https://experts.colorado.edu/display/fisid\\_125396/](https://experts.colorado.edu/display/fisid_125396/))  
Professor; PhD, Harvard University

Blumenthal, Thomas ([https://experts.colorado.edu/display/fisid\\_143346/](https://experts.colorado.edu/display/fisid_143346/))  
Professor, Visiting Professor; PhD, Johns Hopkins University

Boswell, Robert E. ([https://experts.colorado.edu/display/fisid\\_100196/](https://experts.colorado.edu/display/fisid_100196/))  
Professor; PhD, University of Colorado Boulder

Brumbaugh, Justin J. ([https://experts.colorado.edu/display/fisid\\_164025/](https://experts.colorado.edu/display/fisid_164025/))  
Assistant Professor; PhD, University of Wisconsin-Madison

Cech, Thomas R. ([https://experts.colorado.edu/display/fisid\\_103252/](https://experts.colorado.edu/display/fisid_103252/))  
Distinguished Professor; PhD, University of California, Berkeley

Chen, Zhe  
Assistant Research Professor; PhD, University of Colorado Boulder

Copley, Shelley ([https://experts.colorado.edu/display/fisid\\_104067/](https://experts.colorado.edu/display/fisid_104067/))  
Professor; PhD, Harvard University

DeDecker, Brian S. ([https://experts.colorado.edu/display/fisid\\_143934/](https://experts.colorado.edu/display/fisid_143934/))  
Senior Instructor; PhD, Yale University

Detweiler, Corrella Scott ([https://experts.colorado.edu/display/fisid\\_128240/](https://experts.colorado.edu/display/fisid_128240/))  
Professor; PhD, University of California, San Francisco

Donaldson, Zoe ([https://experts.colorado.edu/display/fisid\\_157087/](https://experts.colorado.edu/display/fisid_157087/))  
Assistant Professor; PhD, Emory University

Dowell, Robin D. ([https://experts.colorado.edu/display/fisid\\_147779/](https://experts.colorado.edu/display/fisid_147779/))  
Associate Professor; DSc, Washington University

Dubin, Mark W.  
Professor Emeritus

Espinosa, Joaquin Maximiliano ([https://experts.colorado.edu/display/fisid\\_134378/](https://experts.colorado.edu/display/fisid_134378/))  
Visiting Associate Professor; PhD, Univ of Buenos Aires (Argentina)

Fillman, Christy L. ([https://experts.colorado.edu/display/fisid\\_145115/](https://experts.colorado.edu/display/fisid_145115/))  
Senior Instructor; PhD, University of Colorado Boulder

Garcea, Robert L. ([https://experts.colorado.edu/display/fisid\\_146103/](https://experts.colorado.edu/display/fisid_146103/))  
Professor; MD, University of California, San Francisco

Gold, Lawrence ([https://experts.colorado.edu/display/fisid\\_100581/](https://experts.colorado.edu/display/fisid_100581/))  
Professor; PhD, University of Connecticut

Guild, Nancy Ann ([https://experts.colorado.edu/individual/fisid\\_111361/](https://experts.colorado.edu/individual/fisid_111361/))  
Professor Attendant Rank; PhD, University of Colorado

Han, Min ([https://experts.colorado.edu/display/fisid\\_105512/](https://experts.colorado.edu/display/fisid_105512/))  
Distinguished Professor; PhD, University of California, Los Angeles

Harvey, Pamela Ann ([https://experts.colorado.edu/display/fisid\\_148012/](https://experts.colorado.edu/display/fisid_148012/))  
Senior Instructor; PhD, Tufts University

Hoenger, Andreas ([https://experts.colorado.edu/display/fisid\\_142883/](https://experts.colorado.edu/display/fisid_142883/))  
Professor; PhD, Universität Basel (Switzerland)

Jones, Kevin Robert ([https://experts.colorado.edu/display/fisid\\_102094/](https://experts.colorado.edu/display/fisid_102094/))  
Associate Professor; PhD, University of California, Berkeley

Junge, Harald Jobst  
Assistant Professor; PhD, Philipps-Universität Marburg (Germany)

Klymkowsky, Michael W. ([https://experts.colorado.edu/display/fisid\\_101226/](https://experts.colorado.edu/display/fisid_101226/))  
Professor; PhD, California Institute of Technology

Knight, Jennifer Kirsten ([https://experts.colorado.edu/display/fisid\\_101933/](https://experts.colorado.edu/display/fisid_101933/))  
Associate Professor; PhD, University of Michigan Ann Arbor

Kralj, Joel M.  
Assistant Professor; PhD, Boston University

Krauter, Kenneth S. ([https://experts.colorado.edu/display/fisid\\_107978/](https://experts.colorado.edu/display/fisid_107978/))  
Professor, Associate Chair; PhD, Yeshiva University

Kuempel, Peter L.  
Professor Emeritus

Leinwand, Leslie Anne ([https://experts.colorado.edu/display/fisid\\_107104/](https://experts.colorado.edu/display/fisid_107104/))  
Distinguished Professor, Faculty Director; PhD, Yale University

Martin, Jennifer Mary ([https://experts.colorado.edu/display/fisid\\_110125/](https://experts.colorado.edu/display/fisid_110125/))  
Senior Instructor; PhD, University of Washington

Mastronarde, David N.  
Professor Attendant Rank; PhD, University of Colorado

McConkey, Edwin H.  
Professor Emeritus

McIntosh, J. Richard  
Distinguished Professor Emeritus

Niswander, Lee ([https://experts.colorado.edu/display/fisid\\_160024/](https://experts.colorado.edu/display/fisid_160024/))  
Chair, Professor; PhD, Case Western Reserve University

Odorizzi, Charles Gregory ([https://experts.colorado.edu/display/fisid\\_118429/](https://experts.colorado.edu/display/fisid_118429/))  
Professor; PhD, University of California, San Diego

Old, William ([https://experts.colorado.edu/display/fisid\\_103039/](https://experts.colorado.edu/display/fisid_103039/))  
Assistant Professor; PhD, University of Colorado Boulder

Olwin, Bradley Bruce ([https://experts.colorado.edu/display/fisid\\_109888/](https://experts.colorado.edu/display/fisid_109888/))  
Professor, Associate Chair; PhD, University of Washington

Orth, James D. ([https://experts.colorado.edu/display/fisid\\_152017/](https://experts.colorado.edu/display/fisid_152017/))  
Assistant Research Professor, Instructor; PhD, Mayo Graduate School of Medicine

Pace, Norman R.  
Distinguished Professor Emeritus

Park, Soyeon ([https://experts.colorado.edu/display/fisid\\_151944/](https://experts.colorado.edu/display/fisid_151944/))  
Assistant Professor; PhD, Mayo Graduate School of Medicine

Parker, Roy Robert ([https://experts.colorado.edu/display/fisid\\_151440/](https://experts.colorado.edu/display/fisid_151440/))  
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Perkins, Thomas T. ([https://experts.colorado.edu/display/fisid\\_124578/](https://experts.colorado.edu/display/fisid_124578/))  
Professor Adjoint; PhD, Stanford University

Runner, Meredith  
Professor Emeritus

Sawyer, Sara Lea ([https://experts.colorado.edu/display/fisid\\_155218/](https://experts.colorado.edu/display/fisid_155218/))  
Professor; PhD, Cornell University

Shen, Jingshi ([https://experts.colorado.edu/display/fisid\\_146414/](https://experts.colorado.edu/display/fisid_146414/))  
Professor; PhD, Columbia University

Singh, Ravinder ([https://experts.colorado.edu/display/fisid\\_112067/](https://experts.colorado.edu/display/fisid_112067/))  
Associate Professor; PhD, Baylor College of Medicine

Staelin, L. Andrew  
Professor Emeritus

Stowell, Michael ([https://experts.colorado.edu/display/fisid\\_124136/](https://experts.colorado.edu/display/fisid_124136/))  
Associate Professor; PhD, California Institute of Technology

Su, Tin Tin ([https://experts.colorado.edu/display/fisid\\_113847/](https://experts.colorado.edu/display/fisid_113847/))  
Professor, Chair; PhD, Carnegie Mellon University

Sueoka, Noboru  
Professor Emeritus

Van Blerkom, Jonathan ([https://experts.colorado.edu/display/fisid\\_100545/](https://experts.colorado.edu/display/fisid_100545/))  
Research Professor; PhD, University of Colorado Boulder

Vigers, Alison Jane  
Instructor; PhD, University of Colorado Denver

Voeltz, Gia Kaarina ([https://experts.colorado.edu/display/fisid\\_143587/](https://experts.colorado.edu/display/fisid_143587/))  
Professor; PhD, Yale University

Weaver, Benjamin  
Assistant Professor; PhD, University of Kansas

Wood, William B. III  
Distinguished Professor Emeritus

Xue, Ding ([https://experts.colorado.edu/display/fisid\\_112336/](https://experts.colorado.edu/display/fisid_112336/))  
Professor; PhD, Columbia University

Yarus, Michael J.  
Professor Emeritus

## Courses

### MCDB 1020 (1) Introduction to Molecular, Cellular and Developmental Biology Major

Introduces students to the Molecular and Cellular Biology major. Provides an overview of the major and how it differs from other CU biology programs; how to get involved in clubs, research, and/or internship opportunities; strategies for succeeding in MCDB courses; and career options. This is a first-year colloquium course specifically designed for freshman and other students exploring their educational and career opportunities in our department.

**Recommended:** New MCDB majors.

### MCDB 1030 (3) Introduction to Molecular Biology

Introduces the foundation of molecular, cell, developmental and evolutionary biology in the context of human development and disease. Including how the immune system works to protect us from infections and technologies being developed towards the goal of better health around the world. For nonmajors.

**Additional Information:** GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### MCDB 1041 (3) Fundamentals of Human Genetics

Covers the basic principles of genetics, human pedigree analysis, and how genetic diseases affect DNA, RNA, and proteins. Considers implications of this research for medicine and society. For nonmajors.

**Recommended:** Requisite good background in high school chemistry and biology.

**Additional Information:** GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### MCDB 1043 (1) Exploring Genetics Laboratory

Provides hands-on experience with fundamental genetic principles. Topics include scientific method, experimental design, mitosis, meiosis, classical genetics, molecular genetics, mutagenesis, DNA analysis, and transgenic organisms. Wherever possible, the focus of the lab will be on integrating science process skills with human-relevant experiments to encourage students to learn and apply science skills while seeing the application to humans.

**Requisites:** Restricted to Biological Sciences (MCDB) non-majors only.

**Recommended:** Corequisite MCDB 1041.

**Additional Information:** Arts Sci Core Curr: Natural Science Lab

Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science Lab or Lab/Lec

### MCDB 1111 (3) Core Concepts in Biology I: Evolutionary, Molecular and Cell Biology

Web-based, in-class discussion course covering the fundamental properties shaping living systems. Uses evolutionary (including social) and physical-chemical mechanisms to frame molecular, cellular and organismic processes. Interpreting and answering questions scientifically as well as quantitative reasoning skills are stressed. Fulfills the MCDB major's requirement for MCDB 1150.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 1150

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### MCDB 1150 (3) Introduction to Cellular and Molecular Biology

Covers biologically important macromolecules and biological processes, together with an introduction to cell structure, function, and physiology. Provides the foundation for advanced MCDB courses to majors, and a rigorous overview of modern biology to non-majors.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 1111

**Recommended:** Prerequisite high school chemistry and algebra, and recommended corequisite of MCDB 1152.

**Additional Information:** GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science Lab or Lab/Lec

### MCDB 1152 (1) Problem Solving Co-Seminar for Introduction to Molecular and Cellular Biology

Uses problem solving and other interactive group work to aid student learning in a corequisite course, MCDB 1150. Students will work in small groups on learning and practicing how to solve difficult conceptual problems, as well as using hands-on activities and concept mapping to help learn content.

**Recommended:** Corequisite MCDB 1150.

### MCDB 1161 (2) From Dirt to DNA: Phage Genomics Laboratory I

Provides laboratory experience working on a bacteriophage genomics research project. Students will study novel bacteriophage they isolate from the environment. Topics covered include phage biology, bacteria and phage culturing and amplification, DNA isolation, restriction digest analysis, agarose gel electrophoresis, and electron microscopy.

**Recommended:** Prerequisites or corequisites: MCDB 1150 or EBIO 1210.

**Additional Information:** Arts Sci Core Curr: Natural Science Lab

Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science Lab or Lab/Lec

### MCDB 1171 (2) Antibiotics Discovery Through Hands-on Screens I

Provides introductory research and laboratory experience. Students will work in teams to screen small molecule libraries for novel antibiotics using the bacterium Salmonella as a model system. Topics covered include the basic biology of the model system, genetics, approaches to screening for new therapeutics, statistical analysis of the data, compound verification and lead compound development.

**Recommended:** Prerequisite or corequisite MCB 1150 or EBIO 1210.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Core Curr: Natural Science Lab

Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science Lab or Lab/Lec

### MCDB 1181 (2) Biological Probiotic/Drug Discovery Through Hands-on Screens

Provides introduction to research and laboratory experience. Students will work in teams to screen novel mycobacterial strains for use as probiotics or immunoregulatory/anti-inflammatory drugs using THP-1 cells, a human monocytic cell line. Topics covered include the hygiene or "Old Friends" hypothesis, the human microbiome, approaches to screening for new probiotics of therapeutics and statistical analysis of the data.

**Equivalent - Duplicate Degree Credit Not Granted:** IPHY 1181

**Grading Basis:** Letter Grade

**MCDB 1234 (1-9) Skills Center: Modular Laboratory of Modern Molecular Biology Skills**

Dedicated to teaching students fundamental laboratory skills in modern molecular biology. The skills are updated on a rolling basis in consultation with MCDB faculty and local Pharma/Biotech companies in an effort to provide students with real world skills that can help them transition from a traditional lab course environment to a more independent research environment. Students can mix and match various skills to receive one or more university credit hours and students who successfully complete a module are given a certificate recognizing their competency. Available skills modules and in more course information can be found at <https://skillscenter.colorado.edu/>

**Repeatable:** Repeatable for up to 15.00 total credit hours.

**Grading Basis:** Letter Grade

**MCDB 2150 (3) Principles of Genetics**

Introduces the behavior of genes and chromosomes in eukaryotic and prokaryotic organisms. Covers three areas: transmission genetics, molecular genetics, and population genetics. Attention is given to genetic mapping, recombinant DNA procedures, and gene expression.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 2222

**Recommended:** Prerequisite MCDB 1150 or EBIO 1210 or CHEN 2810 (minimum grade C-) and recommended corequisite of MCDB 2152.

**Additional Information:** GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 2152 (1) Problem Solving Co-Seminars for Genetics**

Uses problem solving and other interactive group work to aid student learning in MCDB 2150. Students will work in small groups on learning and practicing how to solve difficult conceptual problems, as well as using hands-on activities and concept mapping to help learn content.

**Recommended:** Corequisite MCDB 2150.

**MCDB 2161 (2) From DNA to Genes, Phage Genomics Laboratory II**

Provides laboratory experience working on a bacteriophage isolated during the previous semester. Topics include bioinformatics, genome annotation, open reading frame and RNA identification, BLAST analysis, phylogenetics and submission to a genomic database.

**Requisites:** Requires prerequisite course of MCDB 1161 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 2171 (2) Chemotherapeutic Discovery Through Hands-On Screens 2**

Provides introductory research and laboratory experience. Students will work in teams to screen molecule libraries using fruit flies as a model system. Topics covered include the basic biology of the model system, genetics, approaches to screening for new therapeutics, statistical analysis of the data, compound verification and lead compound development.

**Recommended:** Prerequisite or corequisite MCB 1150 or EBIO 1210.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Core Curr: Natural Science Lab

Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 2200 (3) Introduction to Biophysical Methods: From Brains to Bonds**

Provides a practical overview of modern biophysical methods used to study biological systems from whole body imaging methods to methods for investigating single molecules and molecular bonds. The goal of this course is to provide a broad survey of methods available to the modern biologist rather than a complete in-depth treatment of the physics and mathematics of each individual method.

**Requisites:** Requires prerequisite course of MCDB 1150 or EBIO 1210 (minimum grade C-).

**MCDB 2222 (3) Core Concepts in Biology II: Genes, Genetics and Phenotypes**

Web-based, in-class discussion course focused on the origins of genetic variation and inheritance, genome dynamics and gene expression and their relationship to phenotype(s). Interpreting, explaining and answering questions scientifically as well as quantitative reasoning are stress.

Course fulfills the departmental requirement for MCDB 2150.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 2150

**Requisites:** Requires a prerequisite course of MCDB 1111 or MCDB 1150 (minimum grade C-).

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 2350 (3) Understanding Cancer: Introduction to the disease's biology, medicine, and societal implications**

A course for students who want to learn about cancer but have little or no background in biology. It is based on a text that presents relevant science and medicine in a readable and comprehensible way. Classes will be discussion of material from the text with weekly quizzes for feedback. The ethics and economics of cancer treatments will be discussed, along with ways to minimize one's own cancer risk and live with cancer if necessary.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 2840 (1-3) Lower-Division Independent Study**

Students with adequate prerequisites should take MCDB 4840.

**Repeatable:** Repeatable for up to 8.00 total credit hours.

**MCDB 3000 (3) Synthetic Biology: Engineering Biomolecular Systems in the Laboratory**

Hands-on research experience in engineering biological systems. Students will design biological systems to address relevant medical and environmental problems facing our society. They will learn how to build their molecular designs in the lab using current synthetic biology techniques. Students will also learn how to critically evaluate current research in the field and effectively communicate their own research. Formerly offered as a special topics course.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Requisites:** Requires prerequisite courses of (MCDB 1150 and MCDB 2150) or CHEN 2810 (all minimum grade C).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab

**MCDB 3001 (3) Advanced Synthetic Biology: Engineering Biomolecular Systems in the Laboratory**

This course in engineering biological systems is an extension of the hands-on research experience gained from MCDB 3000 and meant to take following completion of MCDB 3000. Students designed biological systems to address relevant medical and environmental problems facing our society in MCDB 3000. Engineering biological system in the lab often takes longer than one semester. MCDB 3001 teaches students new laboratory techniques that will allow them to take more involved projects to the next step and gain more confidence in the laboratory.

**Requisites:** Requires prerequisite course of MCDB 3000 (minimum grade C-).

**Recommended:** BCHM, ENGR and BCHM majors only.

**MCDB 3010 (2) Undergraduate Teaching in Course-Based Undergraduate Research Experiences**

To address the need for more advanced and continued participation in course-based research, MCDB 3010 is designed to train students who have taken MCDB 1171 or MCDB 2171 or MCDB 4202 as teaching assistants. The aim is to enhance the students' experience and responsibilities in course-based research and to prepare them for research and mentorship in a departmental or graduate laboratory.

**Repeatable:** Repeatable for up to 4.00 total credit hours.

**Requisites:** Requires prerequisite course of MCDB 1171 or MCDB 2171 or MCDB 1161 or MCDB 4202 (minimum grade B).

**Grading Basis:** Letter Grade

**MCDB 3020 (1) Next Steps: Preparing for Life After Graduation**

Helps upper-division students prepare for what comes after graduation.

Topics include exploring careers; how to write a resume or CV; interviewing tips; how to build your portfolio; asking for letters of recommendations. This course is specifically designed for juniors starting to prepare for the next stage post-graduation.

**Equivalent - Duplicate Degree Credit Not Granted:** EBIO 3020 and IPHY 3020

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors).

**Grading Basis:** Pass/Fail

**MCDB 3105 (3) Antibiotics: Functions and Failures**

Learn about treatments for infectious diseases, how the first antibiotics were discovered, where they come from, how and why they work, and how resistance develops. Understand how antibiotics make modern medicine possible. Explore ways clinicians minimize the spread of resistance to antibiotics. Examine how new antibiotics and other approaches to treating infection are being developed.

**Requisites:** Requires prerequisite course of MCDB 2150 (minimum grade C).

**Grading Basis:** Letter Grade

**MCDB 3135 (3) Molecular Biology**

Examines the central dogma of biology by discussing the most important molecules in cells (DNA, RNA and protein) and how their synthesis (DNA replication, transcription, RNA processing and translation) is regulated. Incorporated into the discussion is how recombinant DNA techniques are used to discover and dissect cellular processes, how to design and interpret experiments, and understanding the limits of experiments to draw conclusions.

**Requisites:** Requires prerequisite courses of MCDB 2150 or EBIO 2070 and CHEM 1113 or CHEM 1400 or CHEN 1201 or CHEN 1211 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3140 (2) Cell Biology Laboratory**

Provides laboratory experience using microscopy, bioinformatics, DNA isolation, PCR and gel electrophoresis to study cell biology and gene expression in a model organism. Students will learn research skills such as interpreting data and planning experiments.

**Recommended:** Corequisite MCDB 3135 or MCDB 3145.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3145 (3) Cell Biology**

Examines intracellular mechanisms, including transport of ions and small molecules across membranes; protein targeting to organelles; membrane trafficking between organelles; signal transduction; the cytoskeleton; and the cell cycle.

**Requisites:** Requires prerequisite courses of (MCDB 2150 or EBIO 2070) and (CHEM 1113 or CHEM 1400 or CHEN 1211) (all minimum grade C-).

**Recommended:** Prerequisite or corequisite MCDB 3140 concurrent with either this class or MCDB 3135.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3150 (3) Biology of the Cancer Cell**

Highlights dimensions of the cancer problem; cancer as a genetic/cellular disease; chemicals, viruses, and radiation as causes of cancer; cancer and diet; cancer epidemiology; cancer risk factors; proto-oncogenes, oncogenes, and cancer suppressor genes; and prevention of cancer.

**Recommended:** Prerequisite MCDB 2150 or EBIO 2070 (minimum grade C-).

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3160 (3) Infectious Disease**

Illustrate how cutting edge tools in genomics can be used to study, monitor and cure disease caused by new and re-emerging human pathogens such as SARS/MERS, Ebola virus, Neisseria meningitides, influenza virus and malaria parasites. Technologies covered will include genome sequencing, annotation, transcriptomics, phylogenetics and genotyping of microbial populations. An integrated approach to this topic will be presented, with these concepts threaded throughout: natural history and evolution of pathogens, molecular biology, immunology, epidemiology, public health and clinical diagnosis. There may be some overlap with material covered in MCDB 1030 and MCDB 4750.

**Requisites:** Requires prerequisite course of MCDB 2150 or EBIO 2070 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3161 (2) From DNA to Genes, Phage Genomics Laboratory II**

Provides in-silico laboratory experience annotating bacteriophage genomes from bacteriophages that were isolated in MCDB 1161. Topics include genome annotation, predicting gene functions using BLAST and HHPred, independent research, scientific writing, and preparation of an annotation file that will be submitted to a public genome database.

**Requisites:** Requires prerequisite course of MCDB 1161 (minimum grade C-).

**MCDB 3171 (2) Advanced Discovery Based Lab - Antibiotics**

Provides students an opportunity to expand upon the research they performed in the introductory level course, Drug Discovery Through Hands on Screens I (MCDB 1171). Students will work in teams to validate potential antibiotics against human pathogens. Topics include hit validation, dose response, mechanism of action, applied statistical analysis, and an introduction to the primary literature.

**Repeatable:** Repeatable for up to 4.00 total credit hours.

**Requisites:** Requires prerequisite course of MCDB 1171 (minimum grade C-).

**Grading Basis:** Letter Grade

**MCDB 3181 (3) Microbial Planet Laboratory**

Provides beginner friendly lab & research experience working on a microbiology project. The course teaches how to conduct original scientific research from hypothesis to experimentation, evaluation and reporting. Students study non-pathogenic microorganisms they isolate themselves from nature as part of the course. Hands-on topics covered in class include how to isolate & culture new microbes; how to observe, describe and classify them; and how to examine their metabolic capabilities such as the production of antibiotics.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 3181

**Requisites:** Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (all minimum grade C-).

**Recommended:** Prerequisite GEOL 1180 or MCDB 1150 or EBIO 1210.

**MCDB 3300 (3) Personalized Medicine - Recent Advances in Diagnostics and Therapeutics**

Time for personalized medicine is now. Attempts to learn from and put the patient/person back into the equation because personalized medicine, at its worst, does nothing personal at all. Discusses historical perspective, recent advances in molecular biology and medicine (including OMICS) in regards to diagnostics and therapeutics for selected human diseases, and what the future holds for personalized medicine. Guest lectures (medical experts, patients, family members) will further enrich the course.

**Recommended:** Prerequisites MCDB 2150 or EBIO 2070.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3330 (3) Evolution and Creationism**

Intensive lecture/discussion course on the interrelationships among science, religion, and social policy. Includes historical and scientific development of evolution theory, social Darwinism/sociobiology, and the public perception of science.

**Recommended:** Prerequisite MCDB 1150 or EBIO 1210 (minimum grade C-).

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3332 (1) Scientific Ethics**

A reading/discussion course on the implications of modern biologically-based technologies, from in vitro fertilization and its variants and issues surrounding these techniques, to genomic testing of embryos and adults, the genetic engineering of organisms, including humans, to issues surrounding communicable diseases and vaccination. Discussion will include a serious consideration of various philosophical and non-scientific perspectives.

**Requisites:** Requires prerequisite course of MCDB 1150 or EBIO 1210 (minimum grade C). Restricted to students with 57-180 credits (Juniors or Seniors).

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3333 (3) Biomedical Innovations and Discoveries**

Discusses how biological inventions and discoveries fuel biomedical innovations, how important techniques in molecular biology have advanced our understanding of cellular processes and contributed to biotechnology revolution and biomedical sciences to benefit our society. Guest lectures from experts in industry and site visits will enhance the course by providing a non-academic perspective, networking opportunities, and unexpected avenues for career paths for our graduates. Department enforced prerequisite: MCDB 2150 or EBIO 2070 or instructor consent.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3350 (3) Fertility, Sterility, and Early Mammalian Development**

Describes the production of germ cells, ovulation, fertilization, reproductive cycles, controls of reproduction, early development of the embryo, methods of contraception, and causes and treatments of sterility. Recommended for students planning careers in the health sciences.

**Recommended:** Prerequisite MCDB 1150 or EBIO 1210 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3450 (3) Biological Data Science**

The central function of data science is to extract information from complex datasets. Biology is an increasingly large-data endeavor with health care records, genomics datasets, and extensive imaging. This course will develop core data science skills, including statistical analysis, visualization, data management, machine learning, and modeling.

**Recommended:** Prerequisite MCDB 2150 or EBIO 2070 (minimum grade C-), or exposure to probability theory.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3456 (1-9) Skills Center: Modular Laboratory of Advanced Modern Molecular Biology Skills**

Dedicated to teaching students fundamental laboratory skills in modern molecular biology. The skills are updated on a rolling basis in consultation with MCDB faculty and local Pharma/Biotech companies in an effort to provide students with real world skills that can help them transition from a traditional lab course environment to a more independent research environment. Students can mix and match various skills to receive one or more university credit hours and students who successfully complete a module are given a certificate recognizing their competency. Available skills modules can be viewed at <https://skillscenter.colorado.edu/>

**Repeatable:** Repeatable for up to 15.00 total credit hours.

**Recommended:** Prerequisite MCDB 1234, MCDB 1150, MCDB 1111 or EBIO 1220.

**Grading Basis:** Letter Grade

**MCDB 3501 (3) Structural Methods for Biological Macromolecules**

Newest developments in cryo-electron microscopy opened new avenues to study cellular and molecular processes with high structural detail. The class will explore the most recent strategies in Structural Biology to study protein structure and function with a special focus on viral host-pathogen interactions and cell infection and its implications to cell function and architecture. The class will be composed of lectures, scientific paper discussions and hands-on problem solving and demonstrations on microscopes and software.

**Recommended:** Prerequisite MCDB 2150 or EBIO 2070 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3650 (3) The Brain - From Molecules to Behavior**

Examines the molecular basis of the brain's role in thought, action, and consciousness by exploring issues such as relationship of cognition and localized brain function, sensory systems and their role in cognition, learning and memory, and behavioral neurochemistry.

**Recommended:** Prerequisite MCDB 2150 or EBIO 2070 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3651 (3) The Brain: Dysfunction to Disease**

Misregulation of synaptic function results in abnormal brain function and behavior that is manifested in numerous neurological and psychiatric diseases. Explores the molecular mechanisms responsible for altered synaptic plasticity in neurological diseases such as frontotemporal dementia (FTD), Parkinson's disease, Huntington's disease, Creutzfeldt-Jakob disease, Down syndrome, epilepsy, autism, and Alzheimer's disease.

**Recommended:** Prerequisites MCDB 3650 or NRSC 2100 (minimum grade C-) or instructor consent required.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3700 (3) Poisons in Cell Biology and Society**

Investigate the inner workings of our cells by studying how poisons disrupt these processes. We will learn how selected poisons affect critical processes inside the cell to cause death or destruction. The scientific aspects of the poison will be discussed in the context of its historical significance or impact on society and popular culture.

**Requisites:** Requires prerequisite course of MCDB 2150 or EBIO 2070 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 3990 (3) Introduction to Systems Biology for Biologists**

Introduces majors with relatively little mathematical experience to the major concepts in systems biology, in the context of key processes (cell growth, division, adaptation, development, and disease). Designed to help students master the necessary mathematical tools involved.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 and MATH 1310 (minimum grade C-).

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4001 (3) The What, The Why, and The How of Neural Tube Defects**

Neural tube defects (NTDs) involve incomplete neural tube closure in embryos, resulting in embryonic death or lifelong health complications. Students will select a gene from a list of candidate human NTD genes and investigate whether its loss leads to an NTD in chick embryos. This course will train students in CRISPR, cloning, embryology, and "softer" research skills such as publication formatting, with the ultimate goal of supporting students' development as researchers.

**Requisites:** Requires prerequisite course of MCDB 3140 (minimum grade D-).

**Recommended:** Junior or Senior standing.

**MCDB 4100 (1-6) Special Topics**

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4101 (3) Manipulating Genomes-Discovering Gene Functions**

Discover novel gene function in vertebrate embryonic development using the latest gene-editing technology, CRISPR-Cas9. Pick your gene of interest and design experiments to mutate the gene, confirm the mutation and characterize the phenotype. Search scientific databases to learn more about the gene and formulate a hypothesis about the gene function. Discuss and present your findings to your peer and faculty.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145.

**Grading Basis:** Letter Grade

**MCDB 4105 (3) Function of Cellular and Nuclear, Assemblies, and Machines**

Maintaining cellular functions requires a coordinated interaction of all kinds of organelles, assemblies and machines. This course will explore the structure, function, regulation and interactions of cellular organelles, supramolecular assemblies, and molecular machines (motors, ribosomes, polymerases, channels, etc.). Students will be exposed to a set of lectures and prepare specific papers that will be discussed in the group.

**Grading Basis:** Letter Grade

**MCDB 4111 (3) Experimental Design and Research in Cell and Molecular Biology**

Learning molecular and cell biology experimental design and approaches through independent research projects. Students, working in pairs, will explore the research process and gain extensive first-hand experience in: hypothesis formation; experimental design; solution preparation and experimental methodology; proposal presentation and defense (oral and written); formal presentation of results and conclusions (oral and written in a publication-style format); the publication process; critical reading and evaluation of primary scientific literature.

**Recommended:** Prerequisite MCDB 1150 or EBIO 1210 (minimum grade C-) and recommended corequisite of MCDB 3135.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4150 (3) Biology of Aging and Longevity**

Through lectures and reading assignments, this capstone course will introduce fascinating cellular and molecular mechanisms underlying aging and longevity based on historical and recent research achievements. We will discuss major aging theories and multiple cellular regulatory systems that prominently affect lifespan. The course will integrate basic concepts from multiple other courses by addressing specific physiological problems in the aging field and present students with the opportunity to learn the reasoning process in cutting-edge biomedical research.

**Requisites:** Requires prerequisite courses of (MCDB 1150 or EBIO 1210) AND (MCDB 2150 or EBIO 2070) (minimum grade of C-).

**Recommended:** Prerequisite MCDB 3135 or MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4185 (3) Geomicrobiology**

Examines how microbial and chemical processes interact on the Earth's surface today and have shaped the planet throughout its history. Emphasis will be placed on how the life styles and chemical ingenuity of microorganisms drive key biogeochemical processes including weathering and transformations of carbon, oxygen, sulfur, iron and nitrogen. Towards this goal, major geologic and evolutionary events will be examined through the lens of microbial diversity, metabolic energetics, microbe-mineral interactions, and molecular biomarkers.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5185, ENVS 4185, and GEOL 4185

**Requisites:** Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (minimum grade D-).

**Recommended:** Prerequisites GEOL 1180 or MCDB 1150 or GEOL 3320 or EBIO 3400 or ENVS 4160 or EVEN 4484.

**Grading Basis:** Letter Grade

**MCDB 4201 (3) From Bench to Bedside: The Role of Science in Medicine**

Demonstrates the breadth of research in the life sciences and how such research (not just in medical schools) can lead to medical applications. Lecturers from life sciences, the medical school and biotechnology, discuss drug development and the transfer of research into the clinical arena. Students also prepare a paper and presentation on the development of a commercial drug.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4202 (3) The Python Project**

Studies how python hearts grow after they consume a meal. Understanding the molecular processes of growth and regression in the python heart could lead to development of therapeutics for heart disease. Students work in groups in the laboratory and generate novel data by using modern molecular biology and bioinformatic techniques to clone and sequence candidate molecules of the python genome. May be repeated once.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4234 (3) Research Methods**

Presents a rigorous and pedagogically coherent introduction into the experimental process used to collect data, formulate hypotheses, and answer scientific questions in general, and biological questions in particular. Includes a detailed consideration of the elements of experimental design, data collection and analysis, and the interpretation of results in the context of effective science teaching. Part of the CU Teach course sequence for teacher certification in science and mathematics.

**Requisites:** Restricted to Biological Sciences (MCDB) majors or School of Education (EDUC) undergraduate students only.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4300 (3) Immunology**

Emphasizes cellular and molecular mechanisms by which organisms protect themselves from pathogens and the experimental basis for our understanding of these processes. Discusses development, function, and malfunction of t-cells, b-cells and other components of the immune system, focusing on the human immune system.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5301

**Requisites:** Requires prerequisite courses of MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4310 (3) Microbial Genetics and Physiology**

Examines the physiology and genetics of bacteria, Archaea and viruses. Particular emphasis will be on metabolism, regulation of gene expression and protein function, mechanisms of interactions with and manipulation of the environment, and evolution in response to environmental pressures.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5310

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-) and recommended corequisite of CHEM 4611.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4312 (3) Quantitative Optical Imaging**

Explores the fundamentals of optical imaging in biology, especially molecular and cellular biology. Covered topics include an introduction to optics and microscopes, fluorescence microscopy and image analysis, and biological applications. MATLAB will be taught at the beginning of the course and used throughout for image processing. Prior experience with MATLAB (or Python) is highly recommended but not required.

**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4312, MCDB 5312 and BCHM 5312

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4350 (3) Microbial Diversity and the Biosphere**

Provides a molecular phylogeny-based perspective on microbial diversity and the interactions between organisms that result in the biosphere. Provides overview of recent methods and findings in microbial ecology, as well as computer-based workshop in molecular phylogeny. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5350

**Recommended:** Prerequisites MCDB 1150 or EBIO 1210 and CHEM 1133 and EBIO 3400 and/or CHEM 3311 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4361 (3) Evolution and Development**

Relates how recent discoveries in the molecular mechanisms of development are shaping our understanding of animal evolution. Reviews basic principles of molecular developmental biology and applies these concepts to critically discuss current research in the field of Evo-Devo (evolution and development). Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5361

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4410 (3) Human Molecular Genetics**

Studies the human organism as a genetic system, including effect of mutation on protein structure and function, biochemical basis of human genetic disease, polymorphic gene loci, gene mapping and identification, gene cloning and characterization, and impact of human genetics on medicine and society. Fulfills MCDB scientific reasoning requirement.

**Recommended:** Prerequisite MCDB 3135 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4420 (3) Genetics of Brain and Behavior**

Examines the genetic underpinnings of animal behavior, including an examination of behavioral evolution and the use of genes as tools to examine neural architecture. We will cover topics including foraging, social behavior, personality, parental care and fear. We will explore these behaviors at multiple levels, including genomics, population genetics, molecular genetics, epigenetics, endocrinology and neurobiology. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** NRSC 4420

**Requisites:** Requires prerequisite courses of NRSC 2100 and EBIO 2070 or (MCDB 2150 and (MCDB 1161 or MCDB 1171 or MCDB 1181 or MCDB 2171)) (all minimum grade C).

**Grading Basis:** Letter Grade



**MCDB 4422 (3) Molecular Biology of Free Radicals: Role(s) in Oxidative Stress, Signaling, Disease, Aging**

Examines how free radicals are formed in biological systems and their roles in oxidative stress, cell signalling, aging, and disease. Emphasis will be placed on the recent literature. Fulfills MCDB scientific reasoning requirement.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 and CHEM 3311 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4425 (3) Topics in Membrane Biology: Cell Biology, Physiology and Disease**

Students will apply their knowledge of basic biology to exploring several of the most exciting topics in biomedicine including protein folding and stress responses, nutrient sensing and balance and signal transduction across membranes. Emphasis will be placed upon human physiology and associated human diseases including Alzheimer's disease, diabetes and cardiovascular disease. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5425

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 or instructor consent.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4426 (3) Cell Signaling and Developmental Regulation**

Introduces several cell signaling processes and their biological functions. Students read and analyze original research articles to learn the thinking processes of scientific research. Writing assignments and oral presentations are required. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5426

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 and CHEM 4700 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4427 (3) Biology of the Visual System**

Explores the neurobiology, cell biology, genetics and developmental biology of the visual system. Discusses neurodegenerative and vascular diseases that lead to blindness. Students read and analyze original research articles to train scientific reasoning. Involves student-organized presentations and classroom discussion. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5427

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-) or instructor consent required.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4428 (3) Regulation of Lifespan**

Lectures and literature reading/discussion will introduce students to historical, fascinating and cutting-edge research achievements, as well as the basic genetic/biochemical approaches, towards understanding cellular signaling systems and mechanisms that regulate the aging process and lifespan of animals and humans. Through the combination of presentation, discussion, homework and two exams, students will learn the reasoning process of scientific research in the aging field, become familiar with typical experimental approaches and improve their communication ability.

**Requisites:** Requires prerequisite course of MCDB 3135 (minimum grade C-).

**Grading Basis:** Letter Grade

**MCDB 4441 (4) Animal Developmental Diversity**

Surveys development in a range of vertebrate and invertebrate systems to reconstruct the common bilaterian ancestor, and elucidate the developmental genetic changes underlying animal diversification. Lab focuses on vertebrate embryos and explores key methods in evolutionary developmental biology including in situ hybridization, embryo microinjection, and transgenesis.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5441 and EBIO 4440 and EBIO 5440

**Recommended:** Prerequisites MCDB 1150 or EBIO 1210 and MCDB 2150 or EBIO 2070 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4444 (3) Cellular Basis of Disease**

Explores the cellular basis of disease. Discusses diseases arising from defects in intracellular targeting, cytoskeletal function, intracellular signaling, genomic instability, gene regulation, cell proliferation, and cell death. Involves student-organized presentations and classroom discussion. Fulfills MCDB scientific reasoning requirement.

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4471 (3) Mechanisms of Gene Regulation in Eukaryotes**

Focuses on manifestations of regulated gene expression. Studies gene regulation at multiple steps, including transcription, RNA processing and translation. Is based on critical analysis of primary research papers. Written assignments and oral presentations are required. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5471

**Recommended:** Prerequisite MCDB 3135 (minimum grade C-) or instructor consent required.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4520 (3) Bioinformatics and Genomics**

Computational and experimental methods in bioinformatics and genomics, and how these methods provide insights into protein structure and function, molecular evolution, biological diversity, cell biology and human disease. Topics include database searching, multiple sequence alignment, molecular phylogeny, microarrays, proteomics and pharmacogenomics.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5520

**Recommended:** Prerequisites MCDB 3135 or CHEM 4700 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4521 (1) Bioinformatics and Genomics Laboratory**

Provides experience with, and exposure to, computational and experimental methods in bioinformatics and genomics. Meets once a week. Students are expected to read original research papers, discuss findings, plan and execute data analysis in selected areas.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5521

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4550 (3) Cells, Molecules and Tissues: A Biophysical Approach**

Focuses on the biophysics governing the structure/function of enzymes, cells, extracellular matrix and tissue. Synthesizes ideas from molecular biology, physics, and biochemistry, emphasizing how low Reynolds number physics, not Newtonian physics, is relevant to life inside a cell. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5550 and PHYS 4550 and PHYS 5550

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 and PHYS 2010 and PHYS 2020 and CHEM 1133 and MATH 1300 and/or CHEM 3311 (minimum grade C-) or instructor consent required.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4560 (3) Introduction to Biophysics**

Covers an introduction to the physics of living systems. Focuses on how living systems are able to generate order, with both physical principles and biological examples. Covers the development of quantitative models for biological systems, including estimates. Taught from a physics perspective, with biology background introduced as needed.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5560 and PHYS 4560 and PHYS 5560

**Requisites:** Requires a prerequisites course of PHYS 2210 (minimum grade C-).

**Recommended:** Prerequisite PHYS 4230.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4567 (3) Skills Center Linked Lab Research Project**

This course is a Skills Center Linked Lab independent project. Students who have successfully completed linked lab ( <https://skillscenter.colorado.edu/labs.html>) skills through MCDB 1234/3456 are eligible to take MCDB 4567. Student work with a linked lab advisor and the Skills Center proctors to develop a research project and the student completes the project in the Skills Center or in the Linked Lab and learn research skills such as interpreting data and planning and executing experiments, data interpretation, statistical analysis and presentation.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Requisites:** Requires prerequisite course of MCDB 3456 (minimum grade C-).

**Grading Basis:** Letter Grade

**MCDB 4615 (3) Biology of Stem Cells**

Stem cells have received considerable notice in both the scientific and social arena. Examines the stem cell concept by a critical examination of the primary scientific literature. Topics will include pluripotency and plasticity, environment, technology, self-renewal, transdifferentiation, molecular signature, epigenetic programming and stem cell versus cancer cell. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5615

**Recommended:** Prerequisite MCDB 3135 or MCDB 3145 or instructor consent required.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4621 (3) Genome Databases: Mining and Management**

Develops essential skills for performing genomic analyses, with focus on developing practical research tools. Introduces human genome and microbiome projects, Python/Sql scripting, accessing and understanding genomic data, sequence alignment and search, evolutionary models, expression data, biological networks, and macromolecular structure.

**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 4621, MCDB 5621 and BCHM 5621

**Requisites:** Requires prerequisite course of BCHM 2700 or BCHM 4700 or CSCI 3104 or MCDB 3500 (minimum grade C-).

**Recommended:** Prerequisite MCDB 3135 or CSCI 3104 or CHEM 4700 and recommended corequisite of CSCI 2270.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4650 (3) Developmental Biology**

Explores the development of invertebrate and vertebrate organisms, emphasizing cellular, molecular and genetic mechanisms. Focuses on conceptual understanding and experimental approaches to topics such as embryology, developmental control of gene expression in eukaryotic cells, mechanisms of differentiation and morphogenesis and developmental genetics.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5651

**Requisites:** Requires prerequisite courses of MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4680 (3) Mechanisms of Aging**

Studies aging as a developmental process emphasizing genetic, cellular and molecular mechanisms. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5680

**Recommended:** Prerequisites MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4750 (3) Animal Virology**

Encompasses the structure and replication of both lytic and transforming animal viruses. Emphasizes diversity of naturally occurring genomic structures and the resulting strategies of infection as well as the impact of viral epidemics on society. Includes critical analysis of primary research papers. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5750

**Recommended:** Prerequisite MCDB 3135 (minimum grade C-) or instructor consent required.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4777 (3) Molecular Neurobiology**

Introduces the functional anatomy of the nervous system and explores current knowledge regarding the molecular and genetic basis of the development and function of the nervous system. Studies recent insights into the molecular basis of neurodegenerative diseases, in the last portion of the course.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 5777

**Requisites:** Requires prerequisite courses of MCDB 3135 and MCDB 3145 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4790 (3) Oocytes, Stem Cells, Organisms: Experiments to Discoveries**

Develop critical thinking, scientific reasoning and communication skills by reading and presenting primary research articles and Nobel Prize winning research on patterning, stem cells, cell death, genetic and epigenetic mechanisms that regulate embryonic development. Learn about experimental approaches from a historical and present view, while discussing their ethical implications.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4800 (3) Molecular Evolution: How Natural Selection has Shaped the Molecules of Life**

This course explores how Darwin's idea has shaped the structures of DNA, RNA and proteins across the long history of life on earth. Natural selection driving the evolution these macromolecules and subsequent developmental pathways will be fully appreciated as the process that ultimately produced the amazing variety of species on this planet. Looking ahead, our recent efforts to harness the power of evolution in the test tube to develop new therapies will be covered.

**Requisites:** Requires prerequisite courses of MCDB 3135 and MCDB 3145 (minimum grade C-).

**MCDB 4810 (3) Insane in the Membrane: The Biology and Biophysics of the Membrane**

Studies the biology and physics of the biomembrane. Topics include structure and mechanism of membrane proteins; membrane biogenesis; membrane protein folding and stability; membrane homeostasis; mechanisms of membrane fusion and fission; lipid trafficking. Fulfills MCDB scientific reasoning requirement.

**Recommended:** Prerequisite CHEM 4700 (minimum grade C-) or instructor consent required.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4811 (3) Teaching and Learning Biology**

Provides an introduction to recent research into student learning on the conceptual foundations of modern biology, together with pedagogical methods associated with effective instruction and its evaluation. Students will be involved in active research into conceptual and practical issues involved in biology education, methods to discover student preconceptions, and the design, testing and evaluation of various instructional interventions.

**Equivalent - Duplicate Degree Credit Not Granted:** EDUC 6811 and EDUC 4811 and MCDB 5811 and EBIO 4811

**Recommended:** Prerequisites MCDB 1150 or EBIO 1210 and MCDB 2150 and MCDB 3145.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**MCDB 4840 (1-6) Upper-Division Independent Study**

An independent study contract is required.

**Repeatable:** Repeatable for up to 8.00 total credit hours.

**Recommended:** Prerequisite MCDB 2150.

**MCDB 4900 (1-3) Public Health Practicum**

Offers practical experience in Public Health with direct supervision.

**Equivalent - Duplicate Degree Credit Not Granted:** EBIO 4900 and IPHY 4900

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**MCDB 4960 (1) Research Communication: Analyzing Data and Effectively Communicating Science for Honors Students**

This course is intended for MCDB honors students and to be taken the same semester as their undergraduate thesis defense. The course will teach honors students how to analyze their research data with proper statistics and effectively write their undergraduate honors thesis. Students will also gain experience in presenting their research to an audience with constructive feedback given.

**Requisites:** Requires prerequisite courses of MCDB 3135 and MCDB 3145 (minimum grade C-).

**MCDB 4980 (3) Honors Research**

Provides faculty-supervised research for students who have been approved by the departmental honors committee. Normally taken during the semester before completion of the honors thesis.

**Recommended:** Prerequisite MCDB 4840 or comparable research experience, and minimum GPA of 3.20.

**Additional Information:** Arts Sciences Honors Course

**MCDB 4990 (3) Honors Thesis**

Involves the preparation and defense of an honors thesis, based on faculty-supervised original research, including final phases of the research project.

**Recommended:** Prerequisites MCDB 4840 or MCDB 4980 or comparable research experience, and minimum GPA of 3.3 and approval by the MCDB Honors Committee.

**Additional Information:** Arts Sciences Honors Course

**MCDB 5201 (1) Graduate Lab in Molecular Evolution**

Ever wonder what functional clues might reside in the DNA sequence of your favorite gene? In this course, graduate students will learn the fundamentals of phylogenetics with an emphasis on evolutionary models that infer selective pressures in protein-coding DNA sequences (genes). During the course, students will be working on their favorite gene and using it as a case study for applying all of the concepts that we will cover. By the end of the course they will have generated a publication-quality summary figure, along with appropriate supplemental figures, of the selective pressures shaping their favorite gene. Additionally, they will learn how to design and execute an experimental approach based off of findings from the evolutionary analysis.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**MCDB 5210 (3) Cell Structure and Function (Lecture and Discussion)****MCDB 5220 (3) Graduate Core 2**

**Requisites:** Restricted to graduate students only.

**MCDB 5230 (3) Graduate Core 1**

**Requisites:** Restricted to graduate students only.

**MCDB 5250 (3) Topics in Developmental Genetics (Methods and Logic)**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**MCDB 5301 (3) Immunology**

Emphasizes cellular and molecular mechanisms by which organisms protect themselves from pathogens and the experimental basis for our understanding of these processes. Discusses development, function, and malfunction of t-cells, b-cells and other components of the immune system, focusing on the human immune system.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4300

**Requisites:** Restricted to Biological Sciences (MCDB) graduate students only.

**MCDB 5310 (3) Microbial Genetics and Physiology**

Examines the physiology and genetics of bacteria, Archaea and viruses. Particular emphasis will be on metabolism, regulation of gene expression and protein function, mechanisms of interactions with and manipulation of the environment, and evolution in response to environmental pressures.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4310

**MCDB 5312 (3) Quantitative Optical Imaging**

Explores the fundamentals of optical imaging in biology, especially molecular and cellular biology. Covered topics include an introduction to optics and microscopes, fluorescence microscopy and image analysis, and biological applications. MATLAB will be taught at the beginning of the course and used throughout for image processing. Prior experience with MATLAB (or Python) is highly recommended but not required.

**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5312, MCDB 4312 and BCHM 4312

**Grading Basis:** Letter Grade

**MCDB 5350 (3) Microbial Diversity and the Biosphere**

Provides a molecular phylogeny-based perspective on microbial diversity and the interactions between organisms that result in the biosphere. Provides overview of recent methods and findings in microbial ecology, as well as computer-based workshop in molecular phylogeny.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4350

**Requisites:** Restricted to graduate students only.

**MCDB 5361 (3) Evolution and Development**

Relates how recent discoveries in the molecular mechanisms of development are shaping our understanding of animal evolution. Reviews basic principles of molecular developmental biology and applies these concepts to critically discuss current research in the field of Evo-Devo (evolution and development).

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4361

**MCDB 5425 (3) Topics in Membrane Biology: Cell Biology, Physiology and Disease**

Students will apply their knowledge of basic biology to exploring several of the most exciting topics in biomedicine including protein folding and stress responses, nutrient sensing and balance and signal transduction across membranes. Emphasis will be placed upon human physiology and associated human diseases including Alzheimer's disease, diabetes and cardiovascular disease.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4425

**Requisites:** Restricted to graduate students only.

**MCDB 5426 (3) Cell Signaling and Developmental Regulation**

Introduces several cell signaling processes and their biological functions. Students read and analyze original research articles to learn the thinking processes of scientific research. Writing assignments and oral presentations are required.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4426

**MCDB 5427 (3) Biology of the Visual System**

Explores the neurobiology, cell biology, genetics and developmental biology of the visual system. Discusses neurodegenerative and vascular diseases that lead to blindness. Students read and analyze original research articles to train scientific reasoning. Involves student-organized presentations and classroom discussion.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4427

**Requisites:** Requires prerequisite courses of MCDB 3135 and MCDB 3145 (all minimum grade C-).

**MCDB 5441 (4) Animal Developmental Diversity**

Surveys development in a range of vertebrate and invertebrate systems to reconstruct the common bilaterian ancestor, and elucidate the developmental genetic changes underlying animal diversification. Lab focuses on vertebrate embryos and explores key methods in evolutionary developmental biology including in situ hybridization, embryo microinjection, and transgenesis.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4441 and EBIO 4440 and EBIO 5440

**Requisites:** Restricted to graduate students only.

**MCDB 5471 (3) Mechanisms of Gene Regulation in Eukaryotes**

Focuses on manifestations of regulated gene expression. Studies gene regulation at multiple steps, including transcription, RNA processing and translation. Is based on critical analysis of primary research papers. Written assignments and oral presentations are required.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4471

**MCDB 5520 (3) Bioinformatics and Genomics**

Computational and experimental methods in bioinformatics and genomics, and how these methods provide insights into protein structure and function, molecular evolution, biological diversity, cell biology and human disease. Topics include database searching, multiple sequence alignment, molecular phylogeny, microarrays, proteomics and pharmacogenomics.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4520

**Requisites:** Restricted to graduate students only.

**MCDB 5521 (1) Bioinformatics and Genomics Laboratory**

Provides experience with, and exposure to, computational and experimental methods in bioinformatics and genomics. Meets once a week. Students are expected to read original research papers, discuss findings, plan and execute data analysis in selected areas.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4521

**Grading Basis:** Letter Grade

**MCDB 5550 (3) Cells, Molecules and Tissues: A Biophysical Approach**

Focuses on the biophysics governing the structure/function of enzymes, cells, extracellular matrix and tissue. Synthesizes ideas from molecular biology, physics, and biochemistry, emphasizing how low Reynolds number physics, not Newtonian physics, is relevant to life inside a cell.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4550 and PHYS 4550 and PHYS 5550

**MCDB 5560 (3) Introduction to Biophysics**

Covers an introduction to the physics of living systems. Focuses on how living systems are able to generate order, with both physical principles and biological examples. Covers the development of quantitative models for biological systems, including estimates. Taught from a physics perspective, with biology background introduced as needed.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4560 and PHYS 4560 and PHYS 5560

**Grading Basis:** Letter Grade

**MCDB 5615 (3) Biology of Stem Cells**

Stem cells have received considerable notice in both the scientific and social arena. Examines the stem cell concept by a critical examination of the primary scientific literature. Topics will include pluripotency and plasticity, environment, technology, self-renewal, transdifferentiation, molecular signature, epigenetic programming and stem cell versus cancer cell. Fulfills MCDB scientific reasoning requirement.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4615

**Requisites:** Restricted to graduate students only.

**MCDB 5621 (3) Genome Databases: Mining and Management**

Lec. Develops essential skills for performing genomic analyses, with focus on developing practical research tools. Introduces human genome and microbiome projects, Python/Sql scripting, accessing and understanding genomic data, sequence alignment and search, evolutionary models, expression data, biological networks, and macromolecular structure.

**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5621, MCDB 4621 and BCHM 5621

**MCDB 5650 (2) Teaching and Learning in Undergraduate Science Courses**

Discusses recent research on how students learn and applications to the teaching of undergraduate science courses. Conducted as an interactive workshop, in which active-engagement in learning approaches are modeled and experienced by participants. Open to undergraduate and graduate students. May be used to fulfill the pedagogical training requirement for undergraduate Learning Assistants in upper division science courses. Post-doctoral and faculty auditors are welcome to participate as regular auditors.

**MCDB 5651 (3) Developmental Biology**

Explores the development of invertebrate and vertebrate organisms, emphasizing cellular, molecular and genetic mechanisms. Focuses on conceptual understanding and experimental approaches to topics such as embryology, developmental control of gene expression in eukaryotic cells, mechanisms of differentiation and morphogenesis and developmental genetics.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4650

**Requisites:** Restricted to graduate students only.

**MCDB 5680 (3) Mechanisms of Aging**

Studies aging as a developmental process emphasizing genetic, cellular and molecular mechanisms.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4680

**Requisites:** Restricted to graduate students only.

**MCDB 5750 (3) Animal Virology**

Encompasses the structure and replication of both lytic and transforming animal viruses. Emphasizes diversity of naturally occurring genomic structures and the resulting strategies of infection as well as the impact of viral epidemics on society. Includes critical analysis of primary research papers. Fulfills MCDB scientific reasoning requirement. Course has additional graduate student level requirements.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4750

**Requisites:** Restricted to graduate students only.

**MCDB 5776 (1) Scientific Ethics and Responsible Conduct in Research**

Lect. Advanced discussion of topics in scientific ethics, including requirements for responsible conduct of research, case histories of fraud, research misconduct, ethical misconduct and development of professional values and ethical standards.

**Equivalent - Duplicate Degree Credit Not Granted:** BCHM 5776

**Requisites:** Requires a corequisite course of MCDB 5230 or BCHM 5771.

**MCDB 5777 (3) Molecular Neurobiology**

Introduces the functional anatomy of the nervous system and explores current knowledge regarding the molecular and genetic basis of the development and function of the nervous system. Studies recent insights into the molecular basis of neurodegenerative diseases, in the last portion of the course.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4777

**MCDB 5811 (3) Teaching and Learning Biology**

Provides an introduction to recent research into student learning on the conceptual foundations of modern biology, together with pedagogical methods associated with effective instruction and its valuation. Students will be involved in active research into conceptual and practical issues involved in biology education, methods to discover student preconceptions, and the design, testing and evaluation of various instructional interventions.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 4811 and EDUC 4811 and EDUC 6811

**Requisites:** Restricted to graduate students only.

**MCDB 6000 (3) Introduction to Laboratory Methods**

Introduces methodology and techniques used in biological research. Designed as a tutorial between a few students and one faculty member. Students are expected to read original research papers, discuss findings, and to plan and execute experiments in selected areas.

**Repeatable:** Repeatable for up to 15.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to Biological Sciences (MCDB) graduate students only.

**MCDB 6440 (1-3) Special Topics in MCD Biology**

Acquaints students with various topics not normally covered in the curriculum. Offered intermittently or upon student demand, and often presented by visiting professors.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students only.

**MCDB 6441 (1) Faculty Res Seminar**

Acquaints students with various topics not normally covered in the curriculum. Offered intermittently or upon student demand, and often presented by visiting professors.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**MCDB 6442 (2) Research Grant Writing**

Acquaints students with various topics not normally covered in the curriculum. Offered intermittently or upon student demand, and often presented by visiting professors.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**MCDB 6940 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**MCDB 6950 (1-6) Master's Thesis**

Students seeking a master's degree should consult a departmental advisor. Plan I or Plan II is offered.

**MCDB 7840 (1-6) Graduate Independent Study**

An independent study contract is required.

**Repeatable:** Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.

**MCDB 7910 (2) Seminar Practicum**

Designed for graduate students to give oral presentations on their thesis research, field questions, respond to critiques, and present background information. Students attend weekly seminar speaker presentations to gain knowledge on specialized research.

**Repeatable:** Repeatable for up to 4.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**MCDB 8990 (1-10) Doctoral Dissertation**

All doctoral students must register for not fewer than 30 hours of dissertation credit as part of the requirements for the degree. For a detailed discussion of doctoral dissertation credit, refer to the Graduate School section.

**Repeatable:** Repeatable for up to 30.00 total credit hours.

**Requisites:** Restricted to graduate students only.