

**270. Multimedia II.** Prerequisite: 170. FALL. [3] Hosford.

**288. Selected Topics.** May be repeated with change of content up to a total of 9 hours. FALL, SPRING. [3] Staff.

**289. Independent Research.** Supervised work in extension of regular offerings in the curriculum. Registration only with agreement of instructor involved and with written approval of the director of undergraduate studies. FALL, SPRING. [Variable credit: 1–3 per semester, not to exceed a total of 6] Staff.

**290. Directed Study: Senior Show and Contemporary Practices.** Theoretical and practical concerns including professional practices for artists. Students visit exhibitions and discuss contemporary art with directed readings and lectures, participate in critiques, and exhibit their work. Seniors with a concentration in art only. FALL. [3] Rowe.

## Biological Sciences



CHAIR Charles K. Singleton

DIRECTOR OF UNDERGRADUATE STUDIES (BioSci and EEOB majors)

David E. McCauley

DIRECTOR OF UNDERGRADUATE STUDIES (MCB major) Wallace M. LeSturgeon

DIRECTOR OF GRADUATE STUDIES Douglas G. McMahon

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ASSOCIATE PROFESSORS Bruce H. Appel, Kenneth C. Catania

ASSISTANT PROFESSORS D. Kilpatrick Abbot, Kefyn M. Catley, Brandt F. Eichman,

Katherine L. Friedman, Daniel J. Funk, Joshua T. Gamse, Chris Janetopoulos,

Daniel J. Kaplan, Andrzej M. Krezel, Manuel Leal, Donna J. Webb

RESEARCH ASSISTANT PROFESSORS Irina Bruck, Jeff Rohrbough, Diane Sepich,

Shin Yamazaki, Yao Xu, Daoqi Zhang

SENIOR LECTURERS Steve J. Baskauf, Amanda R. Benson, A. Denise Due-Goodwin,

Mark A. Woelfle

✦ THE biological sciences encompass the study of living organisms and life processes at all levels: ecosystems, populations, individual organisms, tissues, cells, subcellular structures, and molecules. The Department of Biological Sciences offers courses that address all of these levels and programs of study for undergraduates and for graduate students seeking the Ph.D.

For undergraduates, the department offers three majors and a minor. All three majors have honors tracks. The Biological Sciences (BioSci) major is designed for the student seeking a broad base in the biological sciences, though it is a highly flexible program that allows a certain amount of specialization in upper-level courses. The Molecular and Cellular Biology (MCB) major is designed for students with an interest in

developing an in-depth understanding of how living systems function at the molecular and cellular levels, with upper-level course options ranging in content from biophysics and biochemistry to developmental biology, and to molecular aspects of evolution and of toxicology. The Ecology, Evolution, and Organismal Biology (EEOB) major is designed for students with an interest in ecology, evolutionary biology, environmental biology, and conservation biology. The department also offers a minor in Biological Sciences for students majoring in other disciplines. Interested students should consult the appropriate director of undergraduate studies.

The department offers undergraduates opportunities for engaging in faculty-led research projects for course credit. Students may receive an introduction to the workings of a scientific laboratory through an internship, or a more intensive, hands-on experience in directed or independent laboratory research. Students on the honors track of any of the three majors carry out a major honors research project and write an honors thesis. More information about the majors and minor offered by the department, the honors track of each major, and research opportunities open to undergraduates is available at our Web site: <http://sitemason.vanderbilt.edu/biosci>.

#### *General Requirements*

All students in programs of concentration offered by the Department of Biological Sciences must take two semesters of general chemistry and lab (Chemistry 102a,b and 104a,b) and two semesters of organic chemistry and lab (Chemistry 219a,b and 220a,b). It is strongly recommended that students in all three majors take one year of calculus or calculus/statistics and one year of physics. A total of 30 hours of Biological Sciences courses, including the 8 hours of 110a,b and 111a,b, are required in all majors. All Biological Sciences courses count toward the major *except* 100, 105, and 115. Below is a listing of the required courses for the Biological Sciences (BioSci) major, for the Molecular and Cellular Biology (MCB) major, and for the Ecology, Evolution, & Organismal Biology (EEOB) major. Students with specialized interests within either of the specialized majors may substitute one of the intermediate courses with an upper level course with the permission of the director of undergraduate studies and the Biological Sciences Curriculum Committee. (*Intermediate Biological Sciences courses: 201, 202, 205, 210, 211, 218, 219, 220, 221, 237, 238*).

Students may declare only one of the majors offered by the Department of Biological Sciences; double or triple majors within the department are not permitted.

For honors in all three majors, additional requirements must be met: (a) normally a minimum GPA of 3.25 in courses that count toward the major; (b) at least 10 of the 30 hours of Biological Sciences course work must be directed/independent research with a minimum of 8 hours being honors research (BSCI 296); (c) an honors thesis and oral defense. For students in the MCB major, 265 must be taken; an alternate advanced course may be substituted with the permission of the director of undergraduate studies. For students in the EEOB major, one of the following courses must

be taken: 230, 238, 239, 246, 247, 257, 270. For the BioSci major, at least two lecture courses must be at a course number level of greater than 221.

*Program of Concentration in Biological Sciences (BioSci)*

At least 30 hours satisfying the general requirements above, and including the following:

1. Introductory Courses: 110a/111a and 110b/111b
2. Intermediate Courses:
  - a. 205, 210
  - b. one additional intermediate course: 201, 218, 219, 220, or 238
  - c. with at least one intermediate lab: 202 (with 201), 211 (with 210), 221 (with 220), 237 (with 238), or either 218 or 219 taken above
3. Laboratory: One additional intermediate or upper-level laboratory course, or two semesters of directed and/or independent research (BSCI 283, 286, 296).
4. Seminar/Independent Studies: A minimum of 2 credit hours of 275, 282, 283, 286, or 296 is required. Only one seminar (275) may count toward the major. A total of no more than 6 credit hours of 282, 283, and 286 may be counted toward the major.

For students intending to perform honors research, at least two Biological Sciences lecture courses must have a course number of greater than 221.

*Program of Concentration in Molecular and Cellular Biology (MCB)*

At least 30 hours satisfying the general requirements above, and including the following:

1. Introductory Courses: 110a/111a, 110b/111b
2. Intermediate Courses: 201, 210, 220, and either 202 (with 201) or 211 (with 210)
3. Laboratory: One additional intermediate or upper-level laboratory course, or two semesters of directed and/or independent research (BSCI 283, 286, 296).
4. Seminar/Independent Studies: A minimum of 2 credit hours of 275, 282, 283, 286, or 296 is required. Only one seminar (275) may count toward the major. A total of no more than 6 credit hours of 282, 283, and 286 may be counted toward the major.

Of the remaining courses, at least two must be from the following: 205, 226, 230, 240, 246, 247, 252, 256, 258, 262, 265, 266, 273, 274, 279, Honors Research (296).

For students intending to perform honors research in the MCB major, 265 must be taken; an alternate advanced lecture course may be substituted with the permission of the director of undergraduate studies.

*Program of Concentration in Ecology, Evolution, and Organismal Biology (EEOB)*

At least 30 hours satisfying the general requirements above, and including the following:

1. Introductory Courses: 110a/111a and 110b/111b
2. Intermediate Courses: 205, 210, and 218 or 219 or 238; one intermediate lab course if 218 or 219 are not taken: 211 (with 210), 237 (with 238).
3. Laboratory: One additional intermediate or upper-level laboratory course, or two semesters of directed and/or independent research (BSCI 283, 286, 296).
4. Seminar/Independent Studies: A minimum of 2 credit hours of 275, 282, 283, 286, or 296 is required. Only one seminar (275) may count toward the major. A total of no more than 6 credit hours of 282, 283, and 286 may be counted toward the major.

Of the remaining courses, at least two must be from the following: 224, 230, 239, 246, 247, 257, 266, 270, 273, Honors Research (296); or 218, 219, or 238 if not used for the intermediate course requirement.

For students intending to perform honors research in the EEOB major, one of the following courses must be taken: 230, 239, 246, 247, 257, 270.

*Minor in Biological Sciences*

A minor in Biological Sciences requires a minimum of 18 hours made up as follows: (a) 8 hours of BSCI 110a,b and 111a,b; (b) 210 and one other intermediate lecture course; (c) two other Biological Sciences courses, at least one of which must be a 3 hour lecture course, excluding 282, 283, 286, and 296.

*Starred courses Biological Sciences 110a–110b and 111a–111b serve as prerequisites for all higher numbered courses (except 115).*

**100. Biology Today.** Broad coverage of the biological sciences presenting evolution as a unifying concept. Particular emphasis on basic biological processes in cells and the relationships/interactions between organisms and their environment. Topics include cell structure and function, genetics and inheritance, evolution and diversity, populations, communities and ecosystems, and topics related to biology and society. Students who take 110a–110b may not receive credit for 100. Three lectures and one laboratory per week. FALL, SPRING. [4] Woelfle, Due-Goodwin.

**105. Human Biology.** An overview of the biology of humans with special emphasis on recent advances in genetics, reproduction, and biotechnology. The social, legal, and ethical implications of these advances will be explored. Not intended for students majoring in Biological Sciences. Students who take 110a–110b may not receive credit for 105. SPRING. [3] Johnson.

**★110a–110b. Introduction to Biological Sciences.** An integrative approach to the science of life from molecules to ecosystems. 110a: structure/function of macromolecules; cell structure; cell division; energy production and basic metabolism; molecular genetics; gene structure and regulation. 110b: cell signaling and hormones; physiology, development, immunology; Mendelian and population genetics; evolution and speciation; populations and

ecosystems. Ordinarily accompanied by 111a–111b. Corequisite or prerequisite: Chemistry 102a, FALL; 102b, SPRING. [3–3] Staff.

★**111a–111b. Biological Sciences Laboratory.** Laboratory to accompany 110a–110b. Corequisite: 110a–110b. One three-hour laboratory per week. 111a, FALL; 111b, SPRING. [1–1] Baskauf.

#### **115F. First-Year Writing Seminar.**

**201. Introduction to Cell Biology.** Structure and function of cells, subcellular organelles, and macromolecules. Fundamentals of organelle function, membrane transport, energy production and utilization, cell motility, cell division, intracellular transport and mechanisms of signal transduction. Prerequisite: Biological Sciences 110a–110b. SPRING. [3] Graham, Webb.

**202. Cell Biology Laboratory.** One three-hour laboratory and discussion period per week. May only be taken concurrently with or following 201. SPRING. [1] Janetopoulos.

**205. Evolution.** Evolutionary theory, with emphasis on evolutionary mechanisms. Microevolutionary processes of adaptation and speciation and macro-evolutionary patterns. Evidence from genetics, ecology, molecular biology, and paleontology in the historical context of the neo-Darwinian synthesis. Three lectures per week. No credit for graduate students in Biological Sciences. Prerequisite: 110a–110b. FALL. [3] Funk, McCauley.

**210. Principles of Genetics.** Basic principles and mechanisms of inheritance discussed and related to other biological phenomena and problems. Prerequisite: 110a–110b. FALL, SPRING. [3] Staff.

**211. Genetics Laboratory.** One three-hour laboratory and discussion period per week. May only be taken concurrently with or following 210. FALL. [1] Woelfle.

**218. Introduction to Botany.** Structure and function of plants, employing a survey of anatomical and morphological systems. Three lectures and one laboratory period per week. SPRING. [4] Benson.

**219. Introduction to Zoology.** A structural and functional study of the major animal groups. The problems presented to animals by their environments, and the anatomical and physiological mechanisms by which they adapt. Three lectures and one laboratory period per week. Prerequisite: 110a–110b. SPRING. [4] Leal, Catley.

**220. Biochemistry I.** Structure and mechanism of action of biological molecules, proteins, nucleic acids, lipids, polysaccharides. Enzymology. Carbohydrate metabolism. Prerequisite: 110a–110b and Chemistry 220a–220b. FALL. [3] Krezel, Kaplan.

**221. Biochemistry Laboratory.** Biochemical techniques; illustrations and applications of biochemical principles. Prerequisite: Chemistry 219a–219b and 220a–220b and pre- or corequisite 220. [1] (Not currently offered)

**224. Biology of Insects.** An introductory survey of insects, with emphasis on diversity, taxonomy, and ecology. Two lectures and two laboratory periods per week before spring break; seven days intensive field work at Archbold Biological Station, Florida, during spring break; then individual study and final report preparation.[4] (Not currently offered)

**226. Immunology.** The molecular and cellular basis of immunity. Emphasis on molecular structure, the genetic origin of diversity in B-cell and T-cell receptors, antigen presentation, and the cellular interactions leading to the immune response. Tolerance, tumor and transplantation immunity, autoimmune and immunodeficiency diseases, and allergy. Prerequisite: 201 or 210. FALL. [3] Carter.

**230. Biological Clocks.** Study of innate mechanisms for measurement of time in living organisms. Emphasis on the functional significance and physiological basis of biological clocks in animals and humans. Topics include circadian rhythms, time-compensated celestial navigation, photoperiodism, and the role of biological clocks in human behavior. Not open to students who have taken 115, Biological Clocks and Human Behavior. Prerequisite: 110a–110b. FALL. [3] McMahon.

**237. Ecology Lab.** One three-hour laboratory and discussion period or field trip per week. Prerequisite or Corequisite: 238. SPRING. [1] Due-Goodwin.

**238. Ecology.** Population biology, evolutionary ecology, community structure, with emphasis on species interactions, including competition, predation, and symbiosis. Prerequisite: 110a–110b. SPRING. [3] Abbot.

**239. Behavioral Ecology.** Theoretical and empirical research on shaping the evolution of behavior. The role of behavior in population regulation, habitat selection and spacing, foraging behavior, predatory-prey interactions, sexual selection, evolution of mating systems, new approaches to animal communication, game theory. Prerequisite: 110a–110b, 205. FALL. [3] Leal.

**240. Developmental Biology.** Genetic, molecular, and cellular mechanisms underlying development of eukaryotic organisms with emphasis on insects and vertebrate animals. Topics include regulation of gene expression during developmental processes, specification of embryonic polarity, generation and patterning of germ layers, organogenesis, axonal specificity, evolution of chordate body plan. Prerequisite: 201 and 210. FALL. [3] Solnica-Krezel, Zwiebel.

**242. Advanced Developmental Biology: Vertebrate Organogenesis.** Cellular and molecular regulation of the morphogenetic processes that shape vertebrate tissues and organs. Emphasis on development of digestive, respiratory, hematopoietic, cardiovascular, urogenital, sensory and nervous systems. Where appropriate, correlation to invertebrate development and reference to evolutionary changes in organ structure and function. Prerequisite: 240. [3] (Not currently offered)

**243. Genetics of Disease.** Application of genetics, cell biology, and molecular biology to the study of human diseases. Genomics, gene mapping, and molecular techniques. Animal models of disease. Chromosomal abnormalities, single-gene and multifactorial diseases, and epigenetics. Prerequisite: 210. FALL. [3] Gamse.

**246. Evolutionary Genetics.** Fundamentals of population and quantitative genetics. Natural selection, gene flow, genetic drift, population structure, linkage disequilibrium and the analysis of polygenic traits, including genetic map-based approaches. Special emphasis will be given to the genetics of adaptation and speciation. Prerequisite: 205 and pre- or corequisite 210. [3] (Not currently offered)

**247. Molecular Evolution.** The theory of evolution at the molecular level. The evolution of DNA and RNA sequences, proteins, and genome structures will be studied using models from population genetics and comparative approaches. Molecular clocks, the evolution of gene regulation and globin genes, molecular phylogeny, and human evolution. Prerequisite: 210 and 205. [3] (Not currently offered)

**252. Cellular Neurobiology.** Structure and function of nerve cells. Emphasis on electrical excitability, synaptic transmission, and sensory transduction. Cellular mechanisms underlying simple behaviors, sensory information processing, and learning and memory. Prerequisite: 110a–110b. FALL. [3] Page.

**253. Laboratory in Neurobiology.** Laboratory studies focusing on experimental methods in neurophysiology. Introduction to techniques for recording membrane potentials, studying

synaptic transmission, and analyzing neural mechanisms involved in sensory information processing and regulation behavior. May only be taken concurrently with or following 252. Prerequisite: 111a–111b. SPRING. [1] Catania.

**254. Neurobiology of Behavior.** Nerve cell interactions in neuronal networks of the central nervous system of animals and their impact for regulating behavior. Sensory systems, sensory-motor integration, central processing of information, neuronal-hormonal interactions; and brain anatomy and organization in invertebrates and vertebrates. Prerequisite: 110a–110b. FALL. [3] Catania.

**256. Molecular Neurobiology.** Comparative, evolutionary perspectives of molecular mechanisms underlying the development of neural circuits, the foundations of nerve cell communication, nervous system plasticity, and sensory processing, especially vision. Relation of these mechanisms to causes of human neurological diseases. Prerequisite: 110a and 110b. SPRING. [3] Broadie.

**257. Plant-Animal Interactions.** Ecology and evolution of species interactions at individual, population, and community levels; coevolution; pollination biology; fruit and seed dispersal; mammal and insect herbivore and plant defense mechanisms; ant-plant and animal-fungus interactions. Prerequisite: 205. [3] (Not currently offered)

**258. Vertebrate Physiology.** Fundamental mechanisms of the major vertebrate physiological systems with an emphasis on humans. Special physiological adaptations of vertebrates to their environment (respiration of aquatic animals, birds, and deep diving mammals; salt balance in fresh and saltwater environments; altitude adaptation). Prerequisite: 201 or 220. SPRING. [3] Oeltmann, Carter.

**259. Physiology Laboratory.** Laboratory to accompany 258. Experiments investigating major physiological processes (glucose-glycogen-protein metabolism, enzyme regulation during starvation; exertion, digestion, blood circulation, respiration, cold adaptation). May only be taken concurrently with, or following, 258. One three-hour laboratory per week. [1] (Not currently offered)

**262. Bimolecular Interactions.** Energetics and kinetics of interactions between proteins and nucleic acids and their ligands. Topics include cooperativity, allostery, rates of binding reactions. Students will gain direct experience in computer use, but no programming is required. Prerequisite: 220 and Physics 117a–117b. One lecture and two calculation sessions per week. [3] (Not currently offered)

**265. Biochemistry II.** Mechanistic biochemistry of the expression, transmission, and maintenance of genetic information. Replication, transcription, translation, recombination, and DNA repair. Prerequisite: 220. SPRING. [3] Eichman, Krezel.

**266. Advanced Molecular Genetics.** Principles of classical and molecular genetic analysis: mutation and recombination, mapping, and the application of genetic methodology to the study of complex systems. Special emphasis on modern genomic approaches. Prerequisite: 210. SPRING. [3] Friedman.

**268. Molecular Membrane Biology.** Biological membrane synthesis and its relationship to human disease. Regulation of cholesterol and phospholipid metabolism; integration of proteins into membranes; and trafficking of proteins and lipids. Prerequisite: 201 FALL. [2] Graham.

**270. Statistical Methods in Biology.** An introduction to statistical methods used in the analysis of biological experiments, including the application of computer software packages. Emphasis on testing of hypotheses and experimental design. Topics include descriptive statistics, analysis of variance, regression, correlation, contingency analysis, and the testing of methods for sampling natural populations. Prerequisite: 110a–110b. FALL. [3] McCauley.

**273. Molecular Mechanisms of Environmental Toxins.** Molecular interactions of environmental toxins with specific subcellular components and biochemical basis of their toxicity. Environmental mutagens, heavy metals, synthetic estrogens and other analogs of natural substrates, oxidants, and the question of synergy. Prerequisite: 210. FALL. [3] LeStourgeon.

**274. Proteins.** Molecular structures and biological functions of proteins. Underlying chemical and physical properties. Structural motifs and topology; folding and dynamics; enzyme catalysis; protein-DNA interactions. Structure-based drug design; protein symmetry; supramolecular protein machines. Chemical and spectroscopic methods to probe protein structure and behavior in solution. Prerequisite: 220. FALL. [3] Eichman.

**275a–275b. Undergraduate Seminar.** Discussions and papers based on readings in original research journals. Specific topics listed in the *Schedule of Courses*; further information from the listed instructor. May be taken for credit more than once, but only two hours count toward the major. Prerequisite: fulfillment of the intermediate course requirements for the major. FALL, SPRING. [2–2]

**279. Chemistry of the Brain.** Special biochemical reactions in brain, with emphasis on human brain. Synthesis and breakdown of brain molecules and their functions in membranes, synaptic transmission, and sensory transduction. Normal brain metabolism and the changes in neurological disease. Prerequisite: 220. [3] (Not currently offered)

**280a–280b. Introduction to Research.** Work in the laboratory of a member of the Biological Sciences faculty. A term paper on the research of the laboratory will be required. Prerequisite: 110a. Prerequisite or corequisite: 110b. Consent of course coordinator and enrollment by arrangement before the end of the previous semester is required. FALL, SPRING. [1 credit only per semester; course may be repeated to a total of two credits] Carter, coordinator.

**282. Independent Reading.** Reading and discussion of research papers with a member of the faculty. Permission to enroll by arrangement before the end of the previous semester. May be taken for credit twice. Prerequisite: consent of Biological Sciences 282 coordinator. FALL, SPRING. [1] Staff; Carter, coordinator.

**283. Directed Laboratory Research.** Directed student research on a project conceived by a member of the Biological Sciences faculty. Enrollment by arrangement before the end of the previous semester. May be taken only once, and participants ordinarily expected to have overall grade point average of *B* or better. Prerequisite: 110a–110b, one intermediate BSCI course appropriate to the major, and consent of Biological Sciences 283 coordinator. FALL, SPRING. [Variable credit: 2–4] Staff; Singleton, coordinator.

**286. Independent Laboratory Research.** Original student research on a defined problem in Biological Sciences and under the supervision of Biological Sciences faculty. Some independence in the design and execution of the problem. Enrollment by arrangement before the end of the previous semester. May be taken for credit more than once. Prerequisite: 283, consent of Biological Sciences 286 coordinator, overall grade point average of *B*. FALL, SPRING. [Variable credit: 2–6] Staff; Singleton, coordinator.

**290. Special Topics in Biological Sciences.** Topics offered vary and are cited in the *Schedule of Courses*. May be taken for credit more than once by permission of the director of undergraduate studies. Prerequisite: 110a–110b. SPRING. [3] Staff.

**296. Honors Research.** Open only to majors in the Honors Program. May be taken for credit more than once. FALL, SPRING. [Variable credit: 4–6] Staff; Patton, coordinator.