

MCDB

DEPARTMENT OF MOLECULAR, CELLULAR AND DEVELOPMENTAL BIOLOGY

Guide for Undergraduate Majors

2013 - 2014

Teaching and research in the Department of Molecular, Cellular, and Developmental Biology are directed at understanding the molecular and cellular mechanisms that are the basis of biological structure, growth, evolution, embryonic development, and genetic inheritance. As undergraduate majors, students learn about the scientific methods, experimental approaches, and groundbreaking discoveries that have made modern molecular and cellular biology such an important force in medicine, agriculture, and the biotechnology industry. They also learn about the diverse tools of modern biology, recombinant DNA, genomic mapping, transgenic organisms, gene targeting, analysis of mutants, biochemical purification, antibody probes, laser manipulation of living cells, electron microscopy, and computer modeling. In addition to general and specialized classes, students have ample opportunities to participate in ongoing research in the laboratories of the department.

An online, hypertext version and PDF of this document is available at
<http://mcdb.colorado.edu>

ADVISING FOR MCDB MAJORS

All undergraduate advising for the MCDB major, including Core Curriculum and other Arts and Sciences requirements, is done in the Department. Each new MCDB major is assigned to one of the MCDB advisors. Students who enter MCDB from another major will normally be assigned to the advisor who processes their change of major.

MCDB advisors

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REQUIREMENTS FOR THE MCDB UNDERGRADUATE MAJOR

OVERVIEW

The MCDB undergraduate major leads to a Bachelor of Arts (B.A.) degree from the College of Arts and Sciences (A&S). Students majoring in MCDB must satisfy MCDB major and ancillary requirements as well as A&S requirements. These requirements are summarized in a one-page **checklist** on page 16.

- See detailed descriptions in University catalog.
- Sample degree plans are on pages 15.

MAJOR COURSE REQUIREMENTS - GENERAL

- A minimum of 30 credit hours in MCDB, including 19 hours of specified courses and a minimum of 11 hours of upper-division electives.
- All courses counted in the 30 hours of MCDB coursework must have C- or better grades.
- A grade point average (GPA) of 2.0 is required for all MCDB courses attempted (including repeats and courses not counted as part of the 30 credit hours).
- Transfer students must take a minimum of 12 credit hours of upper-division courses with MCDB course numbers at CU Boulder, including at least one MCDB upper-division elective.

MCDB REQUIRED COURSES

Note: Some courses are available only once a year. Be sure to plan accordingly.

MCDB 1150, Introduction to Cell and Molecular Biology, 3 credit hours

AND

MCDB 1151, Introduction to Cell and Molecular Biology Laboratory, 1 credit hour (Fall only)

OR

MCDB 1111, Biofundamentals 4 credit hrs

- EBIO 1210/1230, CHEN 2810 or equivalent transfer credit, International Baccalaureate or Advanced Placement may be used to satisfy the requirement for MCDB 1150/1151. Students that take CHEN 2810 must take MCDB 1151 to fulfill the lab requirement.
- We strongly urge each student to discuss these options with an MCDB advisor. A&S recognizes MCDB 1150/1151 as sufficiently different from EBIO 1210/1230 so that no credit is lost by also taking MCDB 1150/1151.

MCDB 2150, Principles of Genetics, 3 credit hours (Fall and Spring)

AND

MCDB 2151, Principles of Genetics Laboratory, 1 credit hour (Fall and Spring)

- MCDB 2150 (or genetics transfer credit) is a strict prerequisite for MCDB 3135 and MCDB 3145.
- MCDB 1150 or equivalent is a prerequisite.

MCDB 3135, Molecular Cell Biology I, 3 credit hours (Fall only)

- MCDB 2150 is a prerequisite and CHEM 1131 a pre/co-requisite.

MCDB 3140, Cell Biology Lab, 2 credit hours (Fall & Spring)

May be taken with MCDB 3135 or 3145.

MCDB 3145, Molecular Cell Biology II, 3 credit hours (Spring only)

MCDB 3135 is a prerequisite and CHEM 3311 is a pre/co-requisite.

MCDB CAPSTONE COURSE:

MCDB 4300 Immunology, 3 credit hours

OR

MCDB 4650 Developmental Biology, 3 credit hours

OR

MCDB 4777 Molecular Neurobiology (effective Spring 2011), 3 credit hours

MCDB 3135 and MCDB 3145 are prerequisites

MCDB ELECTIVE COURSES

MCDB majors must also complete a minimum of 11 hours of MCDB upper-division electives.

- **Elective Courses:** At least two of the MCDB upper division elective courses (6 hours) must be lecture courses. One of these must be an MCDB Scientific Reasoning Course. The following are some of the approved Scientific Reasoning courses: MCDB 4330, 4361, 4410, 4425, 4426, 4444, 4471, 4501, 4530, 4550, 4600, 4615, 4680, 4750, 4790, 4810 and 4811.
- Students who have used transfer courses with lesser credit in place of required MCDB courses must take additional electives to bring total MCDB credits to 30 hours.

- There is no upper limit on MCDB electives, but A&S requires students to complete at least 75 credit hours outside their major department. **Independent study:** Six hours of MCDB upper-division independent study (MCDB 4840), honors research (MCDB 4980) or honors thesis (MCDB 4990) may be counted as MCDB elective courses.
- Additional independent study, up to a total of 8 hours in any one department, (16 hours in all departments) can be counted toward the 120 hours for graduation.
- MCDB majors are encouraged to do independent study research, which together with a grade point average of 3.3 or better can lead to graduation with Honors. (See page 5-6 for details.)
- **Electives from other departments:** A maximum of six credit hours from two of the courses listed on page 14 may be used as MCDB electives.
- Approved independent study in another department may be counted as an MCDB elective if the project is closely related to MCD Biology. A member of the MCDB Faculty must sponsor the project.
- Students may petition the Undergraduate Committee *in advance* to have one course (three credit hours) not on the approved list, from another department count as an MCDB elective.

MCDB ANCILLARY COURSE REQUIREMENTS

In addition to the 30 credit hours of major courses, MCDB requires the following ancillary courses in Chemistry, Calculus, and Physics.

All ancillary courses must be completed with a grade of C- or better.

CHEM 1113 and 1114, General Chemistry I and Lab, CHEM 1133 and 1134, General Chemistry II and Lab 10 credit hours (Fall, Spring, Summer)

- Students with no high school chemistry or a weak background in chemistry should take CHEM 1021, Introductory Chemistry, before attempting General Chemistry.
- Honors General Chemistry, CHEM 1351 and 1371 and General Chemistry for CHEM/BCHM majors, CHEM 1251 and 1271 are accepted.
- Students transferring from Engineering may substitute CHEN 1211 and CHEM 1221 for CHEM 1111, but must take CHEM 1133 & 1134 .

CHEM 3311, Organic Chemistry I, 4 credit hours (Fall, Spring, Summer)

AND

CHEM 3321, Organic Chemistry Lab I, 1 credit hour (Fall, Spring, Summer)

- Prerequisite for CHEM 3311: General Chemistry II.
- CHEM 3351 and 3361, Organic Chemistry I and Lab for BCHM/CHEM Majors are recommended for BCHM double majors.
- Student planning graduate school, medical school, or work in the biotechnology industry should plan to take CHEM 3331 and CHEM 3341, Organic Chemistry II and Lab.

CHEM 4611, Survey of Biochemistry, 3 credit hours (Fall, Spring and Summer) Prerequisite: C- or better in CHEM 3311.

OR

CHEM 4711, General Biochemistry I, 3 credit hours (Fall & Spring) Prerequisite: C- or better in CHEM 3331.

MATH 1300, Calculus and Analytical Geometry I or Statistics (MATH 2510 [QRMS], PSYC 3101 or IPHY 2800)

- MATH 1310, Calculus with Biological Applications or APPM 1350, Engineering Calculus I are acceptable alternatives. (BCHM double majors should take MATH 1300.)
- All of the calculus courses require advanced algebra and trigonometry as prerequisites. Students with weak backgrounds should first take MATH 1150.

Do not take MATH 1071 & 1081, which are courses for business and social science students.

- BCHM double majors and others planning to take Physical Chemistry must take MATH 2400.

General Physics I and II with Lab, 9-10 credit hours (Fall, Spring, Summer)

- MCDB majors may select algebra-based General Physics, PHYS 2010/2020 (10 hours) or calculus-based General Physics, PHYS 1110/1120/1140 (9 hours). PHYS 1120 & 1140 require Calculus II.

MINIMUM GRADE REQUIREMENTS FOR MCDB MAJORS

Grade requirements in the major are set by A&S.

- All courses counted toward the required 30 credit hours in MCDB must have grades of C- or better.
- In addition, the GPA in all MCDB courses plus any non-MCDB course used as an MCDB elective must be at least 2.000. This includes all repeated courses and all MCDB courses not counted in the 30 credit hours.

FOUR-YEAR GRADUATION

A&S guarantees four-year graduation for students with no MAPS deficiencies who meet criteria of adequate progress set by the College and the major department. The plan is only available to students admitted as new freshmen. The MCDB statement of requirements and adequate progress is as follows.

The MCDB major must be started in the first semester. Adequate progress is defined as cumulative completion of at least one fourth of the required coursework for the major during each academic year, including the following specific requirements: a) either general chemistry or the introductory MCDB sequence must be completed during the first year; b) general chemistry and the introductory MCDB sequence must both be completed by the end of the second year; c) organic chemistry and the second level sequence in MCDB (Molecular Cell Biology I & II) must be completed by the end of the third year.

See Sample Degree Plan page 15.

- The MCDB major requires at least 63 hours of required coursework. Thus, approximately 16 hours must be completed yearly, including timely completion of advanced course prerequisites.
- The four-year guarantee also requires completion of 30 hours of core curriculum courses by the end of the sophomore year. Calculus counts as *three* hours of QRMS.

TRANSFER STUDENTS

Transfer students should meet with an MCDB advisor as soon as possible after arrival to review the CU equivalencies that have been given to their transferred credits, to determine which credits may be used for the MCDB major, and to develop an efficient plan for completion of the remaining requirements for graduation. Transfer students need to give special attention to the following items:

- Arts and sciences students must complete a minimum of 45 credit hours in University of Colorado courses on the Boulder campus. Of these 45 credits, a minimum of 30 credits must be in arts and sciences upper-division credit hours completed as a matriculated student in the College of Arts and Sciences at the University of Colorado at Boulder and at least 12 of these upper-division hours must be in the major. A maximum of 6 credit hours taken at other University of Colorado campuses (CU-Denver and CU-Colorado Springs) can be counted toward the minimum 45 credits required on the Boulder campus. Courses taken while on CU-Boulder study abroad programs, through CU-Boulder continuing education, or CU-Boulder correspondence courses are considered to be in residence.
- If courses are transferred with lesser credit than equivalent MCDB courses, additional MCDB electives must be taken to satisfy the A&S required minimum of 30 hours in the major.
- Graduation requires 45 hours of upper-division credit. It is important to verify that upper-division transfer credit has been granted for upper-division courses from previous schools. Courses taken as lower-division at other schools will not be given upper-division credit even if the equivalent course is upper-division at CU Boulder.

RESEARCH OPPORTUNITIES FOR UNDERGRADUATES

Research plays a major role in the overall program of MCDB. Many of the faculty are recognized leaders in their specialties, and the Department is rated among the best research departments in its field. Many opportunities are available for undergraduate research experience and the Department actively encourages students to participate in its research activities.

Most research projects begin in the sophomore or junior years and continue until graduation. Individual faculty members differ in the amount of classroom experience they expect before accepting a student for independent study.

Students can receive course credit for Independent Study research, and a successful project combined with good grades can lead to graduation with Honors. There are also work-study and part-time paid positions in many laboratories.

The University also has Bioscience Undergraduate Research Skills and Training Program (BURST) and Undergraduate Research Opportunities Program (UROP) to encourage development of joint student-faculty research projects and to help with their costs. Details are available online at:

<http://www.colorado.edu/Outreach/BSI/>

Advantages of undergraduate research include the following:

- *Laboratory experience.* A research project is an excellent way to learn modern experimental techniques in depth and also learn first-hand how scientific discoveries are made. Such experience is valuable both to students seeking laboratory employment after graduation and to those preparing for advanced study.
- *Close contact with professional researchers.* This is the best way to learn science and also makes it easier for students to obtain meaningful letters of recommendation from individuals who know their abilities well.
- *Publication.* Significant undergraduate research can sometimes lead to co-authorship of publications in scientific journals.
- *Admission to graduate school.* Strong undergraduate research experience is one of the most important qualifications for admission to the leading graduate programs in areas related to MCDB.

Independent Study Credit

The College of Arts and Sciences will accept up to 16 credit hours of independent study credit toward the 120 credit hours required for graduation, but **the limit from any one department is 8 credit hours.**

Students who are candidates for Departmental Honors can take Honors Research (MCDB 4980) and Honors Thesis (MCDB 4990), which allow a total of six additional hours of research credit beyond the normal limits of 8 credit hours of independent study.

MCDB 4840, Upper Division Independent Study, requires MCDB 2150 as a prerequisite.

How To Get Involved In MCDB Research

Students must first identify and contact a faculty member who is willing to serve as a sponsor. A brief summary of faculty research interests is provided on page 7 of this guide. More detailed information is available at:

<http://mcdb.colorado.edu/faculty/>

After the student and faculty sponsor have agreed on a project, they must complete and sign an independent study contract. The Independent Study Contract is available from the MCDB Student Affairs Office (MCDB A1B50). The signed contract should be submitted for approval before the end of the first week of classes. Registration must be completed by the end of the drop/add period for the semester in which the research will be done.

GRADUATION WITH DISTINCTION OR HONORS

Outstanding accomplishment by undergraduates at UCB is recognized in two ways: graduation with distinction and graduation with honors.

Graduation with distinction is based solely on academic performance and is automatically conferred on all students graduating with a grade point average (GPA) of 3.75 or better, both at UCB and in all collegiate work completed.

Graduation with Honors requires a GPA of at least 3.3 plus active participation in an Honors program. Two types of Honors programs are available, General Honors and Departmental Honors.

The General Honors Program is operated solely by the Honors Department and emphasizes a broad liberal arts education rather than specialization. Students for general honors must complete at least 12 hours of Honors Program or Honors Residential Academic Program courses. This coursework must include one course from each area of the General Honors Core: Humanities, Social Science, Natural Science, and a Senior Seminar course. Students must meet with the Director for Honor Program to receive approval for their thesis project.

The Departmental Honors Program is organized around a student research project undertaken in MCDB or a related department. It is not necessary to take Honors Department courses to qualify. Candidates for Departmental Honors must satisfy GPA requirements, complete a research project, prepare an Honors thesis describing the research project in a scholarly fashion and pass an oral examination. To be considered for Departmental Honors, candidates must have an overall GPA of 3.3 or better.

Departmental Honors in MCDB will ordinarily be based on laboratory research. In special cases, a library or computer research project may be considered. However, candidates for Honors should recognize that *magna* or *summa cum laude* will rarely be recommended if the thesis is not based on laboratory research.

For laboratory-based Honors, a minimum of two semesters of undergraduate research directly related to the Honors project must be completed prior to the start of the graduation semester. This can be independent study credit (MCDB 4840) or equivalent research experience, including projects supported by undergraduate fellowships (BURST, UROP, etc.). The quality of the preliminary research must be equivalent to a B or better grade. For research not done for academic credit, the faculty mentor must certify the quality.

The deadline to apply to become a candidate for Departmental Honors is the 5th week of the semester *prior* to the semester in which the thesis will be presented. This is a strict deadline established by the Honors Department. The student must prepare a brief outline of the proposed thesis research (one or two typewritten pages). The outline, together with written approval from the faculty sponsor must be submitted to the MCDB Honors Representative by the deadline date.

Honors candidates may register for MCDB 4990, Honors Thesis, and will receive credit the semester the thesis is successfully defended. (Students who will graduate in August should plan to complete their Honors thesis during the Spring Semester). In MCDB, the Honors thesis is normally written following the format of a journal article describing the results of the research project. The thesis must be approved by the faculty sponsor and submitted to the MCDB Honors Representative no later than the tenth week of the semester in which the oral examination occurs, normally within two weeks after the thesis is submitted.

In MCDB, the Honors oral examination consists of an informal public seminar on the Honors research followed by questions from the audience and the examining committee, which normally consists of the faculty sponsor, the MCDB Honors Representative, and one faculty member from outside the department. A completed statement of major status must be on file in the Departmental office prior to the oral examination.

The examining committee will make a recommendation to the University Honors Council as to whether Honors should be granted and whether they should be *cum laude*, *magna cum laude*, or *summa cum laude*. Factors considered in the recommendation include the quality of the research, the quality of the thesis, the student's performance during the oral examination, and the student's overall academic record. The University Honors Council makes final decisions on Honors.

Current Honors information can be obtained at

<http://www.colorado.edu/honors>

DEPARTMENTAL FACULTY RESEARCH INTERESTS

- Thomas Blumenthal**Professor
How organization of genes on *C. elegans* chromosomes relates to RNA processing, splicing and 3' end formation.
- Robert Boswell** Professor
Molecular and developmental genetics of *Drosophila*, cytoplasmic localization, germ cell determination
- Zhe Chen**.....Assistant Research Professor
Mechanisms of axon guidance during neural development, neurological disorders
- Shelley Copley**..... Professor
Evolution of enzymes and metabolic pathways; biodegradation of xenobiotic pollutants; bioinformatics
- Brian DeDecker**.....Assistant Research Professor
How cell fates are determined by the regulation of the notch developmental pathway. Drug development for Autoimmune diseases by targeting class II MHC
- Corrella Detweiler**.....Associate Professor
How bacteria evade and manipulate mammalian immune systems. Molecular mechanisms of typhoid fever
- Robin Dowell**Assistant Professor
Noncoding transcription, comparative genomics, transcriptional regulation and bioinformatics
- Joaquin Espinosa**Associate Professor
Mechanisms of transcriptional regulation by the tumor suppressor p53
- Christy Fillman**Instructor
Biology Education
- Robert L. Garcea**Professor
Structure and assembly of small DNA viruses (polyoma and Papilloma); development of low cost vaccines for under-resourced areas of the world.
- Nancy Guild** Professor Attendant Rank
Biology Education
- Min Han** Professor
Genetic and molecular analysis of *C. elegans* development
- Andreas Hoenger** Professor
Structural and functional investigations into cytoskeletal assemblies by cryo electron microscopy and 3D image analysis
- Kevin Jones**Associate Professor
Molecular genetics of mouse neural development
- Harald Junge**.....Assistant Professor
Molecular mechanisms of vascular development and vascular diseases
- Michael W. Klymkowsky**..... Professor
Cell adhesion, cytoskeletal organization, and gene expression. Teaching and technology
- Jennifer Knight**..... Senior Instructor
Biology Education
- Kenneth Krauter** Professor
Human genetics; comparative DNA sequence analysis; behavioral genetics; complex trait mapping
- Leslie Leinwand**Professor
Genetic manipulation of cardiac and skeletal muscle development and function in mice; gene therapy
- Jennifer Martin**Senior Instructor
B-cell immortalization by Epstein-Barr virus; signal transduction; tumor virology; malignant transformation
- Gregory Odorizzi**.....Associate Professor
Genetics and cell biology; membrane trafficking and phosphoinositide signaling in eukaryotic cells
- Bradley Olwin** Professor
Molecular and developmental biology of the heart and skeletal muscle; skeletal muscle stem cells and gene therapy
- James Orth**.....Assistant Research Professor
Molecular, cellular and tissue basis of cancer chemotherapy
- Norman Pace**Distinguished Professor
Ribozyme biochemistry; molecular ecology of extreme ecosystems
- Soyeon Park**Assistant Professor
Proteasome Biogenesis: Mechanisms of building a unique molecular machine via its assembly chaperone system
- Thomas Perkins** Professor
Single-molecule biophysics; molecular motors; protein-DNA interactions
- Robert O. Poyton**Professor
Oxygen sensing and control of gene expression; yeast mitochondrial biogenesis
- Jingshi Shen** Assistant Professor
Signal transduction across membranes; Auto-feedback cellular homeostasis systems
- Ravinder Singh**.....Associate Professor
RNA-protein interactions in gene regulation; pre-mRNA splicing and sex determination
- Gretchen Stein** Sr. Research Associate
Control of cell proliferation in human cells; cellular aging
- Michael Stowell**Associate Professor
Structure and Mechanism at the chemical synapse
- Tin Tin Su**..... Professor
Coordination of mitosis and DNA replication in *Drosophila*
- Jonathan Van Blerkom** Research Professor
Regulation of oogenesis and early mammalian embryogenesis
- Gia Voeltz**Associate Professor
Organelle biogenesis: the regulation of organelle structure and shape by membrane proteins
- Mark Winey**..... Professor and Interim Chair
Genetics and molecular biology of the yeast *S. cerevisiae*; centrosome assembly
- Ding Xue** Professor
Mechanisms of regulation and execution of programmed cell death in the nematode *C. elegans* and mammals
- Rui Yi**..... Assistant Professor
MicroRNA-mediated regulation in mammalian skin development, stem cells & cancer.

MCDB COURSES

PREREQUISITES

Prerequisites for MCDB courses are described in terms of CU course numbers. All students are encouraged to take prerequisites very seriously.

SEMESTER OFFERED

In most cases, the semester in which the course is usually offered is shown. However, class schedules differ from year to year and some classes are not offered every year.

4000/5000 COURSES

Courses that carry 4000/5000 numbers can be taken either at the 4000 level for undergraduate credit or at the 5000 level for graduate credit. Undergraduate students who register at the 5000 level will be required to complete the work required of the graduate student in the course.

USE OF VERTEBRATE ANIMALS IN LABORATORY COURSES

Biology is the science of life; therefore a major in MCDB must include some "hands-on" experience with living organisms to be complete. Exercises involving the use of living animals or animal tissues are included in required MCDB laboratory courses. Majors with moral objections may arrange to limit their participation in these exercises, although doing so will compromise their educational experiences. Non-majors may take MCDB lecture courses without the accompanying laboratories.

COURSES FOR MCDB MAJORS

MCDB 1111-4 Biofundamentals: The Evolutionary, Molecular, and Cellular Basis of Life.

A web-based, in-class discussion and online laboratory course designed for MCDB majors, covering the fundamental properties of biologic systems. Focusing on common evolutionary, molecular and cellular mechanism. The course provides a thorough introduction to the biological sciences and fulfills the departmental requirement for MCDB 1150 & 1151. Credit is not granted for this course and and MCDB 1150 or 1151. Approved for arts and sciences core curriculum: natural science.

MCDB 1150-3. Introduction to Cell and Molecular Biology. (Fall & Spring) 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. MCDB 1151 must be taken concurrently by majors in MCDB and Biochemistry and pre-health science students. Students may not receive credit for both MCDB 1150 and 1111. Prerequisite: high school chemistry and algebra. Approved for A&S Core: Natural Sciences.

MCDB 1151-1. Introduction to Cell and Molecular Biology Laboratory. (Fall) One 2-hour lab per week designed to acquaint students with current research techniques and concepts in molecular and cellular biology. Topics include cell structure, function, physiology, and recombinant DNA. MCDB 1150 must be taken concurrently. Students may not receive credit for both MCDB 1151 and 1111. Approved for A&S Core: Natural Sciences

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 co-requisite 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. 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. Coreq., MCDB 1150 or successful completion of 2 semesters of General Biology AP credit. Enrollment is by instructor consent.

MCDB 2150-3. Principles of Genetics. (Fall and Spring)

Introduces the behavior of genes and chromosomes in eukaryotic and prokaryotic organisms. Covers three areas: transmission genetics, molecular genetics and population genetics. Attention given to genetic mapping, recombinant DNA procedures and gene expression. MCDB 2151 must be taken concurrently by majors in MCDB or Biochemistry, and by pre-health science students. Prerequisite: MCDB 1150, EBIO 1210 or CHEN 3838. Approved for A&S Core: Natural Sciences.

MCDB 2151-1. Principles of Genetics Laboratory. (Fall and Spring) One 2-hour lab per week. Provides "hands on" experience with principles introduced in MCDB 2150. Topics include mitosis, meiosis, classical genetics, complementation, mutagenesis, DNA replication, natural selection and evolution. Prerequisites: MCDB 1150 & 1151, EBIO 1210 & 1230 or CHEN 3838. Corequisite: MCDB 2150. Approved for the A&S Core: Natural Sciences.

MCDB 2152-1. Problem Solving Co-Seminar for Genetics. Uses problem solving and other interactive group work to aid student learning in co-requisite course 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. 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 data base. Prereqs., MCDB 1150 and 1161. Coreq., MCDB 2150. Enrollment is by instructor consent.

MCDB 2840-(1-3). Lower Division Independent Study. Instructor consent and Independent Study Contract required (see MCDB 4840 for details). May be repeated for credit, but only 8 hours of MCDB 2840 plus MCDB 4840 can be counted toward graduation. Students with adequate prerequisites should take MCDB 4840. Corequisite: MCDB 1150.

MCDB 3135-3. Molecular Cell Biology I. (Fall) 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. These principles are the foundation for subsequent examination of intracellular mechanisms in MCDB 3145. Prereq: MCDB 2150 or EBIO 2070. Pre/Corequisite: CHEM 1133.

MCDB 3140-2. Cell Biology Laboratory. (Fall and Spring) One 4-hour lab/week. Provides hands-on experience with modern cell biology laboratory techniques. Topics include microscopy, immunocytochemistry, Western blotting, Southern blotting, and flow cytometry. Course does not use vertebrate animals. Pre/Coreq: MCDB 3135 or MCDB 3145.

MCDB 3145-3. Molecular Cell Biology II, (Spring) 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. Analysis of these activities is from the experimental perspective established in MCDB 3135. Prerequisite: MCDB 3135.

MCDB 3150-3. Biology of the Cancer Cell. (Spring and occasionally Summer) 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; proto-oncogenes, oncogenes, and cancer suppressor genes; prevention of cancer. Prerequisite: MCDB 2150 or EBIO 2070 or instructor consent. Approved for A&S Core: Natural Sciences, non-sequence.

MCDB 3280-3. Molecular Cell Physiology. Cellular mechanisms analyzed from a molecular perspective. Examines unicellular organisms and tissues of animals to learn how cells process signals from both in and outside themselves, and use this information to react and accomplish physiological tasks. Prerequisites: MCDB 3135 and CHEM 1131.

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. Prereq., MCDB 1111 or 1150 or instructor consent.

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 the causes and treatments of sterility. Prerequisite: MCDB 1150 or EBIO 1210.

MCDB 3650-3. The Brain – From Molecules to Behavior. Examines the brain's role in thought, action and consciousness by exploring issues such as: relationship of cognition and localized brain function; functional neuroimaging, behavioral neurochemistry; learning and memory; animal consciousness; machine consciousness, artificial intelligence, and implications of modern physics. Prereqs: MCDB 1150 and MCDB 2150 (or equivalents).

MCDB 4100 1-3. Special topics. Course selection varies.

MCDB 4111 -3. Experimental Design & Research. Learning molecular and cell biology experimental design through independent research projects. Students explore the research process and gain experience in: hypothesis formation; experimental design; methodology; proposal presentation; presentation of results and conclusions; the publication process; critical reading and evaluation of scientific literature. Prereq., MCDB 1150 or equivalent and instructor consent. Recommended Pre/Coreq. MCDB 3145.

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. Prereqs., MCDB 3135 and 3140.

MCDB 4202-3. The Python Project. Studies how python hearts grow after they consume a meal. Understanding the molecular process 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. Prereqs., MCDB 1150 and 2150. Recommended Prereqs. MCDB 3135, 3145, CHEM 4711 and 4731.

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 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. Prereqs. MCDB 1150 or 1111, 2150, 31202140 or 3135/3145 or instructor consent.

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 immune system components, focusing on the human immune system. Prereqs., MCDB 3135 and MCDB 3145.

MCDB 4310/5310-3. 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. Prereqs., MCDB 2150, 3145 and EBIO 3400. recommended Pre/Co-req. – MCDB 3135 or CHEM 4711.

MCDB 4314/5314-3. Algorithms for Molecular Biology. Surveys combinatorial algorithms used to understand DNA, RNA and proteins. Introduces students to methods used to process genomic data. Topics covered include a review of algorithms and molecular biology, sequence analysis, RNA and protein structure analysis, and comparative genomics. Students will get hands-on experience processing recent genomic data. Prereqs., CSCI 2270 and CSCI 3104, or CHEM 4711 or MCDB 3145 or IPHY 4200. Same as CSCI 4314 and MCDB 5314.

MCDB 4330/5330-3. Bacterial Disease Mechanisms. Explores molecular and cellular interactions between bacteria and their eukaryotic hosts that precipitate disease. Activities include critical reading of research articles and student presentations. Recommended prereqs., MCDB 2150, 3135, and 3145. Scientific reasoning course

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. Overview of recent methods and findings in microbial ecology. Computer-based workshop in molecular phylogeny. Required Prerequisite: CHEM 1131 or 1171. Recommended Prerequisites: EBIO 3400 and CHEM 3311.

MCDB 4361/5361-3. Evolution and Development. Relates how recent discoveries in the molecular mechanisms of development are shaping our understanding of animal evolution. The course will review basic principles of molecular developmental biology and apply these concepts to critically discuss current research in the field of Evo-Devo (evolution and development). Prereqs., MCDB 3135 and 3145. Scientific reasoning course

MCDB 4410-3. Human Molecular Genetics. Studies the human organism as a genetic system. Effect of mutation on protein structure and function; biochemical basis of human genetic disease; polymorphic gene loci; gene mapping; impact of human genetics on medicine and society. Prerequisite: MCDB 3145. Scientific reasoning course

MCDB 4422-3. 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 signaling, aging and disease. Emphasis will be placed on the recent literature. Prereqs., MCDB 3135 and 3145. Recommended prereq., CHEM 3311.

MCDB 4425-3. Coping With Cellular Stresses: Molecular Mechanisms, Physiology, and Human Diseases. Studies how the cell maintains cellular homeostasis and copes with stress conditions. This course will examine research papers and will provide students with knowledge about auto-feedback signaling pathways and research approaches used to investigate them. Students are expected to understand the molecular players, the roles of pathways in animal physiology and how imbalances cause human diseases. Prereqs., MCDB 3135 and 3145. Scientific reasoning course

MCDB 4426-3. Cell Signaling and Developmental Regulation. Introduces several cell signaling processes and their biological functions. Students will read and analyze original research articles to learn the thinking processes of scientific research. Writing assignments and oral presentations will be part of the requirements. Prerequisites: MCDB 3135, MCDB 3145 and CHEM 4711. Scientific reasoning course

MCDB 4427/5427-3. 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. Prereqs., MCDB 3135 and 3145 or instructor consent. Scientific reasoning course

MCDB 4441/5441-4. Animal Developmental Diversity. Surveys development in a range of vertebrate and invertebrate systems to reconstruct the common bilaterian ancestry, 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. Prereqs. EBIO 1210, 1220 & 2070 or MCDB 1150, & 2150. Same as EBIO 4440

MCDB 4444-3. The 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 will be discussed. The course involves student organized presentations and classroom discussion. Prerequisites: MCDB 2150, MCDB 3135 and MCDB 3145. Scientific reasoning course

MCDB 4471/5471-3. Mechanisms of Gene Regulation in Eukaryotes. Focuses on manifestations of regulated gene expression. Studies gene regulation at multiple steps, *i.e.*, transcription, RNA processing and translation. Written assignments and oral presentations are required. Prerequisite: MCDB 3135 or instructor consent. Scientific reasoning course

MCDB 4501-3. Structural Methods for Biological Macromolecules. This course teaches fundamental knowledge about protein structures, protein interactions and protein folding. It will discuss in detail the most common methods on how proteins and macromolecular complexes are studied, such as X-Ray crystallography, NMR-spectroscopy, and electron microscopy. The course will offer about 50 percent direct teaching, 40 percent discussion of papers in a journal club style, and 10 percent hands-on practicals on software packages relevant to structural biology. Prereqs., MCDB 3135 and 3145. Scientific reasoning course.

MCDB 4520/5520-3. 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, micorarrays, proteomics, and pharmacogenomics. Prereqs., CHEM 4711 & 4731, or CHEM 4711 and MCDB 3145.

MCDB 4550/5550-3. Cells, Molecules and Tissues: A Biophysical Approach. Focuses on the biophysics governing enzyme mechanisms, cellular mechanisms, cellular structure and motion. Synthesizes ideas from molecular biology, physics, and biochemistry, emphasizing how low Reynolds number physics, not Newtonian physics, is relevant to life inside the cell. Prereq., CHEM 1133 or 1371, PHYS 2010, 2020, MCDB 3135 or instructor consent. Recommended Prereq., MATH 1300 and/or CHEM 3311. Scientific reasoning course

MCDB 4600-3. Molecular Approaches to Human Diseases. Studies basic research using molecular biology and its contribution to treatment of human diseases. Includes an overview of physiology, clinical presentation, basic research, and detailed analyses of molecular approaches taken to understand and treat human diseases. Prereqs., MCDB 2150, 3135, and 3145. Scientific reasoning course

MCDB 4615/5615-3. Biology of Stem Cells. The course will examine 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. Prereqs., MCDB 2150, 3135, 3145 or instructor consent. Scientific reasoning course

MCDB 4621/5361-3. 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. Prereqs., MCDB 3145, CSCI 3104 or CHEM 4711: coreq., CSCI 2270. Same as MCDB 5621. Credit not granted for this course and CHEM 4621 or CSCI 4317.

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. Prerequisites: MCDB 3135 and MCDB 3145, or instructor consent.

MCDB 4680/5680-3. Mechanisms of Aging. Studies aging as a developmental process emphasizing cellular and molecular mechanisms involved. Prerequisites: MCDB 3135 and MCDB 3145. Scientific reasoning course

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. Prereq: MCDB 3135 or instructor consent. Scientific reasoning course

MCDB 4777/5777-3. 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 neuro-degenerative diseases, in the last part of the course. Prerequisites: MCDB 3135 and MCDB 3145.

MCDB 4790-3. Experimental Embryology. Embryology is studied by considering experiments relevant to specific topics of early development. Both historical and contemporary material will be considered. This course emphasizes reading, interpretation and discussion of research articles. Frequent writing assignments and active participation in discussions are required. Prereqs: MCDB 3120 and MCDB 3145. Scientific reasoning course

MCDB 4810/5810-3. 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. Prereq., CHEM 4711 or instructor consent. Scientific reasoning course

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 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. Prereqs., MCDB 3135. Scientific reasoning course

MCDB 4840-(1-6). Upper Division Independent Study. Prerequisites: MCDB 2150 and consent of instructor. A research contract must be completed and signed by the student and the faculty sponsor and approved by the MCDB Coordinator of Independent Study. Enrollment must be completed by the end of the drop-add period. The signed contract should be submitted by the end of the first week of classes of the semester in which the research will be done. Contact the MCDB Student Affairs Office (MCDB A1B48) for details. May be repeated for credit, but only 8 hours of MCDB 2840 and MCDB 4840 can be counted toward graduation.

MCDB 4980-3. Honors Research. Faculty-supervised research by students who have been approved by the Departmental Honors Committee. This course is normally taken during the semester before completion of the Honors Thesis. Prerequisites: one semester MCDB 4840, or equivalent research experience; GPA of 3.20 or better.

MCDB 4990-3. Honors Thesis. Preparation and defense of an Honors Thesis based on faculty-supervised original research, including final phases of the research project. Prerequisites: MCDB 4840 or 4980, GPA of 3.30 or better, and approval by the MCDB Honors Committee.

MCDB 5680-1. TPC-Teach/Learn Seminar. 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.

Courses numbered 5000-5999 are intended primarily for graduate students, but are also available to qualified undergraduates.

NON-MCDB COURSES THAT MAY BE USED AS MCDB ELECTIVES

Electives from other departments: MCDB majors may take 2 courses (maximum of 6 credit hours) from the following list as MCDB upper division electives without petitioning. When choosing to take courses from this list, check for prerequisites and major restrictions. It is also possible to petition the MCDB Undergraduate Committee to use a course that is not on the following list as an MCDB elective.

CHEM 3331-4. Organic Chemistry 2

CHEM 3341-1. Organic Chemistry 2 Laboratory

CHEM 4731-3. General Biochemistry 2

CHEM 4761-4. Biochemistry Laboratory

EBIO 3400-4. Microbiology

EBIO 4800-3. Critical Thinking – approved topics:

DNA, Development & Diversity

Diet, Genes, Health, Mood

Genetically Engineered Organisms

***EDUC 5215-3. Elementary Science Theory and Methods**

***EDUC 5315-3. Perspectives on Science**

***EDUC 5385-3. Project- Based Science Instruction**

IPHY 3430-3. Human Physiology

IPHY 3435-2. Human Physiology Laboratory

IPHY 3470-3. Human Physiology 1 for IPHY majors

IPHY 3480-3. Human Physiology 2 for IPHY majors

IPHY 3450-5. Comparative Animal Physiology

IPHY 3500-2. Applied Clinical Research

IPHY 3800-3. Forensic Biology

IPHY 3810-1. Forensic Biology Laboratory

PSYC 4052-4. Behavioral Neuroscience

PSYC 4072-3. Clinical Neuroscience: A Clinical and Pathological Perspective.

* Consult Education Department for appropriate course.

Please see your advisor for updates to this list.

COURSES FOR NON-MAJORS

The following courses satisfy A&S Core Curriculum requirements, as indicated. However, they do not count toward the MCDB major.

MCDB 1030-3. Molecules. Plagues and People. Introduces molecular and cell biology in the context of microorganisms and their impact on humans, both positive and negative. Includes exploration of the biology and social impact of human plagues and emerging human pathogens, how the immune system works to combat such invasions, and the impact of technology and molecular biology on curtailing diseases. Approved for A&S Core Curriculum: 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 non-majors. Good background in high school chemistry and biology is recommended. Approved for A&S Core Curriculum: Natural Science,

MCDB 1042-1. Fundamentals of Human 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. When 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 which seeing the application to humans. Coreq., MCDB 1041.

SAMPLE DEGREE PLANS

There are many ways to fit all of the Departmental and College graduation requirements into a four-year degree plan. We encourage each student to develop a personalized degree plan in consultation with a departmental advisor. An individualized plan is very important for students planning to take the MCAT in the spring of their junior year. The following sample degree plans assume no MAPS deficiencies. The following notations and assumptions are incorporated

in all plans:

- MATH 1300 is used for QRMS. MCDB majors may substitute MATH 1310. MCDB/BCHM double majors should take MATH 1300 (or APPM 1350).
- The required writing courses are designated "LD-writing" Lower Division and "UD-writing" Upper Division.
- "MCDB-elective" refers to an upper-division MCDB elective approved for majors.

A. Assumes a high school background adequate to enter directly into MATH 1300 and CHEM 1113. Must complete a total of at least 120 credit hours of which 45 credit hours must be upper division.

	Freshman	hrs	Sophomore	hrs	Junior	hrs	Senior	hrs	
F	MCDB 1150/1151	4	MCDB 3135/3140	5	MCDB UD Elective	3	MCDB Capstone	3	
A	CHEM 1113 & 1114	5	CHEM 3311/3321	5	CHEM 4611	3	A&S-CORE	3	
L	LD-writing	3	A&S-CORE	3	PHYS 2010	5	A&S-CORE (UD)	3	
L	A&S-CORE	3	A&S Elective	3	A&S-CORE	3	2 A&S Electives	6	
	<i>Total hours</i>	15	<i>Total hours</i>	16	<i>Total hours</i>	14	<i>Total hours</i>	15	
S	MCDB 2150/2151	4	MCDB 3145	3	MCDB UD Elective	3	MCDB Elective	3	
P	CHEM 1133 & 1134	5	MATH 1300*	5	PHYS 2020	5	MCDB Elective	3	
R	A&S-CORE	3	A&S-CORE	3	2 A&S Elective (UD)	6	A&S Elective (UD)	3	
N	A&S-Elective	3	A&S Elective	3	UD-writing	3	2 A&S Elective (UD)	6	
G	<i>Total hours</i>	15	<i>Total hours</i>	14	<i>Total hours</i>	17	<i>Total hours</i>	15	
	<i>Total hours</i>	30	<i>Total hours</i>	30	<i>Total hours</i>	31	<i>Total hours</i>	30	121

• If statistics is taken rather than calculus additional A&S elective hours must be taken.

B. Designed for a double major in MCDB and BCHM. Assumes a high school background adequate to enter directly into MATH 1300 and CHEM 1113. CHEM 3331 & 3341 count as MCDB upper division electives.

	Freshman	hrs	Sophomore	hrs	Junior	hrs	Senior	hrs	
F	MCDB 1150/1151	4	MCDB 3135/3140	5	CHEM 4711	3	MCDB Capstone	3	
A	CHEM 1113 & 1114	5	CHEM 3351/3361*	6	PHYS 1110	4	CHEM 4411	3	
L	A&S-CORE	3	MATH 2300	5	A&S-CORE	3	UD-writing	3	
L	LD-writing	3			A&S Elective	3	2 A&S Electives	6	
	<i>Total hours</i>	15	<i>Total hours</i>	16	<i>Total hours</i>	13	<i>Total hours</i>	15	
S	MCDB 2150/2151	4	MCDB 3145	3	CHEM 4731	3	MCDB Elective	3	
P	CHEM 1133 & 1134	5	CHEM 3371/3381*	6	CHEM 4761	4	MCDB Elective	3	
R	MATH 1300	5	MATH 2400	4	PHYS 1120/1140	5	CHEM 4431	3	
N	A&S-CORE	3	A&S-CORE	3	A&S-CORE (UD)	3	A&S CORE	3	
G							A&S-CORE	3	
	<i>Total hours</i>	17	<i>Total hours</i>	16	<i>Total hours</i>	15	<i>Total hours</i>	15	
	<i>Total hours</i>	32	<i>Total hours</i>	32	<i>Total hours</i>	28	<i>Total hours</i>	30	122

*Or CHEM 3311/3321 and 3331/3341

MCDB REQUIRED COURSES

_____ MCDB 1150 (3) Intro _____ (Fall Only) _____
_____ MCDB 1151 (1) Intro Lab _____ (Fall Only) _____
_____ MCDB 2150 (3) Genetics _____
_____ MCDB 2151 (1) Genetics Lab _____
_____ MCDB 3135 (3) Molecular Cell Biology I _____ (Fall Only) _____
_____ MCDB 3140 (2) Cell Biology Lab _____
_____ MCDB 3145 (3) Molecular Cell Biology II _____ (Spring Only) _____
_____ MCDB Capstone Course: MCDB 4300, 4650 or 4777 (Spring 2011) _____

MCDB Upper Division Elective Courses: A minimum of 11 credit hours

2 courses (6 hours) must be lecture courses.

6 hours of MCDB 4840, 4980 or 4990 may be counted towards the major

5-6 hours of the 11 elective hours may be approved out of department courses

_____ MCDB _____
_____ MCDB 4 _____ must be a scientific reasoning course – refer to degree audit for approved courses

ANCILLARY REQUIRED COURSES

_____ CHEM 1113 (4) & 1114 (1) [CHEM 1111] Gen. Chemistry I & lab _____
_____ CHEM 1133 (4) & 1134 (1) [CHEM 1131] Gen. Chemistry II & lab _____
_____ CHEM 3311 (4) Organic Chemistry I _____
_____ CHEM 3321 (1) Organic Chemistry I lab _____
_____ CHEM 4611 or 4711 (3) Biochemistry I _____
_____ MATH 1300, 1310, APPM 1350, MATH 2510, PSYC 3101 OR IPHY 2800 _____
_____ PHYS 2010 (5) [Alg.-based] or 1110 (4) [Calc.-based] Physics I _____
_____ PHYS 2020 (5) [Alb.-based] or 1120 & 1140 (1) [Calc.-based] Physics II _____

A & S CORE REQUIREMENTS NOT COVERED BY THE MAJOR

_____ MAPS (other than Foreign Language) _____
_____ Foreign Language _____
_____ Quantitative Reasoning _____
_____ Written Communication – Lower Division _____
_____ Written Communication – Upper Division _____
_____ Historical Context _____
_____ Human Diversity _____
_____ United States Context _____
_____ Literature and Arts _____
_____ Literature and Arts – Upper Division _____
_____ Contemporary Societies _____
_____ Ideals and Values _____