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# Undergraduate Handbook Molecular & Cell Biology

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## MOLECULAR & CELL BIOLOGY

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UC Berkeley MCB

**MCB Student Clubs**

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## Welcome to Molecular & Cell Biology (MCB) at UC Berkeley

The MCB major emphases are regarded as some of the more challenging undergraduate programs on the Berkeley campus. Each emphasis will provide an excellent foundation for research and/or teaching in the life sciences, employment at the bachelor's level in the biotechnology industry as well as for further study leading to professional work in any aspect of the health or environmental studies.

All MCB students, regardless of emphasis, receive a Bachelor of Arts degree in Molecular and Cell Biology upon graduation. The first two years of coursework are similar for all MCB majors. Juniors and seniors are then expected to take the courses specified for their particular emphasis. It is critical that students contact a staff advisor or faculty advisor early in the decision-making process. These advisors are here to help, are your advocates, and can provide essential information and guidance.

Students who successfully complete this major will be able to:

- describe basic biological concepts and principles,
- appreciate the different levels of biological organization, from molecules to ecosystems,
- understand that Biology has a chemical, physical, and mathematical basis,
- explain the importance of the scientific method to understanding natural phenomena,
- effectively communicate scientific data and ideas, both orally and in writing,
- critically evaluate data, develop a hypothesis, and design experiments to address an interesting and novel problem, and
- demonstrate advanced knowledge in a specialized field of molecular and cell biology.

The MCB teaching program provides excellent preparation for careers in basic biological and biomedical research and the health care professions. New careers ranging from biotechnology to patent law or scientific journalism have been launched with an undergraduate degree from Cal's MCB Department.

### BIOCHEMISTRY & MOLECULAR BIOLOGY (BMB)

The study of Biochemistry and Molecular Biology is one of the most rapidly advancing and exciting areas in biology today. One of the unique characteristics of BMB is the natural and complementary fusion of incredibly powerful molecular biological methodologies such as cloning, gene splicing and gene expression with biophysical and biochemical strategies for dissecting structure and function of macromolecules. A major emphasis which distinguishes BMB is the rigorous and reductionist approach to defining living systems in biochemical terms. Recently, our ability to take apart complex biological processes and machinery such as those governing DNA replication, transcription, transposition, recombination, protein synthesis, and RNA processing, have greatly advanced our understanding of the living cell. Moreover, the molecular visualization capabilities of X-ray crystallography, 2-D NMR, cryo-electron microscopy and other structural biology techniques have opened new horizons and greatly extended our mechanistic understanding of important biological molecules. The combined approaches of molecular biology and biochemistry have consequently played a major role in unraveling many complex biological processes such as development, differentiation, mutagenesis, gene regulation, pathogenesis, oncogenesis, and aging. Perhaps the most exciting and invigorating aspect of these studies is that they can be done by individual students armed with keen interest and curiosity.

The major program has two tracks. Track 1, Biochemistry & Molecular Biology, comprises 6 upper-division courses. Track 2, Biological Chemistry, comprises 7 upper-division courses.

### CELL & DEVELOPMENTAL BIOLOGY (CDB) EMPHASIS

Cell biology and developmental biology are two closely related disciplines at the very heart of the biological sciences. Cell biology focuses on understanding the mechanisms by which the basic functions of homeostasis, gene regulation, ion transport, growth and division, secretion, signaling and locomotion are achieved at the molecular and cellular levels. Thus, cell biology links the more reductionist fields of biochemistry, genetics, molecular biology and structural biology to the study of organ systems and whole organisms in the fields of developmental biology, immunology, neurobiology and physiology.

Because cell biologists seek to understand how cells function both under normal conditions and in disease states such as cancer, cystic fibrosis, diabetes and muscular dystrophy, the CDB emphasis constitutes a "middle road" for those planning medical careers. In addition to the standard techniques of biochemistry and molecular biology, cell biologists employ a powerful array of optical and physiological techniques to measure and manipulate the location and concentration of ions and molecules within living cells and subcellular organelles, and even the forces exerted by cells on their surroundings.

Developmental biologists seek to provide an explanation for how mature organisms arise from a single cell, i.e. the fertilized egg. To succeed in this will ultimately require understanding how all the basic cell biological processes are orchestrated, with stunning intricacy and precision, by dynamic arrays of cells in the developing embryo. Another central issue in biology is that of how developmental processes in ancient life forms were modified during evolution to give rise to the diversity of modern plants and animals. To approach this question, it is necessary to compare developmental processes in different organisms. In this department, developmental studies are carried out on annelids, arthropods, chordates, echinoderms, nematodes, and yeast.

The major program has 2 tracks. Track 1, is CDB: Cell & Systems Biology and Track 2 is CDB: Medical Biology & Physiology.

### GENETICS, GENOMICS, & DEVELOPMENT (GG&D) EMPHASIS

The Division of Genetics, Genomics and Development represents the biological disciplines most transformed by the genome sequences of an ever-increasing spectrum of life. The research and courses of this Division stress the mechanisms these genomes use to program the orderly development of diverse organisms including humans, classical model organisms (bacteria, yeast, worms, flies, fish, frogs) and other species representing pivotal nodes in evolution. In addition, GG&D explores how sequence variation leads to phenotypic differences among individuals, and how these differences are inherited and fixed by natural selection. Emerging foci of the division concern how changes in the sequences that control animal development have contributed to the diversification of animal form and function, and dissecting how cells with the same genome can stably and heritably express different portions of their genomes.

Recent research advances in the Division include revealing the mechanism of sex determination in *Drosophila* and *C. elegans*, identifying and dissecting regulatory sequences that govern gene activation, providing insight into vertebrate germ layer specification and segmentation, working out the molecular basis of pattern formation in invertebrates and chordates, deciphering the mechanism of heterochromatin formation, understanding the regulation of transposon activity, describing the control of cell migrations in development, and discovering a new mode of gene regulation using alternative splicing and mRNA degradation. Many advanced genetic and genomic methods have been developed and widely adopted within the Division. These experimental methods place even the most complex problems within reach of the functional analysis that puts genetic studies at the forefront of modern biology.

The students and faculty of this Division will play critical roles in addressing the central problems that biology faces in this century, such as interpreting the variation in human and other genomes, learning the circuitry by which organisms develop, defining how specialized chromatin structures template their own replication, genetically manipulating organisms for scientific, health, and practical interests, and developing an active interface between computation and experimentation to exploit the enormous size and complexity of datasets characteristic of modern biology. Join us in unraveling some of modern biology's most exciting problems!

This major program has two tracks. Track 1 is Genetics, Genomics & Development and Track 2 is Developmental Genetics.

### **IMMUNOLOGY & PATHOGENESIS (IMMP) EMPHASIS**

Humans inhabit an environment teeming with microbes and their toxins. The omnipresent threat of infection and the emergence of new infectious diseases have catapulted immunology to the forefront of modern biomedical science. Immunology is the study of the cellular and biochemical mechanisms, which protect us from these threats. Infectious agents such as human immunodeficiency virus, which causes AIDS, and immune-based diseases such as asthma have increased the public awareness about the importance of immunology in examining the causes and treatments of these diseases. Immunology is unique amongst the natural sciences in that it covers and integrates aspects of modern biological science including cell and developmental biology, biochemistry, genetics, and molecular biology.

Using approaches from many disciplines and techniques as diverse as recombinant DNA, flow cytometry, physical chemistry, mouse transgenesis, and targeted mutation in mice, immunologists have made major advances and striking discoveries leading to an ever-growing understanding of the immune system. We continue to explore questions such as how the immune system distinguishes self from non-self, how antibodies, T cells and natural killer cells specifically recognize and distinguish millions of different foreign invaders, why some individuals are more susceptible to the development of autoimmune diseases, and how the immune system rejects transplanted organs but often fails to reject tumors. In addition, immunologists study questions of broader biological significance including how gene expression is regulated during animal development, the biochemistry and regulation of gene rearrangement, the mechanism and function of immune surveillance, and the control of programmed cell death.

These recent advances in basic knowledge have in turn led to potential treatments for autoimmune diseases and cancers, new approaches to the design of effective vaccines, strategies to combat AIDS, and treatments to prevent tissue transplant rejection. Students with an emphasis in Immunology will be exposed not only to the unique aspects of the immune system but also to a broad array of disciplines across the full spectrum of modern biomedical sciences.

The major program has two tracks. Track 1, the traditional Immunology & Pathogenesis major, includes coursework in biophysical chemistry, a biochemistry course and an elective. Track 2, Infectious Diseases, includes an elective in cell biology, an elective course dealing with infectious disease and a survey of biochemistry course.

This major has two tracks. Track 1 is Immunology & Pathogenesis and Track 2 is Infectious Diseases.

### **NEUROBIOLOGY EMPHASIS**

Neurobiology is the study of the brain and nervous system, which are the cells and tissue that generate sensation, perception, movement, learning, emotion, and many of the functions that make us human. In the past decades, neurobiological research has made tremendous advances in understanding how this complex organ works, and what goes wrong in neurological disease. Neurobiology is intrinsically multi-disciplinary, spanning from molecular biology and gene regulation in neurons, to chemical and electrical signaling in neurons, to information processing by neural circuits and brain regions, to nervous system development and plasticity. Knowledge at each of these levels is merged to generate a mechanistic, molecular-to-systems level understanding of animal and human behavior. Active research areas in neurobiology include: What is the genetic program that makes a neuron? Can new neurons be created to treat disease? How do ion channels work that mediate electrical signaling in neurons? How do synapses work, and how do they store information during learning? How do networks of neurons process information and perform computations for behavior? How does the brain develop, and how is it specialized through evolution to generate species-specific behavior? Why do neurons die in neurodegenerative disease, and how can they be saved?

Recent research advances within the Division include understanding how voltage-gated ion channels function, development of new optical approaches to monitor and control activity in specific neurons, how taste sensation works in *Drosophila*, how neural activity is homeostatically controlled via novel gene regulation pathways, how the retina and cerebral cortex processes sensory information, and how sensory use alters synapses to store sensory information in the brain. Overall, 50 faculty at Berkeley (in MCB and other departments) conduct neurobiology research, reflecting the diversity and importance of this field within modern biology.

The Neurobiology emphasis prepares students for careers in medicine, including in medical specialties involving the nervous system (neurology, pharmacology, psychiatry, neuropsychiatry, ophthalmology, otolaryngology, optometry), in scientific research in neurobiology (postgraduate study), in biotechnology (including technical and research oriented careers), and in other biology-related careers (nursing, pharmacy, physical therapy). All Neurobiology majors receive essential coursework in molecular and cell biology, as well as rigorous training in specific neurobiology courses. We are distinguished from other MCB emphases by the multi-level, multi-disciplinary approach, and by the focus on the brain. We are distinguished from Psychology and Cognitive Science by emphasizing a mechanistic, molecular, cellular and circuit-level understanding of behavior and disease.

## Advising and Student Services

MCB has three levels of undergraduate advising: peer advising, staff advising, and faculty advising.

### PEER ADVISORS

The Peer Advising Program provides an excellent service to MCB students and the department. Our MCB peer advisors

- advise undeclared students,
- help with choosing an emphasis,
- share firsthand knowledge of course demands,
- make suggestions on finding and getting into a lab,
- provide general information about applying to medical, pre-health professional and graduate schools, and
- are a great resource for information about many other student experiences.

Availability (fall and spring only): Monday through Thursday, 10 am - 12 noon, 1 pm - 4 pm, and Friday, 10 am – 12 noon and 1 pm - 3 pm, in 3060 Valley Life Sciences Building.

### UNDERGRADUATE AFFAIRS OFFICE & STAFF ADVISORS

Staff advisors are trained to support students and assist them in successfully completing their MCB major. They are excellent resources for questions concerning administration and academics, or finding out about other available services. Students should see a staff advisor to

- ask questions about major requirements,
- ask advice about schedule planning,
- begin the process of declaring the MCB major,
- consult about research opportunities, graduate & professional schools, career opportunities, scholarships and internships,
- get their Advisor Code (AC) to access Tele-BEARS registration,
- get information and course control numbers for independent research,
- request general assistance, advice or information, and
- find out about upcoming events and programs.

Availability: Monday through Thursday, 9 am - 12 noon, 1 pm - 4 pm, and Friday, 9 am – 12 noon and 1 pm - 3 pm, in 3060 Valley Life Sciences Building.

### FACULTY ADVISORS

Faculty advisors are MCB professors assigned to advise students about the MCB department, its courses, research, and other academic issues. Students are assigned a faculty advisor when they declare an MCB major. Students should see their faculty advisors to

- receive guidance toward achieving academic and career goals,
- ask questions about the content of MCB courses,
- request exceptions to MCB major requirements and policies (obtain signatures for the MCB Substitution Form),
- ask questions about biological research and about the field of biology in general,
- ask for recommendations on which graduate schools to attend, and
- continue the declaration of the major process begun in the UAO.

Availability: Varies by semester and faculty member. Look on the MCB website for current office hours and office locations.

### STUDENT CLUBS

Getting actively involved in your educational interests is important to your academic success. There are two departmentally funded student organizations to consider: mcbUSA (Undergraduate Student Association) and MCBcDNA (Cell & Developmental Biology/Neurobiology Association). Both groups work independently and with the UAO to publish newsletters, plan interesting tours, workshops & events, and assist the department in undergraduate programs workshops. Whether you want to be on the executive committee, volunteer, or just participate in one of their events, MCBcDNA and mcbUSA are glad to have you.

For more information, visit their websites:

MCBcDNA: <http://mcb.berkeley.edu/groups/mcbcdna/>

mcbUSA: <http://mcbusa.berkeley.edu>

## Major Course Requirements

### LOWER-DIVISION COURSES

| Subject                                       | Course   |
|---|--|
| Calculus <sup>1</sup>                         | Mathematics 10A (4 units)<br>Mathematics 10B (4 units)       |
| General Chemistry <sup>2</sup>                | Chemistry 1A (3 units)<br>Chemistry 1AL (1 unit)             |
| Organic Chemistry <sup>3</sup>                | Chemistry 3A/3AL (3/2 units)<br>Chemistry 3B/3BL (3/2 units) |
| General Biology                               | Biology 1A/1AL (3/2 units)<br>Biology 1B (4 units)           |
| General Physics (calculus based) <sup>4</sup> | Physics 8A (4 units)<br>Physics 8B (4 units)                 |

<sup>1</sup>The mathematics requirement for MCB is Math 10A/10B. Any exception to this requirement must be approved by an undergraduate advisor in the UAO.

<sup>2</sup>Chem 1B is also required for BMB, track 2, Biological Chemistry. Chem 4A can substitute for Chem 1A. Chem 4B can substitute for Chem 1B.

<sup>3</sup>For BMB, Track 2, you must take Chem 112A, 112B instead of Chem 3A/AL & Chem 3B/BL.

<sup>4</sup>Physics 7A, 7B can substitute for Physics 8A, 8B.

**Note:** All lower-division course requirements must be taken for a letter grade

### AP CREDIT INFORMATION

Technically, AP scores can waive you from some of the MCB lower-division requirements (see chart below), but we strongly advise you to take your lower-division major courses here at Cal. This gives you a solid background in science and math before you begin your upper-division course work. In particular, we recommend taking Biology 1A/AL regardless of AP credit. (Note: Biology 1A/AL has prerequisites of Chem 1A/1AL and 3A and therefore cannot be taken during your freshman year.) The classes at Cal have in-depth labs that correspond with the lecture portion of a particular subject. Several health professional and graduate schools require that you take college-level courses, (e.g., two semesters of general biology course with a lab); they will not accept AP credit.

AP scores in the following subjects allows waivers of the following lower-division requirements.

| Exam         | Exam score | Will waive                  |
|--------------|------------|-----------------------------|
| AP Chemistry | 4 or 5     | Chemistry 1A /1AL only      |
| AP Biology   | 4 or 5     | Biology 1A/1AL & Biology 1B |
| IB Chemistry | 5, 6, or 7 | Chemistry 1A/1AL            |
| IB Biology   | 5, 6, or 7 | Biology 1B only             |

Note that AP waivers are not allowed for either of the physics requirements.

\*\*Effective for fall 2012 freshman admits: AP waivers are not allowed for the math requirement.

### TRANSFER STUDENTS

The MCB Department accepts transferable courses from many other colleges and universities. Students who are transferring from a California Community College can check course articulation on the Articulation System Stimulating Inter-institutional Student Transfer website (ASSIST): <http://www.assist.org/>

Students who are transferring from out of state or from a 4-year or private institution must submit their transcripts and complete course descriptions to the MCB Undergraduate Advising Office prior to their first term at UC Berkeley.

Students hoping to transfer into Berkeley with the intention of declaring MCB must complete all lower-division requirements, with the exception of physics, before transfer. Complete the equivalent of:

- Math 10A & 10B or Math 1A & 1B= 1 year of calculus
- Chem 1A/1AL = 1 semester of general chemistry
- Chem 3A/3AL, 3B/3BL = 1 year of organic chemistry
- Biology 1A/1AL, Biology 1B = 1 year of general biology



We recommend that you complete physics as well, although it is not required for admission. Complete the equivalent of:

- Physics 8A & 8B = 1 year of calculus-based physics, or equivalent of, **OR**
- Physics 7A, 7B = 1 year of calculus-based physics for scientists and engineers

\*\*\*For students that complete one or both Physics courses from a non-Assist.org institution, the Physics department will make the articulation determination. Students may also access the Transfer Evaluation Systems [http://admissions.berkeley.edu/transfer\\_info](http://admissions.berkeley.edu/transfer_info) to see if their non-Assist.org course has been entered into the system already as an articulated class.

### **130-UNIT MAXIMUM AFTER FOUR SEMESTERS**

As a transfer student at Cal, you are given four semesters with unlimited units. After your fourth semester, you may not register for a regular fall or spring term after exceeding 130 total units. This means that it is very important to complete your lower-division requirements before you begin coursework at Cal. Not only does this ensure that you will be able to graduate on time, but it also allows you to take advantage of the rich array of courses offered at Cal, both in MCB and other departments. Our recommendation would be to postpone your application process until you will have completed, or be enrolled in, all lower-division requirements by the time you are admitted to Cal.

If you have been admitted to Berkeley and have not completed the equivalent of all lower-division courses with the exception of the physics requirement, please contact an advisor in the UAO as soon as possible.

Transfer students can declare MCB as their major after one full term at Berkeley with an overall 2.0 GPA, and a 2.0 GPA in major requirements. All courses intended for the major must be taken for a letter grade.

## UPPER-DIVISION COURSES

### Biochemistry & Molecular Biology Emphasis (2 Tracks)

| <b>Track 1: Biochemistry &amp; Molecular Biology</b>           | <b>Track 2: Biological Chemistry</b>  |
|--|---|
| MCB C100A – Biophysical Chemistry                              | MCB C100A – Biophysical Chemistry   |
| MCB 100B – Biochemistry: Pathways, Mechanisms, and Regulations | Chem 130B – Biophysical Chemistry   |
| MCB 110 – General Biochemistry and Molecular Biology           | Chem 135 – Chemical Biology   |
| MCB 140 – General Genetics or<br>MCB C148 – Microbial Genetics | MCB 130A – Cell & Systems Biology or<br>MCB 140 – General Genetics                    |
| MCB C110L – Biochemistry Laboratory                            | MCB C110L – Biochemistry Laboratory   |
| BMB Elective   | NOTE: All Biological Chemistry Majors must take Chem 112A/112B instead of Chem 3A/3B. |

Note: All upper-division requirements must be taken for a letter grade.

#### **Approved Electives List for BMB, Track 1**

##### **BMB Electives**

##### **Molecular and Cell Biology**

|      |  |
|------|--|
| C103 | Bacterial Pathogenesis (Sp; 3 units)                       |
| C112 | General Microbiology (F; 4 units)                          |
| C114 | Introduction to Comparative Virology (Sp; 4 units)         |
| C116 | Microbial Diversity (Sp; 3 units)                          |
| 130A | Cell & Systems Biology (Sp; 4 units)                       |
| 132  | Biology of Human Cancer (F; 4 units)                       |
| C134 | Chromosome Biology / Cytogenetics (Sp, alt years; 3 units) |
| 135A | Molecular Endocrinology (F, alt. years, 3 units)           |
| 136  | Physiology (F; 4 units)                                    |
| 137  | Computer Simulation in Biology (Sp; 3 units)               |
| 141  | Developmental Biology (Sp; 3 units)                        |
| 143  | Evolution of Genomes, Cells and Development (F; 3 units)   |
| C148 | Microbial Genomics & Genetics (Sp; 4 units)                |
| 150  | Molecular Immunology (F, Sp; 4 units)                      |
| 160  | Molecular and Cellular Neurobiology (Fa, 4 units)          |
| C160 | Introduction to Neurobiology (4 units)                     |
| 163  | Mammalian Neuroanatomy (F; 4 units)                        |
| 165  | Neurobiology of Disease (Sp; 3 units)                      |
| 166  | Biophysical Neurobiology (F; 3 units)                      |
| 167  | Physiological & Genetic Basis of Behavior (Sp; 3 units)    |

Or courses from the following departments:

##### Bioengineering

|      |                               |
|------|-------------------------------|
| C141 | Statistics for Bioinformatics |
|------|-------------------------------|

##### Chemistry

|      |  |
|------|--|
| 113  | Advanced Organic Chemistry (F; 3 units)                |
| 115  | Organic Chemistry - Advanced Lab Methods (Sp; 4 units) |
| 130B | Biophysical Chemistry (Sp; 3 units; track 1 only)      |

##### Environmental Science, Policy & Management

|      |  |
|------|--|
| C148 | Pesticide Chemistry and Toxicology (Sp; 3 units) |
|------|--|

- Mathematics
- 110 Linear Algebra (F, Sp, Su; 4 units)
- 127 Mathematical & Computational Methods in Molecular Biology (4 units)
- Nutritional Sciences & Toxicology
- C114 Pesticide Chemistry and Toxicology (Sp; 3 units)
- Physics
- 112 Intro to Statistical and Thermal Physics (F, Sp; 4 units)
- 132 Contemporary Physics (Sp; 3 units)
- 177 Principles of Molecular Biophysics (Sp; 3 units)
- Plant & Microbial Biology
- C112 General Microbiology (F, 4 units)
- C114 Comparative Virology (Sp, 4 units)
- C116 Microbial Diversity (F, 3 units)
- C 134 Chromosome Biology/ Cytogenetics (Sp, 3 units)
- 135 Physiology and Biochemistry of Plants (F; 3 units)
- C148 Microbial Genomics & Genetics (Sp, 4 units)
- 150 Plant and Microbial Biology (F; 3 units)
- 160 Plant Molecular Genetics (Sp; 3 units)
- Public Health
- 141 Intro to Biostatistics (Su; 5 units)
- 142 Intro to Probability & Statistics in Biology & Public Health (F; 4 units)
- Statistics
- 131A Statistical Inferences for Social and Life Scientists (F, Sp; 4 units)
- C141 Statistics for Bioinformatics [*see prereqs*]

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## Cell & Developmental Biology Emphasis (2 Tracks)

| Track 1: Cell & Systems Biology                             | Track 2: Medical Biology & Physiology             |
|---|---|
| MCB 102 – Survey of Biochemistry                            | MCB 102 – Survey of Biochemistry                  |
| MCB 104 – Genetics, Genomics & Cell Biology                 | MCB 104 – Genetics, Genomics & Cell Biology       |
| MCB 130A – Cell and Systems Biology (taught only in spring) | MCB 136 – Physiology                              |
| MCB 133L – Cell Biology and Physiology Laboratory           | MCB 133L – Cell Biology and Physiology Laboratory |
| CDB Elective List A (2 courses)                             | CDB Elective List B (2 courses)                   |

**Note:** All upper-division requirements must be taken for a letter grade.

### **Approved Electives List for CDB: Cell & Systems Biology**

#### **Elective A List**

#### **Molecular and Cell Biology**

- C100A Biophysical Chemistry: Physical Principles & the Molecules of Life (F, Sp; 4 units)
- C103 Bacterial Pathogenesis (Sp; 3 units)
- C112 General Microbiology (F; 4 units)
- C114 Introduction to Comparative Virology (F; 4 units)
- C116 Microbial Diversity (Sp; 3 units)
- 132 Biology of Human Cancer (F; 4 units)
- C134 Chromosome Biology / Cytogenetics (Sp, alt years; 3 units)
- 135A Molecular Endocrinology (F, alt. years, 3 units)
- 136 Physiology (F; 4 units)
- 137 Computer Simulation in Biology (Sp; 3 units)

|      |  |
|------|--|
| 141  | Developmental Biology (Sp; 3 units)                      |
| 143  | Evolution of Genomes, Cells and Development (F; 3 units) |
| C148 | Microbial Genomics & Genetics (Sp; 4 units)              |
| 150  | Molecular Immunology (F, Sp; 4 units)                    |
| C160 | Introduction to Neurobiology (4 units)                   |
| 163  | Mammalian Neuroanatomy (F; 4 units)                      |
| 165  | Neurobiology of Disease (Sp; 3 units)                    |
| 166  | Biophysical Neurobiology (F; 3 units)                    |
| 167  | Physiological & Genetic Basis of Behavior (Sp; 3 units)  |

### **Approved Electives List for CDB: Medical Biology & Physiology**

#### **Molecular and Cell Biology**

**Any course from *Elective A List* above**

Or courses from the following departments:

#### Integrative Biology

|           |  |
|-----------|--|
| 103LF     | Invertebrate Zoology                                       |
| 104LF     | Natural History of the Vertebrates (Sp; 5 units)           |
| 117/117LF | Medical Ethnobotany & Lab (F, Su; 2 & 2 units)*            |
| 123AL     | Exercise Physiology & Lab (F; 5 units)                     |
| 131       | General Human Anatomy (F, Su; 3 units)                     |
| 137       | General Endocrinology (F; 4 units)                         |
| 140       | Biology & Sociobiology of Human Reproduction (Sp; 4 units) |
| C143A     | Biological Clocks: Physiology & Behavior (3 units)         |
| C143B     | Hormones & Behavior (Sp; 3 units)                          |
| 148       | Comparative Animal Physiology (F; 3 units)                 |

\*both lecture AND lab courses must be taken for IB 117/117L and IB 123A/123AL to satisfy one elective requirement\*

#### Nutritional Sciences & Toxicology

|      |   |
|------|---|
| 103  | Nutrient Function & Metabolism (F; 3 units)                                   |
| 108A | Intro & Application of Food Science (F; 3 units)                              |
| 110  | Toxicology (F; 3 units)   |
| 150  | Mechanisms of Metabolic Regulation (F; 3 units)                               |
| 160  | Human Nutrition: Normal Physiology & Pathophysiology of Disease (Sp; 4 units) |
| 161A | Medical Nutrition Therapy (F; 4 units)  |

#### Plant & Microbial Biology

|     |  |
|-----|--|
| 135 | Plant Physiology & Biochemistry (F; 3 units) |
| 150 | Plant and Microbial Biology (F; 3 units)     |
| 160 | Plant Molecular Genetics (Sp; 3 units)       |

#### Psychology

|      |   |
|------|---|
| 110  | Intro to Biological Psychology (F, Sp, Su; 3 units)       |
| C113 | Biological Clocks: Physiology & Behavior (F, Sp; 3 units) |
| C116 | Hormones & Behavior (Sp; 3 units)                         |

#### Public Health

|      |   |
|------|---|
| 141  | Intro to Biostatistics (Su; 5 units)                                  |
| 142  | Intro to Probability & Statistics in Bio & Public Health (F; 4 units) |
| 150A | Intro to Epidemiology and Human Disease (Sp; 3 units)                 |
| 150B | Intro to Environmental Health Sciences (F; 3 units)                   |
| 162A | Public Health Microbiology (F, Su; 3 units)                           |

#### Statistics

|      |  |
|------|--|
| 131A | Statistical Inference for Life Scientists (F, Sp; 4 units) |
|------|--|

## Genetics, Genomics & Development Emphasis (2 Tracks)

| <b>TRACK 1: Genetics, Genomics &amp; Development</b> | <b>TRACK 2: Developmental Genetics</b>      |
|--|---|
| MCB C100A – Biophysical Chemistry                    | MCB 102 – Survey of Biochemistry            |
| MCB 110 – General Biochemistry and Molecular Biology | MCB 104 – Genetics, Genomics & Cell Biology |
| MCB 140 – General Genetics                           | MCB 141 – Developmental Biology             |
| MCB 140L – Genetics Laboratory                       | MCB 140L – Genetics Laboratory              |
| GG&D Elective A or B                                 | GG&D Elective A or B                        |
| GG&D Elective B                                      | GG&D Elective B                             |

Note: All upper-division requirements must be taken for a letter grade.

### Approved Electives List for GG&D

#### Elective A List

#### Molecular and Cell Biology

|      |   |
|------|---|
| 100B | Biochemistry: Pathways, Mechanisms, and Regulation (F, Sp; 3 units) |
| C103 | Bacterial Pathogenesis (Sp; 3 units)                                |
| C112 | General Microbiology (F; 4 units)                                   |
| C114 | Comparative Virology (Sp; 4 units)                                  |
| C116 | Microbial Diversity (F; 3 units)                                    |
| 130A | Cell & Systems Biology (Sp; 4 units)                                |
| 135A | Molecular Endocrinology (F; 3 units)                                |
| 136  | Physiology (F; 4 units)   |
| 150  | Molecular Immunology (F, Sp; 4 units)                               |
| 160  | Molecular and Cellular Neurobiology (Fa, 4 units)                   |
| C160 | Intro to Neurobiology (4 units)                                     |
| 165  | Neurobiology of Disease (Sp; 3 units)                               |
| 166  | Biophysical Neurobiology (F; 3 units)                               |

#### Chemistry

|      |  |
|------|--|
| 113  | Advanced Mechanistic Organic Chemistry (Sp; 3 units)   |
| 115  | Organic Chemistry - Advanced Lab Methods (Sp; 4 units) |
| 130B | Biophysical Chemistry (Sp; 3 units)                    |

#### Environmental Science, Policy & Management

|      |  |
|------|--|
| C148 | Pesticide Chemistry & Toxicology (Sp; 3 units) |
| 162  | Bioethics & Society (Sp; 4 units)              |

#### Integrative Biology

|     |                        |
|-----|------------------------|
| 160 | Evolution (F; 4 units) |
|-----|------------------------|

#### Mathematics

|     |                                     |
|-----|-------------------------------------|
| 110 | Linear Algebra (F, Sp, Su; 4 units) |
|-----|-------------------------------------|

#### Physics

|     |   |
|-----|---|
| 112 | Introduction to Statistical and Thermal Physics (4 units) |
| 132 | Contemporary Physics (3 units)                            |

#### Plant and Microbial Biology

|     |   |
|-----|---|
| 135 | Physiology and Biochemistry of Plants (F; 3 units)    |
| 150 | Cellular and Developmental Plant Biology (F; 3 units) |

**Elective B List****Molecular and Cell Biology**

- 132 Biology of Human Cancer (F; 4 units)
- C134 Chromosome Biology/Cytogenetics (Sp; 3 units)
- 137 Computer Simulation in Biology
- 141 Developmental Biology (Sp; 3 units) (for track 1 students only)
- 143 Evolution of Genomes, Cells and Development (F; 3 units)
- C148 Microbial Genomics & Genetics (Sp; 3 units)
- 149 The Human Genome (Sp, 3 units)
- 167 Physiological & Genetic Basis of Behavior (Sp; 4 units)

## Bioengineering

- 131 Intro to Computational Molecular and Cell Biology (F; 4 units)
- C141 Statistics for Bioinformatics (4 units)
- 142 Programming & Algorithm Design for Computational Biology & Genomics Applications (4 units)
- 143 Computational Methods in Biology (F, Sp; 4 units)
- 144 Introduction to Protein Informatics (F; 4 units)

## Environmental Science and Policy Management

- 108B Forest Genetics (F; 3 units)

## Integrative Biology

- 161 Population & Evolutionary Genetics (Sp; 4 units)
- 162 Ecological Genetics (F; 4 units)
- 163 Molecular & Genomic Evolution (3 units)
- 165 Introduction to Quantitative Genetics (4 units)

## Mathematics

- \*127 Mathematical & Computational Methods in Molecular Bio (F, Sp; 4 units)

## Plant &amp; Microbial Biology

- C134 Chromosome Biology/Cytogenetics (Sp; 3 units)
- 160 Plant Molecular Genetics (Sp; 3 units)

## Public Health

- 142 Intro to Probability and Statistics in Bio and Public Health (F; 4 units)
- \*143 Intro to Statistical Methods in Computational & Genomic Bio (Sp; 4 units)
- 256 Molecular and Genetic Epidemiology and Human Health in the 21<sup>st</sup> Century (F; 4units)

## Statistics

- 131A Statistical Inferences for Social and Life Scientists (F, Sp; 4 units)
- 134 Concepts of Probability (F, Sp; 3 units)
- \*C141 Statistics for Bioinformatics [see prereqs] (4 units)

**\*GG&D electives with an asterisk showing before the course number have pre-requisites outside of courses usually required of MCB majors. Please be sure to check these online.**

## Immunology & Pathogenesis Emphasis (2 Tracks)

| <b>TRACK 1: Immunology &amp; Pathogenesis</b>   | <b>TRACK 2: Infectious Diseases</b>         |
|---|---|
| MCB C100A – Biophysical Chemistry   | MCB 102 – Survey of Biochemistry            |
| MCB 110 – General Biochemistry and Molecular Biology                                    | MCB 104 – Genetics, Genomics & Cell Biology |
| *MCB 104 - Genetics, Genomics & Cell Biology or MCB 140 – General Genetics              | MCB 150 – Immunology                        |
| MCB 150 – Immunology  | MCB 150L – Immunology Laboratory            |
| MCB 150L – Immunology Laboratory  | IMMP Elective from List A                   |
| IMMP Elective List C  | IMMP Elective from List B                   |
| *Students who choose to take MCB 104 instead of MCB 140 will receive 3 units of credit. |   |

Note: All upper-division requirements must be taken for a letter grade.

### **Approved Electives List for Immunology & Pathogenesis, Track 1**

#### **Elective C List**

##### **Molecular & Cell Biology**

- 100B Biochemistry: Pathways, Mechanisms, and Regulation (Sp; 3 units)
- C103 Bacterial Pathogenesis (Sp; 3 units)
- C112 General Microbiology (F; 4 units)
- C114 Intro to Comparative Virology (Sp; 4 units)
- 130A Cell & Systems Biology (Sp; 4 units)
- 132 Biology of Human Cancer (F; 4 units)
- C134 Chromosome Biology/Cytogenetics (Alt. Sp; 3 units)
- 135A Molecular Endocrinology (F, 3 units)
- C141 Developmental Biology (Sp; 3 units)
- 250 Advanced Immunology (Sp; 4 units)

##### **Bioengineering**

- 131 Intro to Computational Molecular and Cell Biology (F, Sp; 4 units)

### **Approved Electives List for Infectious Diseases, Track 2**

#### **Elective A List (Infectious Disease electives)**

##### **Molecular & Cell Biology**

- C103 Bacterial Pathogenesis (Sp; 3 units)
- C112 General Microbiology (F; 4 units)
- C114 Intro to Comparative Virology (Sp; 4 units)

#### **Elective B List**

##### **Molecular & Cell Biology**

- 130A Cell & Systems Biology (Sp; 4 units)
- 132 Biology of Cancer (F; 4 units)
- C134 Chromosome Biology/Cytogenetics (Sp; 3 units)
- 135A Molecular Endocrinology (Alt. F, 3 units)
- 136 Physiology (F; 4 units)
- 141 Developmental Biology (Sp; 4 units)
- 143 Evolution of Genomes, Cells and Development (F; 3 units)
- 160 Molecular and Cellular Neurobiology (F; 4 units)
- C160 Intro to Neurobiology (4 units)
- 250 Advanced Immunology (Sp; 4 units)

## Neurobiology Emphasis

| <b>Neurobiology</b>                                     |
|---|
| MCB 102 – Survey of Biochemistry                        |
| MCB 104 – Genetics, Genomics & Cell Biology             |
| MCB 160 – Cellular and Molecular Neurobiology*          |
| MCB 161 – Circuit, Systems and Behavioral Neuroscience* |
| Neurobiology Lab, either MCB 160L or MCB 163            |
| NEURO Elective  |

\*MCB 160 (fall only) and MCB 161 (spring only) are intended to be taken in sequence. The prerequisite for MCB 161 is MCB 160 and this is enforced.

\*\*\*The new curriculum is effective for students declaring this emphasis in Spring 15 and beyond, and for declared NEU students who do not complete MCB C160 by Spring 15.

Note: All upper-division requirements must be taken for a letter grade.

### **Approved Electives List for Neurobiology**

#### **Bioengineering**

- 121 Introduction to Micro and Nanobiotechnology: BioMEMS (F, Sp; 3 units)
- 143 Computational Methods in Biology (4 units)

#### **Cognitive Science**

- C127 Cognitive Neuroscience (F; 3 units)

#### **Integrative Biology**

- 139 The Biology of Stress (3 units)
- C143A Biological Clocks: Physiology & Behavior (3 units)
- C143B Hormones & Behavior (Sp; 3 units)
- C144 Animal Behavior (F; 4 units)

#### **Mathematics**

- 110 Linear Algebra (F, Sp, Su; 4 units)

#### **Molecular & Cell Biology**

- C100A Biophysical Chemistry (F, Sp; 4 units)
- 130A Cell & Systems Biology (Sp; 4 units)
- 132 Biology of Cancer (F; 4 units)
- 135A Molecular Endocrinology (F; 3 units)
- 136 Physiology (F; 4 units)
- 137 Computer Simulation in Biology (Sp; 3 units)
- 141 Developmental Biology (Sp; 4 units)
- 150 Molecular Immunology (F, Sp; 4 units)
- 160L Neurobiology Lab (Sp; 4 units)  
[Allowed only if MCB 163 is used as lab requirement]
- 163 Mammalian Neuroanatomy (F; 4 units)  
[Allowed only if MCB 160L is used as lab requirement]
- 165 Neurobiology of Disease (Sp; 3 units)
- 166 Biophysical Neurobiology (F; 3 units)
- 167 Physiological & Genetic Basis of Behavior (3 units)

#### **Physics**

- 112 Introduction to Statistical and Thermal Physics (F, Sp; 4 units)
- 132 Contemporary Physics (3 units)

#### **Psychology**

- C113 Biological Clocks: Physiology & Behavior (3 units)



C116 Hormones & Behavior (Sp; 3 units)  
C117 Human Neuropsychology (F; 3 units)  
C127 Animal Behavior (4 units)

**Public Health**

141 Introduction to Biostatistics (Su; 5 units)  
142 Introduction to Probability and Statistics in Biology & Public Health (F, Sp; 4 units)

## Declaring the Major

### ELIGIBILITY TO DECLARE

You are eligible to declare the MCB major once you've

- completed or are currently enrolled in Biology 1A/1AL and have a C or better on the first midterm exam, and
- completed or are currently enrolled in Chemistry 3B after the early drop deadline, and
- earned a GPA of 2.0 or higher in all courses taken for the major, and
- decided on an emphasis. (If you haven't decided yet, please come in to the UAO and talk to a peer advisor for advice/planning suggestions!)

**TRANSFER STUDENTS:** You must wait until you complete one full semester at Cal and have earned a 2.0 GPA in the courses taken for the major.

### DECLARATION PROCESS

To begin the major declaration process, you must fill out the MCB declaration form on-line: <https://mcb.berkeley.edu/internal.uao/declaration>

1. No earlier than the next business day, visit the Undergraduate Affairs Office and we will
  - a. review your academic plan,
  - b. give you a Curriculum Planning Form and assign you a faculty advisor for final approval of your plan.
2. Once you have spoken with your faculty advisor and have obtained his/her signature, you must return all paperwork to the Undergraduate Affairs Office. We will make a copy for you and then declare you in the major.

**Note:** There is no existing minor program. A double major within MCB is not permitted.

Once declared, you will be required to meet with an MCB UAO advisor each semester to review your progress toward the major before you receive an advisor code (unique to each semester) in order to be able to use TeleBears. (Note: You need to enter the advisor code only once per semester - the first time you use TeleBears.) We will inform you, via email, when the advisor codes are available, but generally this is two weeks before TeleBears begins.

### MCB MAJOR PROBATION POLICY

An MCB major must maintain a 2.0 grade point average (GPA) in a) the complete set of all upper-and lower-division courses taken for the major at UC Berkeley and b) all upper-division courses taken for the major at UC Berkeley. Upper-division or graduate MCB courses that are not used to satisfy major requirements are excluded from this calculation. Students for whom either GPA calculation falls below 2.0 will either be (A) placed on departmental probation for the following semester, or (B) dismissed from the major. The decision to dismiss or place on probation will be made by the Undergraduate Affairs Committee and communicated to the student before the following semester begins. If placed on probation, the student has one semester to raise both GPAs to the required 2.0, and will be subject to dismissal if this is not achieved. If dismissed from the major, students must work with an L & S advisor in order to pursue another major. (revised 1/2010)

Questions concerning the MCB probation and dismissal policy may be directed to the staff advisors in the MCB Undergraduate Affairs Office.

## Research in the Major

UC Berkeley is a world-renowned research institution, with many opportunities for undergraduates. You are not limited to research in an MCB lab - explore your options and spend your time doing research that you find interesting and fulfilling. Start looking for a research position early! There are a number of resources available to help you determine whether or not research is for you and if so, how you'd go about setting it up.

### RESOURCES FOR FINDING RESEARCH POSITIONS

1. Talk to people who are involved in research
  - Peer advisors. Learn how they found their research positions and hear about their experiences in labs.
  - MCB Professors, Faculty Advisors.
    - Check out the MCB Faculty Research webpage, <http://mcb.berkeley.edu/faculty/all>, and determine which labs you are interested in.
    - Before contacting a professor, **review some of the latest publications** that have come out of his/her lab. (Available on the MCB Faculty Research Interest webpage and in the Biosciences Library in VL5B.) You are not expected to understand the articles completely, but if you read some articles and try to understand the professors' research, they will be more convinced of the seriousness and depth of your interest.
    - **Set up appointments to meet with the professors you have selected.** When calling or emailing professors, it is more effective to express interest in their particular field of research and what you would like to discuss with them than simply asking, "Do you have space in your lab?" Once you make an appointment, keep the appointment and be on time! Otherwise, faculty may be less willing to make other appointments with you.
    - **Bring a resume, contact information, and your most recent UC Berkeley transcript** (an unofficial copy is fine) to your appointment with a professor. Professors often find this information useful so having it on hand is a good idea.
    - During your appointment, **ask the professor if he/she would be willing to accept you into his/her lab to do an independent research project.** Professors want students who are genuinely interested in their research, not students who are primarily interested in improving their resume. Be prepared to discuss the professor's work intelligently. Since there is so much competition for MCB lab positions, it is wise to approach your search for a lab position with the same degree of professionalism with which you would approach any job search.
    - **Clearly indicate whether you are seeking a paid position or seeking work for academic credit.** In almost all cases, professors only offer unit credit during the academic year. Some professors will pay summer salaries to you if you continue into the summer after already working in the lab for the fall and spring. Discuss whether you would like to take MCB 199 or, if you are eligible, H196A/B (honor research credit – see section on Honors). Be sure to find out how many hours a week the professor expects you to work. If you're going to earn units, 3 hours/week = 1 unit, during a 15 week semester.
  - GSI's. Ask them about their research experiences (undergraduate and graduate) and find out how to get started.
2. Attend a research workshop sponsored by the Haas Scholar's Program. See <http://research.berkeley.edu/resources.php> for specific dates and times.
  - Workshop A – Getting started in undergraduate research.
  - Workshop B – Writing a research proposal.
3. Apply to Structured Research Programs, such as the Undergraduate Research Apprenticeship Program (URAP), at <http://research.berkeley.edu/urap>, or the Summer Undergraduate Research Program (SURP) sponsored through mcbUSA. Details on the latter come out each spring semester.
4. Sign up for research mailing lists.
  - Research listserv (Office of Undergraduate Research @ Berkeley), <http://research.berkeley.edu/listserve.php>
  - Health & Pre-Med Career Mail (Career Center), <http://callisto.berkeley.edu>.
5. Diversify your interests. Look in places outside of the MCB department.
  - Non-MCB departments. Anthropology, Chemistry, Environmental Science, Policy and Management, Integrative Biology, Nutritional Sciences and Toxicology, Plant and Microbial Biology, Psychology-Biopsychology Group, and Public Health, just to name a few.
  - Off campus sites. Lawrence Berkeley National Laboratories (LBNL), Children's Hospital Research Institute (CHORI), and University of California, San Francisco (UCSF) are three examples and the most popular choices.
6. Online Resources;

- Undergraduate research: <http://research.berkeley.edu>.
- Search for faculty by keywords: <http://research.chance.berkeley.edu>.
- Finding a faculty mentor: [http://research.berkeley.edu/haas\\_scholars/documents/findmentor.html](http://research.berkeley.edu/haas_scholars/documents/findmentor.html).
- Finding a research mentor in the physical sciences:  
[http://research.berkeley.edu/haas\\_scholars/documents/phycsmentor.html](http://research.berkeley.edu/haas_scholars/documents/phycsmentor.html) .

## EARNING MCB CREDIT FOR RESEARCH

A large percentage of MCB majors gain valuable experience in scientific research under the guidance of a faculty sponsor and may receive academic credit for their work by enrolling in an independent study course such as MCB 99, MCB 199 or MCB H196.

MCB 99 and MCB 199 are courses that are open to students with adequate backgrounds and have arranged to work in a laboratory under the supervision of an MCB faculty member. (Research is not restricted to MCB labs.)

**MCB 99 – Supervised Independent Study, variable units (1-4)** – For students with freshman or sophomore standing (up to 60 units completed). You must have a minimum UCB GPA of 3.0.

**MCB 199 – Supervised Independent Study, variable units (1-4)** – For students with junior or senior standing (60 or more units completed). You must have a minimum UCB GPA of 2.0.

General Information about MCB 99/199

- Courses must be taken on a P/NP basis.
- 1 unit of credit equals 3 hours/week worked in the lab (or 45 hours/semester).
- You cannot aggregate more than 4 units of credit for independent studies or group studies in a single semester (courses numbered 98, 198, 99, or 199).
- You cannot earn credit for research for which you are getting paid.

To receive MCB 99 or 199 credit for research, you must:

- Find an MCB faculty member to sponsor your research,
- Submit a completed MCB 99 or 199 application (an application must be submitted each semester for which you wish to receive MCB 199 credit) to an advisor in the Undergraduate Affairs Office before the add/drop deadline, in order to obtain the course control number to add on Tele-BEARS, and
- Submit a written report on the research project to your MCB sponsor at the end of each semester for which you receive MCB 199 credit. Be sure to clarify these guidelines with your PI and/or faculty sponsor at the beginning of the semester.

## Departmental Honors

The MCB Honors program offers outstanding seniors the opportunity for recognition of their research through presentation and a thesis. Honors students usually work in an MCB laboratory. However, a student may work in any appropriate lab, on or off campus, provided an MCB faculty member or head advisor sponsors the H196 research. A student is regarded as participating in the MCB departmental honors program once he/she has been working in a laboratory for at least 2 semesters and has enrolled in MCB H196. Students who fulfill all MCB Honors criteria receive a notation on the transcript and diploma, which reads "Departmental Honors in Molecular and Cell Biology."

### Eligibility to Participate in Honors.

You must

- work in a lab and have an MCB faculty research sponsor, and
- currently have a 3.0 cumulative UCB GPA and the mathematical possibility of a cumulative UCB GPA of at least 3.3 or higher by graduation, and,
- currently have a 3.3 GPA in EITHER all courses required for the major, OR all upper-division courses for the major; and the mathematical possibility of achieving an MCB major or upper-division GPA of 3.5 or higher by graduation, and
- enroll in MCB H196A/B by submitting a completed application each semester, and
- have completed at least two MCB requirements for the major (see below).
  - BMB - Track 1: MCB C100A and 100B, Track 2 – MCB C100A and Chem 130B
  - CDB - MCB 102 and one additional upper-division major requirement
  - GG&D - Track 1: MCB C100A and one additional upper-division major requirement  
Track 2: MCB 102 and one additional upper-division major requirement
  - Immuno - Track 1: MCB C100A and one additional upper-division major requirement  
Track 2: MCB 102 and one additional upper-division major requirement
  - Neuro - MCB 102 and one additional upper-division major requirement

**Note:** Only UC Berkeley courses are used in major grade point average calculations; H196 grades are not factored into the honors GPA.

### Requirements to Graduate with Honors

You must:

- write an honors thesis approved by your MCB faculty sponsor to be turned in to the sponsor by the last weekday of instruction. An H196 Honors Approval form must be submitted to the UAO on the last weekday of final exams of the graduating semester,
- present your research in an approved forum, such as an MCB symposium or poster session, or other scientific meeting,
- complete at least two semesters of research including at least 4 units and no more than 8 units of MCB H196A/B,
- have a cumulative UCB GPA of at least 3.3 or higher in all work completed at UCB, and
- have an MCB major or upper-division GPA of 3.5 or higher. MCB H196B cannot be used to calculate the MCB upper-division GPA.

### Calculating the Honors GPA

- We will round the GPA to the hundredths place, for example 3.294=3.29 and 3.295=3.30. In the first case, a student would not be able to participate in the honors program. In the second case, a student would.
- We will include grades of all courses you've taken for the major at UCB, even if you have earned AP credit that would have waived you from those requirements, e.g. if you received a 5 on the AP biology exam, then took Bio 1B here and earned a C, we will include the C in your GPA calculation.
- Your GPA calculation will be based upon the grades in the courses you have taken to date, including electives. We will not disregard a grade in an elective already taken until you have taken and received a grade in a class to replace it. An example would be that you take MCB 165 toward your Neurobiology major and earn a C in it. You decide that you want to use MCB 167 as your elective instead. We will not exclude the C in MCB 165 until you have taken and earned a grade in MCB 167.

Students participating in the MCB Honors Program are encouraged to enroll in appropriate graduate-level courses. Additional information on H196 and receiving honors is available in the Undergraduate Affairs Office.

## Honors Courses H196A/H196B

### General Information

- Both courses are variable unit courses, so you can enroll in between 1-4 units for each course; however, you must have completed at least 4 units of H196A/H196B in order to graduate with honors and must have enrolled in at least 1 unit of H196B.
- MCB H196A can be taken P/NP only.
- MCB H196B must be taken for a letter grade.

### Signing up for H196A/H196B

- make sure that if your PI is not an MCB faculty member, you have found an MCB faculty member who will sponsor your research and assign a grade,
- download an application from the web,
- write up a description of your project and take the form to your PI for his/her signature, and
- submit your completed MCB H196A/H196B application to an advisor in the Undergraduate Affairs Office before the 5<sup>th</sup> week add/drop deadline, in order to obtain the course control number to add on Tele-BEARS.

## Undergraduate Awards

Each year, the MCB department and divisions recognize the achievements of outstanding MCB undergraduates. Students are nominated by their research sponsor or other MCB faculty member for an award. Many awards require participation in a spring MCB undergraduate research symposium. An award usually includes a prize and a certificate presented at graduation. Students are encouraged to bring their interest in a nomination to the attention of an MCB faculty member. Details on each award appear below.

### DEPARTMENTAL AWARDS

#### MCB Departmental Citation

The Departmental Citation represents the highest achievement each year by a graduating senior in the MCB Department, not only in terms of overall grade point average, but in major course work, quality of research, and such other factors that indicate promise of great success in the student's career. The Citation is awarded by a vote of the Undergraduate Affairs Committee, after having examined the records of the nominees from each MCB Division.

#### Outstanding Scholar

The Outstanding Scholar represents the second highest achievement of a graduating senior in the MCB Department. The Scholar is awarded by a vote of the Undergraduate Affairs Committee, after having examined the records of the nominees from each MCB Division.

Each division selects one top student candidate to be considered for the departmental awards. The following information is given to each person present at the meeting to review:

- student's major progress report printout from student database.
- student's abstract, as submitted online and printed from presentation database.
- letter of recommendation by his/her principal investigator

After review of the above information, the Undergraduate Affairs Committee (UAC) will select the recipients for both the Citation and Scholar awards.

### DIVISIONAL AWARDS

Each MCB division selects the respective award recipients according to its own criteria.

#### BMB

##### Jesse Rabinowitz Prize [by invitation only]

This prize is awarded annually to the outstanding junior MCB major in the Biochemistry & Molecular Biology emphasis, based on academic achievement in MCB courses and faculty recommendation. The UAO identifies qualified students in March and invites them to apply. Students must submit a letter of recommendation from their principal investigator, and complete an application provided by the UAO. The recipient is decided at the same time as the senior awards. A stipend of \$1,200 is given to support the student's undergraduate research during the summer between junior and senior years with the MCB faculty member of his/her choice. Students who are to be considered for this award must take the initiative in arranging a research project with a specific faculty member in advance.

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#### BMB Divisional Awards to Graduating Seniors

All students interested in qualifying for the following BMB divisional awards must present their research at the divisional symposium. The student must also submit a draft/copy of his/her honors thesis. BMB forms a three-person committee to select undergraduate awards.

Each committee member shall receive the following:

- student's major progress report printout from student database
- letter of recommendation by the student's principal investigator
- student's honors thesis draft/copy

#### Grace Fimognari Memorial Award

Established in 1969, to be awarded to the outstanding graduating senior in the BMB emphasis based on the same criteria as the Departmental Citation. If there is no qualified undergraduate in the BMB emphasis, the award shall be made to an outstanding female undergraduate in Physics or Chemistry.

#### Kazuo Gerald Yanaba & Ting Jung Memorial Fund Prize

This prize is made possible by the generosity of family, friends, and associates of the late Kazuo Gerald Yanaba and Ting Jung, two graduates of the Microbiology and Immunology major and former employees of Cetus Corporation. Award of the prize is based on the student's oral presentation of his/her research at the annual BMB Undergraduate Honors Research Symposium and by his/her honors thesis.

## **CDB Divisional Awards to Graduating Seniors**

All students interested in qualifying for a divisional award can present their research at either the semiannual poster session or at the divisional symposium in the spring and obtain a letter of recommendation from their principal investigator. Letters of recommendation are also required for review. Award recipients are selected by the UAC division representative.

### **I.L. Chaikoff Awards in CDB**

Dr. Chaikoff was a Professor of Physiology whose area of expertise was thyroid function measurement with radioactive iodine. He was also a pioneer in the role of hormones in lipid metabolism, which influences arteriosclerosis. Each year, Chaikoff awards are given in recognition of outstanding achievement and excellence in the Cell & Developmental Biology emphasis.

### **Paola Timiras Award**

The Paola Timiras award supports outstanding undergraduate research and scholarship in the field of Cell & Developmental Biology. The late Professor Paola Timiras was renowned for many years of dedication and support for undergraduate education and research. The award is given to the top graduating senior in the Cell & Developmental Biology emphasis of the MCB major for high academic achievement and excellence of research in an honors project.

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## **GG&D Divisional Awards to Graduating Seniors**

All students interested in qualifying for a GG&D divisional award must present their research at the divisional symposium in the spring, and obtain a letter of recommendation from their principal investigator. Award recipients are selected by the UAC division representative along with the input of faculty members present at the symposium.

### **Edward M. Blount Award in Genetics, Genomics and Development**

This prize is given each year to the student who has the highest academic achievement in Genetics, Genomics and Development. Award of the prize is based on the student's major and cumulative grade point averages.

### **Spencer W. Brown Award in Genetics, Genomics and Development**

This prize is given each year to the student who has most distinguished him/herself in Genetics research. Award of the prize is based on the student's oral presentation of his/her research at the annual GG&D Undergraduate Research Symposium and by his/her honors thesis.

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## **Immunology & Pathogenesis Divisional Awards to Graduating Seniors**

All students interested in qualifying for an Immunology & Pathogenesis divisional award must present their research at the divisional symposium in the spring, and obtain letters of recommendation from their principal investigator. The award recipient is selected by the UAC division representative along with the input of all Immunology faculty.

### **Outstanding Immunologist Award**

This represents the top award in the Immunology & Pathogenesis emphasis of the MCB major given for excellence in both honors research and high academic achievement, not only in terms of overall grade point average, but in major course work, quality of research, and such other factors that indicate promise of great success in the student's future career.

### **Immunology Distinction in Academic Achievement Award**

This award goes to the graduating senior in the Immunology & Pathogenesis emphasis of the MCB major for high academic achievement in all MCB required classes.

### **Immunology Excellence in Research Award**

This award goes to the graduating senior in the Immunology & Pathogenesis emphasis of the MCB major for exceptional research performance in an honors research project.

## **Neurobiology Divisional Awards to Graduating Seniors**

All students interested in qualifying for a divisional award can present their research at either the semiannual poster session or at a divisional



symposium in the spring and obtain a letter of recommendation from their principal investigator. Letters of recommendation are also required for review. Award recipients are selected by the UAC division representative.

### **I.L. Chaikoff Awards in Neurobiology**

Dr. Chaikoff was a Professor of Physiology whose area of expertise was thyroid function measurement with radioactive iodine. He was also a pioneer in the role of hormones in lipid metabolism, which influences arteriosclerosis. Each year, Chaikoff awards are given in recognition of outstanding achievement and excellence in the Neurobiology emphasis.

### **Jeffery Allan Winer Memorial Award**

The Jeffery Allan Winer Memorial award supports outstanding undergraduate research and scholarship in the field of Neurobiology. The late Professor Jeffery Winer was renowned for many years of dedication and support for undergraduate education and research. The award is given to the top graduating senior in the Neurobiology emphasis of the MCB major for high academic achievement and excellence of research in an honors project.

### MEDICAL SCHOOL & OTHER HEALTH SCHOOLS

There are numerous resources for you as a pre-health major. Most importantly, the Career Center has counselors who are trained to work with pre-health students (this includes pre-med). You can make appointments with them through their website and also gain access to a wealth of information about timing, planning, special programs, recommendations for courses, MCAT preparation, and the application process. Here are some valuable web resources:

- The Career Center, <http://career.berkeley.edu/health/health.stm>, for appointments with pre-health counselors, numerous resources and peer advising (<https://career.berkeley.edu/Peers/Peers.stm>).
- Cal Biology / Pre-Health Clubs: <https://career.berkeley.edu/Health/CalClubs.stm>
- Career Services One Stop Access: <http://callisto.berkeley.edu>, a student portal, of sorts, for Career Services.
- Medical School Admissions Requirements (MSAR): <https://www.aamc.org/students/applying/>, or come in to the MCB UAO to view a copy of the most recent book. The Career Center also has the current MSAR available for viewing.

### GRADUATE SCHOOL IN BIOLOGICAL SCIENCE

Many of you will want to go on to graduate school in order to pursue careers as research scientists, teachers or professors. In addition to excellent academic achievement in appropriate courses and on entrance exams, such as the GRE, laboratory experience is generally required for pursuing graduate study in a biological science. Be sure to talk to your faculty advisors about your interest in graduate school. The Career Center has many resources to draw from, such as workshops, a letter service, individual counseling, graduate school fairs, and more:

- <http://career.berkeley.edu/grad/grad.stm>

### CAREER OPTIONS WITH A B.A. IN MCB

Students with undergraduate degrees in MCB have many different career options. Here are some examples:

Laboratory technicians at universities, biotech companies, pharmaceutical companies, and research institutes • business finance • management • marketing • sales administration • medicine • pharmacy • dentistry • optometry • public health • public policy • education • Environmental Protection Agency (EPA) • Department of Health and Human Services (HHS) • science editing, writing, and illustration • journalism • investment banking • patent law, etc.

For more information about career opportunities, make an appointment with a career counselor at the Career Center.

- <http://callisto.berkeley.edu>

You may want to begin gathering preliminary information about career choices by visiting the Career and Educational Guidance Library. It's housed in the small building directly in front of the Tang center. They offer resources to help you assess where you may want to head in the future:

- <http://www.uhs.berkeley.edu/Students/careerlibrary/index.shtml>

## Appendix 1: Course descriptions

### LOWER-DIVISION REQUIREMENTS FOR THE MCB MAJOR

\*\*\*Visit the [Berkeley Guide](http://guide.berkeley.edu) (<http://guide.berkeley.edu>) for current course information.

#### **Mathematics 10A: Methods of Mathematics: Calculus, Statistics, and Combinatorics (4 units)**

Prerequisites: Three and one-half years of high school math, including trigonometry and analytic geometry, plus a satisfactory grade in one of the following: CEEB MAT test, an AP test, the UC/CSU math diagnostic test, or 32. Consult the mathematics department for details. Credit option: Students will receive 2 units after taking 1A. Description: This sequence is intended for majors in the life sciences. Introduction to differential and integral calculus of functions of one variable. Representation of data, elementary probability theory, statistical models, and testing.

#### **Mathematics 10B: Methods of Mathematics: Calculus, Statistics, and Combinatorics (4 units)**

Prerequisites: Math 10A. Credit option: Students will receive 2 units of credit for 10B after taking 55. Description: Continuation of 10A. Elementary combinatorics and discrete probability theory. Introduction to graphs, matrix algebra, linear equations, difference equations, and differential equations.

#### **Chemistry 1A: General Chemistry (3 units)**

Prerequisites: High school chemistry recommended. Credit option: Students will receive no credit for 1A after taking 4A. Description: Stoichiometry of chemical reactions, quantum mechanical description of atoms, the elements and periodic table, chemical bonding, real and ideal gases, thermochemistry, introduction to thermodynamics and equilibrium, acid-base and solubility equilibria, introduction to oxidation-reduction reactions, introduction to chemical kinetics.

#### **Chemistry 1AL: General Chemistry (1 unit)**

Prerequisites: 1A (may be taken concurrently). Credit option: Students will receive no credit for 1AL after taking 4A. Description: An experimental approach to chemical sciences with emphasis on developing fundamental, reproducible laboratory technique and a goal of understanding and achieving precision and accuracy in laboratory experiments. Proper use of laboratory equipment and standard wet chemical methods are practiced. Areas of investigations include chemical equilibria, spectroscopy, nanotechnology, green chemistry, and thermochemistry. Concurrent enrollment in 1A is recommended.

#### **Chemistry 1B: General Chemistry (4 units) – only required for Biological Chemistry major program (BMB, track 2)**

Prerequisites: 1A or a score of 3, 4, or 5 on the Chemistry AP test. Credit option: Students will receive no credit for 1B after taking 4B. Description: Introduction to chemical kinetics, electrochemistry, properties of the states of matter, binary mixtures, thermodynamic efficiency and the direction of chemical change, quantum mechanical description of bonding introduction to spectroscopy. Special topics: Research topics in modern chemistry and biochemistry, chemical engineering.

#### **Biology 1A: General Biology Lecture. (3 units)**

Prerequisites: A grade of C- or better in Chemistry 1A and 1AL. General introduction to cell structure and function, molecular and organism genetics, animal development, form and function. Intended for biological sciences majors, but open to all qualified students. Sponsored by MCB.

#### **Biology 1AL: General Biology Laboratory (2 units)**

Laboratory that accompanies Bio 1A lecture course. Intended for biological science majors, but open to all qualified students. Must be taken concurrently with Bio 1A, unless exempt by major. Sponsored by MCB.

#### **Biology 1B: General Biology (4 units)**

Description: General introduction to plant development, form, and function; population genetics, ecology, and evolution. Intended for students majoring in the biological sciences, but open to all qualified students. Students must take both Biology 1A and 1B to complete the sequence. Sponsored by Integrative Biology.

#### **Physics 8A: Introductory Physics (4 units)**

Prerequisites: Mathematics 16A/1A/10A or equivalent or consent of instructor. Credit option: Students with credit for 7A will not receive credit for 8A. Description: Introduction to forces, kinetics, equilibria, fluids, waves, and heat. This course presents concepts and methodologies for understanding physical phenomena, and is particularly useful preparation for upper-division study in biology and architecture.

#### **Physics 8B: Introductory Physics (4 units)**

Prerequisites: 8A or equivalent, and Math 10B. Credit option: Students with credit for 7B or 7C will not receive credit for Physics 8B. Description: Introduction to electricity, magnetism, electromagnetic waves, optics, and modern physics. The course presents concepts and methodologies for understanding physical phenomena, and is particularly useful preparation for upper-division study in biology and architecture.

## LOWER-DIVISION MCB DEPARTMENTAL COURSES (NOT REQUIRED FOR THE MAJOR)

\*\*\*Visit the [Berkeley Guide](http://guide.berkeley.edu) (<http://guide.berkeley.edu>) for current course information.

### **MCB 15: Current Topics in the Biological Sciences. (2 units)**

Suitable for freshmen who plan to major in a biological science. Students in this course will critically examine modern methods of biological investigations and their social implications. Relevant literature will be used to present basic biological concepts that address the cultural, technological and health aspects of current topics in the biological sciences. Designing and evaluating scientific questions will be stressed. (Sp)

### **MCB 31: Big Ideas in Cell Biology (3 units)**

Students with credit for Biology 1A and 1B will not receive credit for 31. An introduction for students who do not intend to major in biology but who wish to satisfy their breadth requirement in Biological Sciences. Some major concepts of modern biology, ranging from the role of DNA and the way cells communicate, to interactions of cells and creatures with their environment, will be discussed without jargon and with attention to their relevance in contemporary life and culture. Also listed as Letters and Science C30X. (Alt Sp) Wilt

### **MCB 32: Introduction to Human Physiology. (3 units)**

Prerequisites: One year high school or college chemistry. A comprehensive introduction to human cell biology. Intended for non-majors. The course will concentrate on basic mechanisms underlying human life processes, including cells and membranes; nerve and muscle function; cardiovascular, respiratory, renal, and gastrointestinal physiology; metabolism, endocrinology, and reproduction. (F, Su)

### **MCB 32L: Introduction to Human Physiology Laboratory. (2 units)**

Prerequisites: 32 or may be taken concurrently. Experiments and demonstrations are designed to amplify and reinforce information presented in 32. Exercises include investigations into the structure and function of muscle, nerve, cardiovascular, renal, respiratory, endocrine, and blood systems. (F, Su)

### **MCB 41: Genetics and Society. (3 units)**

Primarily for students not specializing in biology. Students will receive 2 units for Molecular and Cell Biology 41 after taking 41X, Interdepartmental Studies 41X, or Plant and Microbial Biology 41X. Students will receive no credit after taking Letters and Science 18. Basic communication of inheritance; gene mapping; gene expression and genetic disease in animals and humans; social inheritance of genetics. (Alt Sp)

### **MCB C44: Biology for Voters (3 units)**

This is a Discovery Course for non-Biology majors designed to introduce lower-division college students to biology through the lens of the contemporary problems facing people, the planet and the species of the planet. Modern genetic contributions will be presented on such issues as genetic engineering of plants and animals, the emergence of new pathogens, the role of genetic variation among individuals, and the extent to which DNA is and isn't destiny. Each week will close with the presentation and discussion of a defining biological challenge facing the world. (Alt Sp)

### **MCB 50: The Immune System and Disease. (3 units)**

Students will receive no credit for 50 after taking 100B or 102. Prerequisites: High school chemistry or Chemistry 1A and high school biology or Biology 1A. Course will discuss how the immune system resolves, prevents, or causes disease. A general overview of the immune system will be covered in the first five weeks followed by five weeks discussing infectious diseases including anthrax, mad cow, herpes, malaria, tuberculosis, and HIV. Other lectures will focus on current immunology topics including vaccines, autoimmunity, allergy, transplantation, and cancer. (Sp) Beatty

### **MCB 55: Plagues and Pandemics. (3 units)**

Students will receive no credit for 55 after taking 100, 102, C100A, 100B, 103, C103, 150; Chemistry C130; PMB C103; Public Health C102. Discussion of how infectious agents cause disease and impact society at large. We will examine historical and current examples of plagues and pandemics and consider the question of what we should do to ameliorate the impact of infectious disease in the future. The course is intended for non-majors and will begin by briefly providing necessary background in microbiology and immunology. The primary focus in each subsequent week, however, will be on discussing a particular infectious disease. The course will be broad in scope covering biological, historical, ethical and social implications of each disease. (F) Beatty

### **MCB C61: Brain, Mind, and Behavior. (3 units)**

Introduction to human brain mechanisms of sensation, movement, perception, thinking, learning, memory, and emotion in terms of anatomy, physiology, and chemistry of the nervous system in health and disease. Intended for students in the humanities and social sciences and others not majoring in the biological sciences. Also listed as Letters and Science C30W. (Sp) Presti

### **MCB C62: Drugs and the Brain. (3 units)**

Students will receive no credit for C62 after taking 62, L&S 19 or Psych 119. The history, chemical nature, botanical origins, and effects on the human brain and behavior of drugs such as stimulants, depressants, psychedelics, analgesics, antidepressants, antipsychotics, steroids, and other psychoactive substances of both natural and synthetic origin. The necessary biological, chemical, and psychological background material for understanding the content of this course will be contained within the course itself. Also L & S C30T. (F) Presti

**MCB 64: Exploring the Brain: Introduction to Neuroscience. (3 units)**

Students will receive no credit for 64 after taking 61 or 160. Prerequisites: High school chemistry or Chemistry 1A; high school biology or Biology 1A. This course will introduce lower division undergraduates to the fundamentals of neuroscience. The first part of the course covers basic membrane properties, synapses, action potentials, chemical and electrical synaptic interactions, receptor potentials, and receptor proteins. The second part of the course covers networks in invertebrates, memory and learning behavior, modulation, vertebrate brain and spinal cord, retina, visual cortex architecture, hierarchy, development, and higher cortical centers. (F)

**MCB C96: Studying the Biological Sciences. (1 unit)**

Freshmen will be introduced to the "culture" of the biological sciences, along with an in-depth orientation to the academic life and the culture of the university as they relate to majoring in biology. Students will learn concepts, skills, and information that they can use in their major course, and as future science professionals. Restricted to freshmen in the biology scholars program. Also listed as Plant and Microbial Biology C96 and Integrative Biology C96. (F) Matsui

**MCB 99: Supervised research. (1-4 units)**

Course Format: Supervised research. Prerequisites: Students must have freshman or sophomore standing and consent of MCB faculty sponsor. (Juniors and seniors must sign up for MCB 199.) Credit option: Course may be repeated for credit. One unit of credit is given for every three hours of work in the lab per week to a maximum of 4 units. Must be taken on a passed/not passed basis. (F, Sp, Su)

## UPPER-DIVISION MCB DEPARTMENTAL COURSES

\*\*\*Visit the [Berkeley Guide](http://guide.berkeley.edu) (<http://guide.berkeley.edu>) for current course information.

### **MCB C100A: Biophysical Chemistry: Physical Principles & the Molecules of Life (4 units)**

Prerequisites: Chemistry 3A/3AL or 112A, Mathematics 1A, Biology 1A/1AL; Chemistry 3B or 112B recommended. *Students will receive 3 units of credit for Chemistry C130 or MCB C100A after taking Chemistry 120B.* Thermodynamic and kinetic concepts applied to understanding the chemistry and structure of biomolecules (proteins, DNA, and RNA). Molecular distributions, reaction kinetics, enzyme kinetics. Bioenergetics, energy transduction, and motor proteins. Electrochemical potential, membranes, and ion channels. Also listed as Chemistry C130. (F, Sp)

### **MCB 100B: Biochemistry: Pathways, Mechanisms, and Regulations (3 units)**

Prerequisites: C100A/Chemistry C130. *Students will receive 2 units for 100B after taking 102 and no credit after taking MCB 100 or Chemistry 135.* Bioenergetics, metabolic pathways, and regulation of metabolism; the chemistry, structure, function, synthesis, and degradation of the constituent molecules (amino acids, fatty acids, sugars, nucleotides) and cofactors of the major biological macromolecules. Diseases that are linked to metabolic disorders. Designed for majors in the biochemistry and molecular biology, genetics and development, or immunology emphases. (Sp)

### **MCB 102: Survey of the Principles of Biochemistry & Molecular Biology (4 units)**

Prerequisites: Biology 1A/1AL, Chemistry 3B or an equivalent course. Recommended: a course in physical chemistry. Students will receive 2 units of credit for 102 after taking 100/100B or C100A/Chem C130, no credit after taking 110 AND any of 100, 100B or C100A/Chem C130, no credit after taking Chemistry 135. A comprehensive survey of the fundamentals of biological chemistry, including the properties of intermediary metabolites, the structure and function of biological macromolecules, the logic of metabolic pathways (both degradative and biosynthetic) and the molecular basis of genetics and gene expression. (F, Sp, Su)

### **MCB C103: Bacterial Pathogenesis (3 units)**

Prerequisites: C100A or Chemistry C130, 102 or consent of instructor. This course for upper-division and graduate students will explore the molecular and cellular basis of microbial pathogenesis. The course will focus on model microbial systems which illustrate mechanisms of pathogenesis. Most of the emphasis will be on bacterial pathogens of mammals, but there will be some discussion of viral and protozoan pathogens. There will be an emphasis on experimental approaches. The course will also include some aspects of bacterial genetics and physiology, immune response to infection, and the cell biology of host-parasite interactions. Also listed as Public Health C102 and Plant and Microbial Biology C103. (Sp) Portnoy

### **MCB 104: Genetics, Genomics & Cell Biology (4 units)**

Prerequisites: 102. This course will introduce students to key concepts in genetic analysis, eukaryotic cell biology, and state-of-the-art approaches in genomic medicine. Lectures will highlight basic knowledge of cellular processes with the basis for human diseases, particularly cancer. Prerequisite courses will have introduced students to the concepts of cells, the central dogma of molecular biology, and gene regulation. Emphasis in this course will be on eukaryotic cell processes, including cellular organization, dynamics, and signaling. (F, Sp)

### **MCB 110: Molecular Biology: Macromolecular Synthesis & Cellular Function (4 units)**

Prerequisites: C100A (may not be taken concurrently); Plan 1 Emphasis 1 (BMB) majors should take 100B prior to 110. *Students will receive 3 units for 110 after taking 104.* Molecular biology of prokaryotic and eukaryotic cells and their viruses. Mechanisms of DNA replication, transcription, translation. Structure of genes and chromosomes. Regulation of gene expression. Biochemical processes and principles in membrane structure and function, intracellular trafficking and subcellular compartmentation, cytoskeletal architecture, nucleocytoplasmic transport, signal transduction mechanisms, and cell cycle control. (F, Sp)

### **MCB C110L: General Biochemistry and Molecular Biology Laboratory (4 units)**

Prerequisites: 110 (may be taken concurrently). Experimental techniques of biochemistry and molecular biology, designed to accompany the lectures in 100B and 110. (F, Sp)

### **MCB C112: General Microbiology (4 units)**

Prerequisites: C100A/Chemistry C130 or 102. This course will explore the molecular bases for physiological and biochemical diversity among members of the two major domains, Bacteria and Archaea. The ecological significance and evolutionary origins of this diversity will be discussed. Molecular, genetic, and structure-function analyses of microbial cell cycles, adaptive responses, metabolic capability, and macromolecular syntheses will be emphasized. Also listed as Plant and Microbial Biology C112. (F)

### **MCB C112L: General Microbiology Laboratory (2 units)**

Prerequisites: C112 (may be taken concurrently). Experimental techniques of microbiology designed to accompany the lecture in C112 and C148. The primary emphasis in the laboratory will be on the cultivation and physiological and genetic characterization of bacteria. Laboratory exercises will include the observation, enrichment, and isolation of bacteria from selected environments. Also listed as Plant and Microbial Biology C112L. (F, Su)

**MCB C114: Introduction to Comparative Virology (4 units)**

Prerequisites: Introductory chemistry (1A or 3A-3B or equivalent) and introductory biology (1A/1AL and 1B or equivalent) and general biochemistry (C100A or equivalent--preferably completed but may be taken concurrently). Viruses will be considered as infectious agents of bacteria, plants, and animals (vertebrates and invertebrates). Several families of viruses will be compared with respect to biochemical, structural and morphological properties, and strategies of infection and replication. Also listed as Environ Sci, Policy, and Management C138 and Plant and Microbial Biology C114. (Sp)

**MCB C116: Microbial Diversity (3 units)**

Prerequisites: Upper-division standing. C112 or consent of instructor and organic chemistry (may be taken concurrently). This course for upper-division and graduate students will broadly survey myriad types of microbial organisms, both prokaryote and eukaryote, using a phylogenetic framework to organize the concept of "biodiversity." Emphasis will be on the evolutionary development of the many biochemical themes, how they mold our biosphere, and the organisms that affect the global biochemistry. Molecular mechanisms that occur in different lineages will be compared and contrasted to illustrate fundamental biological strategies. Graduate students additionally should enroll in C216, Microbial Diversity Workshop. Also listed as Plant and Microbial Biology C116. (F)

**MCB 118: The Cancer Karyotype: What it Is and What it Does (1 unit)**

Prerequisites: MCB 102 and 104. Mutational cancer theories do not explain why cancers: 1) have clonal individual karyotypes; 2) have polygenic transcriptomes and phenotypes; 3) have flexible karyotypes, which evolve progressive malignancy and drug resistance, but maintain autonomy and even immortality; and 4) Why carcinogens induce cancer only after conspicuously long latent periods of years to decades. To answer these questions, this course tests a new karyotypic theory, which postulates that cancers evolve much like new species. (F) Duesberg

**MCB 130A: Cell & Systems Biology (4 units)**

Prerequisites: 102 and 104. *Students will receive no credit for 130A after taking 130.* This course will provide a detailed discussion of a wide range of topics in cell biology emphasizing experimental approaches and key experiments that have provided important insights. The course is aimed at conveying an understanding of how cellular structure and function arise as a result of the properties of cellular macromolecules. An emphasis will be placed on the dynamic nature of cellular organization and will include a description of physical properties of cells (dimensions, concepts of free energy, diffusion, biophysical properties). Students will be introduced to quantitative aspects of cell biology and a view of cellular function that is based on integrating multiple pathways and modes of regulation (systems biology). (Sp)

**MCB 132: Biology of Human Cancer (4 units)**

Prerequisites: Biology 1A/1AL, Biology 1B; 102 or 110 (may be taken concurrently). The course is designed for students interested in learning about the molecular and cell biology of cancer and how this knowledge is being applied to the prevention, diagnosis and therapy of cancer. Topics covered include tumor pathology and epidemiology; tumor viruses and oncogenes; intracellular signaling; tumor suppressors; multi-step carcinogenesis and tumor progression; genetic instability in cancer; tumor-host interactions; invasion and metastasis; tumor immunology; cancer therapy. (F)

**MCB 133L: Cell Biology and Physiology Laboratory (4 units)**

Prerequisites: MCB 104. *Students will receive no credit for 133L after taking 130L.* Experimental analyses of central problems in cell biology and physiology using modern techniques, including DNA cloning and protein biochemistry, fluorescence microscopy of the cytoskeleton and organelles, DNA transfection and cell cycle analysis of cultured mammalian cells, RNA interference and drug treatments to analyze ion channel function in cell contractility and intracellular signaling, and somatosensation. (F, Sp)

**MCB C134: Chromosome Biology/Cytogenetics (3 units)**

Prerequisites: Upper-division genetics or cell biology course; concurrent enrollment with consent of instructor. Survey of behavior, structure, and function of chromosomes with emphasis on behavior in model organisms. Topics include mitosis, meiosis, chromosome aberrations, genome function, dosage compensation, transposons, repetitive DNA, and modern cytological imaging. Also listed as Plant and Microbial Biology C134. (Sp) Cande, Hollick

**MCB 135A: Molecular Endocrinology (3 units)**

Prerequisites: 102, Biology 1A/1AL, 1B, Chemistry 3A/3AL and 3B/3BL or equivalent, or consent of instructor. Molecular mechanisms by which hormones elicit specific responses and regulate gene expression; hormone-receptor interaction; synthesis, transport and targeting of hormones, growth factors and receptors. (F) Firestone

**MCB 136: Physiology (4 units)**

Prerequisites: Biology 1A/1AL, 1B, Physics 8A. Physics 8B recommended. Credit option: Students will receive no credit for 136 after taking Integrative Biology 132. Principles of mammalian (primarily human) physiology emphasizing physical, chemical, molecular and cellular bases of functional biology. The following topics will be covered: cellular and membrane ion and nonelectrolyte transport; cell and endocrine regulation; autonomic nervous system regulation; skeletal, smooth and cardiac muscle; cardiovascular physiology; respiration; renal physiology; gastrointestinal physiology. Discussion section led by Graduate Student Instructor will review material covered in lecture. (F)

**MCB 137: Computer Simulation in Biology (3 units)**

Modeling and computer simulation of dynamic biological processes using special graphical interfaces requiring very little mathematical or computer experience. First half is realistic models from current literature to teach concepts and technique; second is workshop for student-selected individual projects. (Sp) Macey, Oster

**MCB 140: General Genetics (4 units)**

Prerequisites: C100A/Chemistry C130 and 110 (110 may be taken concurrently). *Students will receive 1 unit of credit for 140 after taking C142 or 104.* In-depth introduction to genetics, including mechanisms of inheritance; gene transmission and recombination; transposable DNA elements; gene structure, function, and regulation; and developmental genetics. Some exams may be given in the evening. (F)

**MCB 140L: Genetics Laboratory (4 units)**

Prerequisites: 140. May be taken concurrently. Experimental techniques in classical and molecular genetics. (Sp)

**MCB 141: Developmental Biology (3 units)**

Prerequisites: 102 or C100A, Biology 1A/1AL, 1B; 110 or 130 recommended. An introduction to principles and processes of embryonic and post-embryonic development, stressing mechanisms of cell and tissue interactions, morphogenesis and regulation of gene expression. (Sp)

**MCB 143: Evolution of Genomes, Cells, and Development (3 units)**

Prerequisites: Biology 1A-1B and Molecular and Cell Biology C100A or 102; 104 or 140 recommended. *Students will receive no credit for 143 after taking Integrative Biology 163.* This course is intended for upper-division undergraduates seeking an interactive course based on modern concepts in evolution and comparative genomics. The course will emphasize the contribution of molecular evolution to a series of seminal events in life's history: origin of life; origin of cells; origin of eukaryotes; origin of multicellularity; evolution of animal development; human origins. (F) King.

**MCB C146: Topics in Computational Biology and Genomics (4 units)**

Prerequisites: Bioengineering 142, Computer Science 61A, or equivalent ability to write programs in Java, Perl, C, or C++; 100B, 102, or equivalent; or consent of instructor. Instruction and discussion of topics in genomics and computational biology. Working from evolutionary concepts, the course will cover principles and application of molecular sequence comparison, genome sequencing and functional annotation, and phylogenetic analysis. Also listed as Bioengineering C146 and Plant and Microbial Biology C146. (Sp)

**MCB C148: Microbial Genomics and Genetics (4 units)**

Prerequisites: 100B or 102. Course emphasizes bacterial and archaeal genetics and comparative genomics. Genetics and genomic methods used to dissect metabolic and development processes in bacteria, archaea, and selected microbial eukaryotes. Genetic mechanisms integrated with genomic information to address integration and diversity of microbial processes. Introduction to the use of computational tools for a comparative analysis of microbial genomes and determining relationships among bacteria, archaea, and microbial eukaryotes. Also listed as Plant and Microbial Biology C148. (Sp)

**MCB 149: The Human Genome (4 units)**

Prerequisites: MCB 140, MCB 104 or equivalent. Credit Restriction: Students will receive 2 units for Molecular and Cell Biology 149 after taking Integrative Biology 164. This is an upper division course for majors in MCB with an interest in an in-depth exploration of the forces that shape the human genome and the human population, as well as the ways that human genetic information can be used in medicine, ancestry and forensics. The course will combine lectures and discussion of research papers. (Sp)

**MCB 150: Molecular Immunology (4 units)**

Prerequisites: C100A/Chemistry C130 or 102. Fundamentals of immunology with emphasis on biochemical and molecular approaches to study of the immune system and its application in medicine and biotechnology. Topics covered include description of the immune system, antibody and T-cell receptor structure and function, genes of the immunoglobulin superfamily, cells and molecular mediators that regulate the immune response, allergy, autoimmunity, immunodeficiency, tissue and organ transplants, and tumor immunology. (F, Sp)

**MCB 150L: Immunology Laboratory (4 units)**

Prerequisites: 150 (may be taken concurrently); consent of instructor. Experimental techniques in mammalian molecular biology and cellular immunology. Molecular techniques covered include PCR and recombinant DNA procedures such as gene cloning, gene transfer, DNA sequencing, Southern blot, and restriction mapping. Immunological techniques covered include cell culture and monoclonal antibody production, flow cytometry, ELISA, immunoprecipitation, and western blot. (F, Sp)



**MCB 160: Molecular and Cellular Neurobiology (4 units)**

Prerequisites: Biology 1A/1AL and Physics 8A. Prerequisite or co-requisite: Physics 8B. Comprehensive introductory survey of cellular and molecular neuroscience, including cellular neurophysiology, ion channel function, synaptic function and plasticity, sensory transduction, and brain development. Includes introduction to molecular basis of neurological disease. Analysis from the level of molecules to cells to simple circuits. (F)

**MCB C160: Introduction to Neurobiology (4 units)**

Prerequisites: 102 or C100A, Biology 1A/1AL, Physics 8A-8B. An introductory course designed to provide a general understanding of the nervous system including how it functions, how it develops, and how it changes with learning and memory. Analysis from the level of molecules to cells to simple circuits to complex networks to higher brain functions. Also listed as Neuroscience C160. (no longer offered after Sp15)

**MCB 160L: Neurobiology Laboratory (4 units)**

Prerequisites: Biology 1A/1AL, Physics 8A, 8B, Molecular and Cell Biology C100A or 102; MCB 160 (or equivalent). Experimental analyses of properties and interactions of nerve cells and systems, illustrating principal features and current methods. Techniques employed include computer simulation of neuron properties, electrophysiological recording and stimulation of nerves and cells, digitally enhanced video imaging of outgrowth, fluorescence immunocytochemistry, analysis of sensory: CNS mapping, human-evoked potential recording, sensory psychophysics. (Sp) Zucker

**MCB 161: Mammalian Neuroanatomy (4 units)**

Prerequisites: MCB 160. Comprehensive survey of circuits and systems neuroscience, including sensory and motor systems, learning and memory, neuromodulatory systems and brain state and higher functions. Biological and computational principles of neural circuit function. Analysis from the level of small circuits to behavior. (Sp)

**MCB 163: Mammalian Neuroanatomy (4 units)**

Prerequisites: Biology 1A. Biology 1AL not required. Development, structure (gross and microscopic), and functional relationships of the mammalian nervous system. (F)

**MCB 165: Neurobiology of Disease (prior to Fa15 - Molecular Neurobiology) (3 units)**

Prerequisites: 102 or 110, and 160. The molecular and biochemical aspects of the structure and function of the nervous system, including ion channels, neurotransmitters and their receptors, second messenger systems, and molecular mechanisms of development and plasticity. (Sp)

**MCB 166: Biophysical Neurobiology (3 units)**

Prerequisites: Biology 1A/1AL, Physics 8A, 8B, Chem 3B or consent of instructor. Biophysical properties of ion channels and excitability, ion selectivity, membrane transport phenomena. Sensory transduction, optical measurements and microscopy. Cellular networks as computational devices, information processing and transfer. (F)

**MCB 167: Physiological & Genetic Basis of Behavior (3 units)**

Prerequisites: Either 102 or 11 and 160, or consent of instructor. Genetic, cellular, and circuit-level analysis of how the nervous system generates behavior. Includes sensory processing, movement, and learning. Focus is on model systems for animal behavior. Principles, cellular and circuit specializations, and neural computations for behavior will be presented. (Sp) Scott, Feldman

**MCB H196A: Honors Research (1-4 units)**

Prerequisites: Senior honors status and consent of MCB faculty sponsor.

Description: Individual research and thesis preparation under the supervision of a faculty member. Acceptance to the Molecular and Cell Biology Honors Program is required. Contact the MCB Undergraduate Affairs Office, 2083 Valley Life Sciences Building, for application and details. Honor students must complete at least two semesters of research, taking a minimum of 4 units and a maximum of 8 units of H196A-196B. If desired, one semester of 199 can be used to replace H196A. (F, Sp)

**MCB H196B: Honors Research (1-4 units)**

Prerequisites: Senior honors status and consent of MCB faculty sponsor.

Description: Individual research and completion of thesis under the supervision of a faculty member. This course satisfies the thesis requirement for the Molecular and Cell Biology Department Honors Program. Contact the MCB Undergraduate Affairs Office, 2083 Valley Life Sciences Building, for program details and an application. Honor students must complete at least two semesters of research, taking a minimum of 4 units and a maximum of 8 units of H196A-196B. One semester of H196B is required. (F, Sp)

**MCB 199: Supervised Independent Study and Research (1-4 units)**

Prerequisites: Consent of instructor. Credit option: Course may be repeated for credit. Grading option: Must be taken on a passed/not passed basis. Description: Enrollment restrictions apply; see the Introduction to Courses and Curricula section of this catalog. (F, Sp, Su)

## Appendix 2: Sample curriculum plans

### FIRST TWO YEARS AT CAL, AS FRESHMEN AND SOPHOMORES

These are suggested plans only

#### Sample plan #1 – Preferred Plan

|                  | Fall                           | Spring                         |
|------------------|--------------------------------|--------------------------------|
| <b>Freshman</b>  | Math 10A<br>Chemistry 1A/1AL   | Math 10B<br>Biology 1A/1AL     |
| <b>Sophomore</b> | Chemistry 3A/3AL<br>Biology 1B | Chemistry 3B/3BL<br>Physics 8A |

#### Sample plan #2 – Alternate Plan

|                  | Fall                           | Spring                       |
|------------------|--------------------------------|------------------------------|
| <b>Freshman</b>  | Math 10A<br>Chemistry 1A/1AL   | Math 10B<br>Chemistry 3A/3AL |
| <b>Sophomore</b> | Chemistry 3B/3BL<br>Physics 8A | Biology 1A/1AL<br>Physics 8B |

#### Sample plan #3 for BMB, Track 2

|                  | Fall                         | Spring                          |
|------------------|------------------------------|---------------------------------|
| <b>Freshman</b>  | Math 10A<br>Chemistry 1A/1AL | Math 10B<br>Chemistry 1B        |
| <b>Sophomore</b> | Chemistry 112A<br>Biology 1B | Chemistry 112B<br>Biology 1A/AL |

## TWO YEAR PLANS FOR TRANSFER STUDENTS

### Sample plan #1 for a transfer student with all prerequisites completed

|        | Fall                                   | Spring                               |
|--------|--|--------------------------------------|
| Junior | MCB C100A or MCB 102 (track dependent) | MCB Core Requirement<br>MCB Elective |
| Senior | MCB Core Requirement<br>MCB Elective   | MCB Core Lab                         |

### Sample plan #2 for tracks requiring MCB 102 – for students without physics completed

|        | Fall                            | Spring                       |
|--------|---------------------------------|------------------------------|
| Junior | MCB 102<br>Physics 8A*          | MCB 104<br>Physics 8B        |
| Senior | MCB Core Course<br>MCB Elective | MCB Core Lab<br>MCB Elective |

### Sample plan #3 for tracks requiring MCB C100A – for students without physics completed

|        | Fall                               | Spring   |
|--------|------------------------------------|--|
| Junior | Physics 8A*<br>MCB Elective        | MCB C100A<br>Physics 8B                            |
| Senior | MCB Core Course<br>MCB Core Course | MCB Core Lab<br>MCB Core Course or Second Elective |

### Sample plan #4 for students interested in NEU and completed physics

|        | Fall                                   | Spring                      |
|--------|--|-----------------------------|
| Junior | MCB 160                                | MCB 161<br>MCB 102          |
| Senior | MCB Core Course or Lab<br>MCB Elective | MCB Core Lab or Core Course |

\*If you have not taken first-semester physics before you come to Cal, you might have to add a summer session or an extra semester to your schedule in order to complete the requirements for the major.