

Biological Sciences

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Manfred D. E. Ruddat, Ecology & Evolution, HM 261, 702-8623; Herbert

C. Friedmann, Biochemistry & Molecular Biology, CLSC 457, 702-6902;

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Program of Study

Biology is the study of living things and their adaptations to the pressures of natural selection. The faculty of the College believes that a sound knowledge of biology is essential for understanding many of the most pressing problems of modern life and for intelligent involvement in their eventual solution. The Biological Sciences Collegiate Division, therefore, provides a variety of general education courses for all College students—prospective biologists and nonbiologists alike. Although most of the course offerings beyond the introductory year are designed to serve the needs of biological sciences concentrators, many of these courses are well suited to students in other areas who wish to study some aspect of modern biology in greater detail. Courses on the ethical and societal implications of the biological sciences, for example, are of interest to all students.

Biological Sciences General Education Sequences

Students choose one of the following options to meet the general education requirement for the biological sciences:

- (1) an integrated Natural Sciences or Environmental Sciences sequence for nonconcentrators, covering all general education requirements in the physical and biological sciences; or
- (2) a two-quarter general education sequence for nonconcentrators; or
- (3) a Fundamental Sequence required for biological sciences concentrators and students preparing for the health professions.

Placement. This section describes ways that students may also meet the general education requirement in biological sciences using credit from the AP biology test or the College's own placement exam. This information is in effect for students matriculating in Autumn Quarter 2003 and after.

For students who do not plan to concentrate in the biological sciences or prepare for the health professions, a score of 4 or 5 on the AP biology test or a strong performance on the College placement exam confers credit for BIOS 10100. These students complete the general education requirement with either one or two topical courses in the biological sciences.

If they register for the "AP 5" Fundamental Sequence (described below), students with a score of 5 on the AP biology test will be awarded two quarters of credit for the general education requirement. This option is especially appropriate for students who plan to concentrate in the biological sciences or prepare for the health professions, but it is open to all qualified students.

Accreditation. Credit for particular biology courses may be granted to students upon satisfactory completion of an accreditation examination. An examination is given the first week of the quarter in which the particular course is offered, and students must register in the office of the senior adviser (HM 261) before the quarter begins. No laboratory requirements can be met by accreditation examinations except by special petition with accompanying documentation.

Biological Sciences Writing Program. The Biological Sciences Writing Program is designed to assist both professors and students in biological sciences courses that are reading and writing intensive. The program hires teaching assistants with both science- and humanities-based backgrounds to conduct writing workshops and discussion sections. Their services may or may not be offered in addition to the assistance of other teaching assistants assigned to a specific course. The program also helps to find alternative pedagogical and resource materials (i.e., books, research articles, films, online information). It further assists both in the conception of writing and reading assignments, and in determining grading criteria. In addition, the program is involved in a collaborative relationship with the John Crerar Science Library that provides information on library services and research strategies. The Biological Sciences Writing Program is affiliated with a limited number of courses for each quarter of each academic year.

Biological Sciences Concentration Program

The goals of the biological sciences concentration program are to give students (1) an understanding of currently accepted concepts in biology and the experimental support for these concepts, and (2) an appreciation of the gaps in our current understanding and the opportunities for new research in this field. Emphasis is placed on introducing students to the diversity of subject matter and methods of investigation in the biological sciences. The concentration is designed to prepare students for graduate or professional study in the biological sciences and for careers in the biological sciences. The following sections describe the requirements for a B.A. in the biological sciences.

General Education

To prepare for more advanced work in the biological sciences, concentrators must take CHEM 11101-11201/11102-11202 or higher to meet the general education requirement in physical sciences; MATH 13100-13200 or higher to meet the mathematics requirement in general education; and two courses in a Fundamental Sequence (BIOS 20181-20182 or 20191-20192) to meet the general education requirement in biological sciences. Concentrators with a score of 5 on the AP biology test may use their AP credit to meet the general education requirement in biological sciences.

Concentration Requirements

Courses in the Physical Sciences Collegiate Division

Biological sciences concentrators must complete the third quarter of general chemistry (CHEM 11301/11302 or higher); two quarters of organic chemistry (CHEM 22000-22100); two quarters of physics (PHYS 12100-12200 or higher); one additional quarter of calculus (MATH 13300 or higher) or statistics (STAT 22000); and one additional course in mathematics, advanced statistics (22000 or higher), chemistry, physics, or approved 20000-level physical science course.

Courses in the Biological Sciences

Fundamental Sequence. Students register for the final three quarters of their Fundamental Sequence (BIOS 20180s or 20190s) in the concentration, or for the two-quarter "AP 5" Fundamental Sequence if they have a 5 on the AP biology test.

20200-level Biological Sciences Courses. Students **also** register for Introduction to Biochemistry (BIOS 20200) plus five additional 20200-level courses in biological sciences. These five courses are selected by the student unless the student chooses to complete a "specialization," in which case three courses are stipulated by the specialization (see below).

NOTE: BIOS 00199, 00206, and 00299 may not be used to meet the requirements of the concentration. In most cases, courses listed under the heading "Specialized Courses" may not be used to meet the requirements of the concentration. Limited exceptions are specifically noted.

Summary of Requirements

General Education		CHEM 11101-11201/11102-11201 or higher† MATH 13100-13200, 15100-15200, or 16100-16200† BIOS 20181-20182 or BIOS 20191-20192 or a 5 on the AP biology test
Concentration	2-3	BIOS 20239 and either 20240, 20246, or 20247* (2) or completion of BIOS 20180s or 20190s (3)
	1	CHEM 11301/11302 or higher†
	1	BIOS 20200 (Biochemistry)
	5	biological sciences courses at the 21000-level or above (may include BIOS 00298)
	2	CHEM 22000-22100
	2	PHYS 12100-12200 or higher†
	1	MATH 13300, 15300, or 16300, or STAT 22000†
	1	additional course in mathematics, advanced statistics (22000 or higher), chemistry, physics, or approved 20000-level physical science course
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† *Credit may be granted by examination.*

* *Open only to students with a 5 on the AP biology test.*

Specialization Programs in the Biological Sciences

Students who wish to complete a "specialization" should discuss their plans with the specialization chair in Spring Quarter of their second year.

Specialization in Cellular and Molecular Biology. Biological sciences concentrators who meet the following requirements will be recognized as having completed a specialization in the area of cellular and molecular biology.

The following requirements must be met:

- Courses*
1. third quarter of organic chemistry (CHEM 22200)
 2. three of the five 20200-level courses in the biological sciences that are required for the biological sciences concentration must be completed within the specialization, with one course each from three of the four following areas being selected:
 - a. BIOS 21207 or 25107. Cell Biology
 - b. BIOS 21226. Genetics
 - c. BIOS 21227 or 23299. Developmental Biology
 - d. BIOS 21208 or 21209. Molecular Biology

- Laboratory Research*
- completion of an independent research project that either:
1. qualifies as a senior honors project; or
 2. is approved by the director of the specialization.

The specialization in cellular and molecular biology is administered by the Department of Molecular Genetics and Cell Biology. Contact Jim Miller (702-0981, jmiller@midway.uchicago.edu) or see Laurens Mets (702-8917, l-mets@uchicago.edu) for additional information or advice.

Specialization in Ecology and Evolution. Biological sciences concentrators who complete the course work indicated below and meet the requirements of the senior honors paper will be recognized as having completed a specialization in ecology and evolution. This specialization is recommended for students who are interested in pursuing graduate work in the field or in laboratory sciences of ecology, evolution, population genetics, or behavior. Based on the student's particular interest, he or she will elect a faculty adviser, who then will recommend specific courses necessary to meet the specialization requirements (see following section). The faculty adviser will also facilitate the placement of the student in an appropriate research laboratory in which to conduct an individual research project.

The following requirements must be met:

<i>Courses</i>	<ol style="list-style-type: none"> 1. three quarters of calculus and two quarters of statistics in lieu of physics requirement 2. three upper-level courses in the biological sciences, as recommended by the faculty adviser, from a menu of courses in ecology, evolution, genetics, and behavior
<i>Laboratory Research</i>	completion of original research in the laboratory under the guidance of a member of the ecology and evolution faculty, which will qualify the student to write a senior honors paper

The specialization in ecology and evolution is administered by the Department of Ecology and Evolution. For more information, consult Manfred Ruddat (702-8623, mrudat@uchicago.edu).

Specialization in Microbiology. Biological sciences concentrators who complete the following requirements will be recognized as having completed a specialization in microbiology. Students in this specialization are required to complete three quarters of organic chemistry. Students register for three core lecture courses in the specialization (BIOS 25206, 25216, and 25286), plus a laboratory requirement (BIOS 25210). Several electives are available to provide additional training in microbiology. With prior approval from the specialization chair, it may be possible to substitute one course from the list of suggested electives for one of the core courses. For more information, consult Olaf Schneewind, chairman of the Committee on Microbiology (834-9060, oschneewind@delphi.bsd.uchicago.edu), or Dominique Missiakas, undergraduate adviser of the Committee on Microbiology (834-8161, dmissiak@bsd.uchicago.edu).

Core Lecture Courses

BIOS 25206. Introduction to Bacterial Physiology

BIOS 25286. Viruses of Eukaryotes

BIOS 25216. Molecular Genetic Analysis of Bacterial Pathogenesis

Laboratory Requirement

BIOS 25210. Experimental Physiology of Bacteria

Electives in the Committee on Microbiology

BIOS 21307. Bacterial Genomes

BIOS 25305/25306. Introduction to Microbes of Men and Beast

Honors Program in the Microbiology Specialization. Students who complete a research thesis have an opportunity to receive rigorous advanced training in microbiology and receive honors. To graduate with honors in the biological sciences with a specialization in microbiology, students are required to (1) maintain a GPA of 3.25 or higher both overall and in the concentration, and (2) meet the lecture and laboratory course requirements of the specialization with a GPA of 3.25 or higher. They must also register for two research/reading courses (see below) and complete an experimental honors thesis project based on an experimental report covering at least two quarters of work in the laboratory of a faculty member of the Committee on Microbiology. The honors thesis paper and progress of the honors student in the final (fourth) year of study will be evaluated by a Committee of three faculty members assembled by the Chair of the Committee on Microbiology. Students interested in a research thesis should discuss their plans with the committee chair and enroll in 00199 (Undergraduate Research, Autumn Quarter), 00299 (Advanced Research in the Biological Sciences, Winter Quarter), and 00298 (Undergraduate Research Seminar, Spring Quarter).

Specialization in Neuroscience. Biological sciences concentrators who complete the three required courses listed below will be recognized as having completed a specialization in neuroscience. Students who elect to specialize should consult the faculty adviser, Dorothy Hanck, who is available to advise on the choice of classes and to help identify laboratories in which individual research projects can be carried out. Students who plan to specialize are encouraged to begin the required sequence below in Spring Quarter of their second year, carry out individual guided research, participate in the honors research program, and attend seminars related to neurobiology/biopsychology. The required courses are:

BIOS 24204. Cellular Neurobiology

BIOS 24205. Systems Neuroscience

BIOS 24214. Cognitive Neuroscience

The following courses deal with topics of interest to neuroscientists. Students specializing in neuroscience may use these courses as electives to meet concentration requirements. Please note that the psychology courses meet concentration requirements only for students specializing in neuroscience.

BIOS 24207. Developmental Neurobiology

BIOS 24211. Neuroethology

BIOS 24216. Neuropharmacology

BIOS 24217. Conquest of Pain

BIOS 24218. Molecular Neurobiology

BIOS 24221. Computational Neuroscience I:
Single Neuron Computation

BIOS 24222. Computational Neuroscience II: Vision
 BIOS 24223. Computational Neuroscience III: Language
 BIOS 24237. Biological Rhythms and Sleep
 BIOS 24238. Scientific Approaches to Mental Illness
 BIOS 29405. Mathematical and Statistical Methods for Neuroscience I
 BIOS 29406. Mathematical and Statistical Methods for Neuroscience II
 BIOS 29407. Mathematical and Statistical Methods for Neuroscience III
 PSYC 31000. Perspectives in Drug Abuse
 PSYC 32000. Color Vision
 PSYC 35000. Physiology of Vision
 PSYC 38000. Seminar: Memory and Learning
 PSYC 38700. Connectionist Modeling: Techniques

Grading. Students must receive quality (letter) grades in all courses in the concentration.

Research Opportunities. Students are encouraged to carry out individual guided research in an area of their interest. A student may propose an arrangement with any faculty member in the Biological Sciences Collegiate Division to sponsor and supervise research on an individual tutorial basis. Students register for BIOS 00199 or 00299 for course credit. Consult the course description section for information about procedures, grading, and requirements for registration in BIOS 00199 and 00299.

Some financial support may be available to students with third- or fourth-year standing for summer research through their research supervisors or through fellowships awarded competitively by the Biological Sciences Collegiate Division.

Honors in Biological Sciences. Students may earn a bachelor's degree with honors in the biological sciences by satisfactorily completing an individual research program and honors thesis. To be eligible for honors, students must also have a GPA of 3.25 or higher overall and in concentration courses based on all course work up to the final quarter of graduation. Students are urged to consult with their advisers and with the director of the honors program well before their senior year for guidance on meeting the requirements for honors.

Honors students rarely begin their research later than the summer before their senior year; most honors students begin research in their junior year or earlier. Fourth-year students usually complete BIOS 00299 during Autumn and Winter Quarters and must complete BIOS 00298 in Spring Quarter. Students prepare oral and visual presentations of their research for a poster session early in Spring Quarter. Fourth-year students who wish to be considered for honors must submit a first draft of their thesis before the end of third week of Spring Quarter; it will be evaluated by two reviewers and returned to them with comments. The final version will then be due at the end of eighth week, and must be approved by the director of the honors program in consultation with the reviewers.

Faculty

P. Amarasekare, Y. Amit, C. Andrews, P. Ashton-Rickardt, J. Austin, W. Barnhart, J. Bates, J. Bergelson, S. Boyle-Vavra, K. Cagney, M. Casadaban, L. Casalino, M. Caserta,

B. Chernoff, K.-S. Chiang, A. Chong, T. Christianson, M. Coates, C. Correll, N. Cox, J. Coyne, J. Crispino, R. Daum, H. de Wit, J. Dignam, A. DiRienzo, W. Du, G. Dwyer, W. Epstein, R. Esposito, M. E. Feder, E. Ferguson, B. Fineschi, J. Flynn, M. Foote, J. Foss, G. Franzoso, H. C. Friedmann, T. Gajewski, P. Gejman, G. Getz, M. Giger, B. Glick, L. Goldman, P. Goldstein, W. Green, J. Greenberg, G. Greene, E. Grove, S. Hackett, M. Hale, K. Hamann, D. Hanck, R. Haselkorn, N. Hatsopoulos, L. Heaney, A. Heller, R. Ho, W. Hoff, R. Hudson, A. Hunter, N. Issa, D. Jablonski, R. Josephs, T. Karr, S. Kent, M. Kreitman, S. Kron, V. Kumar, M. LaBarbera, B. Lahn, G. Lamppa, J. Lantos, E. Larsen, D. Lauderdale, M. Leibold, C. Lese-Martin, W.-H. Li, A. Lin, P. Lloyd, R. E. Lombard, M. Long, K. Macleod, A. Mahowald, M. W. Makinen, J. Malamy, D. Margoliash, S. Margulis, T. E. Martin, D. Maestriperieri, M. McClintock, R. McCrea, D. McGehee, F. McMahan, K. Medina, S. C. Meredith, L. Mets, K. Millen, J. Miller, D. Missiakas, A. Montag, J. Moss, G. Mueller, P. Mueller, S. Mufwene, M. Musch, J. Nachman, T. Nagylaki, D. Nelson, M. Nishimura, A. Noronha, C. Ober, C. Palfrey, T. Pan, N. Patel, S. Patel, B. Patterson, R. Perlman, M. Peter, C. Pfister, J. Piccirilli, K. Pickett, L. Pottenger, R. Potter, D. Preuss, V. Prince, S. Pruett-Jones, J. Quintans, C. Ragsdale, J.-M. Ramirez, P. Rathouz, T. Regier, P. Rice, B. Roizman, M. Rosner, L. F. Ross, L. Rothman-Denes, M. D. E. Ruddat, A. Sanders, J. Saul, U. Schmidt-Ott, O. Schneewind, C. Schonbaum, M. Schreiber, P. Schumacker, E. Schwartz, P. Sereno, J. Shapiro, K. Sharma, N. Shubin, P. Sierwald, H. Singh, S. Sisodia, M. W. Sohn, T. Sosnick, A. Sperling, J. Staley, T. Steck, D. F. Steiner, U. Storb, F. H. Straus II, L. P. Straus, B. S. Strauss, P. Strieleman, S. Szuchet, W.-J. Tang, E. W. Taylor, K. Thompson, A. Turkewitz, P. Ulinski, L. M. Van Valen, M. Verp, P. Vezina, M. Villereal, P. Wagner, C.-R. Wang, M. Westneat, W. Wimsatt, T.-W. Wong, J. T. Wootton, C. Wu, X. Zhuang, Y. Zou

Courses

Students must confirm their registration with their instructors by the second class meeting or their registration may be canceled. In the following course descriptions, L indicates courses with a laboratory. Laboratory courses can also be identified by the final digit in the course number: 0-5 indicates that the course has a laboratory and 6-9 indicates that there is no laboratory associated with the course (with the exception of courses in the general education series and the 00199-00299 series).

General Education Sequences

1. **Integrated physical and biological sciences sequences for nonconcentrators.** These sequences are open only to first- and second-year students and to entering transfer students.
 - A. NTSC 10100-10200-10300-10400 emphasizes the evolution of the physical universe and life on Earth and is described in the Natural Sciences section of this catalog.
 - B. ENST 12100-12600 weaves together several basic science disciplines relevant to our understanding of human impact on the natural environment and is described in the Environmental Studies and Natural Sciences sections of this catalog. This six-quarter sequence also meets the general education requirement in mathematical science for nonconcentrators.
2. **The general education sequences for nonconcentrators.** Students choose from the following options to meet the biological sciences requirement. The requirement should be completed by the end of the second year.

- A. Students in this sequence take Core Biology (BIOS 10100) as their first course. This comprehensive introduction to the biological sciences consists of interactive lectures, discussions, and laboratories. (Laboratory fees apply.) For their second quarter, students choose from a menu of topical courses (BIOS 10101-19999) that are comprehensive reviews of specialized topics of interest in the biological sciences. Nonconcentrators are encouraged to enroll in additional biological sciences courses that cover topics of special interest to them.
- B. Either of the following two sequences may serve as an alternative to the two-quarter BIOS 10100 plus topical course sequence: (1) "Integrative Biology" (BIOS 10200/10201) is appropriate for students interested in a more quantitative and analytical introduction to biology. (2) "Nature of Life" (BIOS 10400/10401) is appropriate for students interested in a more chemical and molecular introduction to biology. Students who elect to take the second sequence should have a strong background in high school chemistry.
- 3. Fundamental Sequences for Concentrators and Students Preparing for the Health Professions.** Biological sciences concentrators take a six-quarter integrated series that includes a five-quarter Fundamental Sequence plus Biochemistry (BIOS 20200). Each quarter includes major laboratory components. Both five-quarter Fundamental Sequences (BIOS 20180s and 20190s) provide comprehensive coverage of modern biology. Topics include cell and molecular biology, genetics, developmental biology, ecology and evolution, and organismal biology. The first two quarters of these sequences are used to meet the general education requirements in the biological sciences.
- 4. Advanced Placement Sequence for Concentrators with a Score of 5 on the AP Biology Test.** Concentrators with a score of 5 on the AP biology test may take the two-quarter Fundamental Sequence described below in place of a five-quarter sequence. These students use two quarters of AP credit to meet the general education requirement for biological sciences and register for the "AP 5" two-quarter sequence in the concentration. BIOS 20239 must be taken first. This course must be followed by either BIOS 20240, 20246, or 20247; and 20200.

General Education Courses

10100. Core Biology. This course addresses the question "what is life?" with a discussion of topics that range from the essential properties characteristic of all life to the complexities of evolution and interactions between all forms of life in the biosphere. Students in the course develop a broad common core of understanding of the nature of life through lectures, small group discussions, writing, and laboratory investigations. A second biology course builds on this core knowledge by focusing on a specialized topic of biological inquiry. *R. Potter, T. Christianson, A. Hunter, B. Fineschi. Autumn, Winter, Spring.*

10200. Integrative Biology I. This sequence is an alternative to BIOS 10100 for students interested in a more quantitative and analytical introduction to the biological sciences. The first quarter covers the

acquisition and use of energy at the cellular and organismal level. Structure and function of organisms are discussed with respect to evolutionary adaptation and biomechanics. The course has interactive lectures, discussions, and labs. *E. Larsen. Winter. L.*

10201. Integrative Biology II. *PQ: BIOS 10200.* This course is the second in the sequence for students interested in a more quantitative and analytical introduction to the biological sciences. We cover the acquisition and use of energy at the population and ecosystem level. Population interactions and ecosystem structure and function are considered. The course has interactive lectures, discussions, and labs. *E. Larsen. Spring. L.*

10300. Cells in their Environment. (=ENST 12200, NTSC 12200) *PQ: ENST 12100 or NTSC 12100, or consent of instructor. This course is an alternative to BIOS 10100 for students enrolled in the Environmental Sciences sequence.* We consider the molecular basis of life. Our focus is on the evolved structure, function and organization of cells and their constituents. We also take up how cells store and express information, obtain and use energy, and interact with their natural environment. *T. Steck. Winter. L.*

10301. Organisms and Ecosystems in the Environment. (=ENST 12400, NTSC 12400) *PQ: BIOS 10100 or 10300, or consent of instructor. This course qualifies as a topical course in the biological sciences general education requirement or as the second biological sciences course in the Environmental Sciences sequence.* This course examines the interactions between organisms and their environments. Topics include reproduction, disease, population, conservation, and interactions between species. Organismal biology and ecology are related to environmental problems (e.g., overpopulation, biodiversity loss, pollution) from a scientific perspective. *A. Hunter. Autumn.*

10400. Molecular and Cellular Nature of Life. *This course is the first in a sequence that is an alternative to BIOS 10100 for students interested in the more chemical and molecular aspects of biology.* In this course we examine the principles underlying the universal processes on which all forms of life, from humans to dandelions to bacteria, are based. We begin by discussing the fundamental chemical strategies that mediate energy conversion, coupling of metabolic pathways, and information storage and expression. With that understanding, we discuss crucial characteristics of life phenomena at the cellular level and then conclude the course with a look at the rapidly advancing field of genetic engineering and its far-reaching implications for our lives. *K.-S. Chiang. Winter. L.*

10401. The Origin of Life. *PQ: BIOS 10400. This course is the second in a sequence that is an alternative to BIOS 10100 for students interested in the more chemical and molecular aspects of biology.* In this course we discuss current thinking about the processes by which life emerged from just a few abiotic molecules and evolved into the present-day dazzling structural complexity characteristic of life. We begin by defining what is necessary and sufficient for life at its most basic level and discussing the fundamental chemical strategies that support life. With that understanding, we examine in some depth current theories and conjectures regarding chemical evolution and the emergence of the very first cell, the precursor to all life on earth. *K.-S. Chiang. Spring.*

Topical Courses

The courses below have a PQ of BIOS 10100, or placement into a topical course, or a score of 4 or 5 on the AP biology test.

11108. Human Heredity. *PQ: BIOS 10100.* This course introduces the progress and problems in human genetics. Topics include genetic and physiologic determinants of sex, patterns of human inheritance, analysis of DNA and DNA fingerprinting, DNA cloning, prenatal genetic diagnosis, the genetics of complex traits, and the genetics of human populations. Assignments are based on current newspaper or magazine articles that reflect the interaction of genetics with some political, social, economic, or ethical issue. *B. Strauss. Winter.*

11109. Molecules to Cells and Back. *PQ: BIOS 10100.* Selected topics of current medical and/or environmental interest are used to illustrate basic principles of cell and molecular biology. *T. Martin. Spring.*

11116. Genetic Engineering. *PQ: BIOS 10100.* This course covers the history and technology of the efforts of humans to manipulate the genetic makeup of organisms. We focus most of our attention on genetic engineering in the production of agricultural, industrial, and medical products. We engage as a group in some virtual engineering projects. We also assess the ethical and public policy issues that are raised by rapid advances in genetic engineering technology. *Field trips to sites where the work of genetic engineers is on display required. L. Mets. Spring.*

11117. Cell Biology. *PQ: BIOS 10100.* This course treats the cell as a molecular machine. The course begins with a brief introduction (or review) of the chemistry of biological molecules and the concept of energy. The sub-assemblies that make up the machine are discussed: information storage system (DNA), manufacturing machinery (protein synthesis), membranes, energy transducers (mitochondria and chloroplasts), motile systems, and communication systems. The coordination of the subassemblies makes the parts function as a living cell. The minimum requirements to be classed as a living cell (past and future) are discussed. *E. Taylor. Spring.*

11118. Introduction to Stem Cell Biology. *PQ: BIOS 10100.* Most classes are presented in a journal club format discussing selected readings from the primary literature. The classes are conducted in an interactive style. Students are assigned papers to present on an alternating basis and those not presenting are expected to participate in the discussion. *K. Medina. Spring.*

12106. Human Physiology. *PQ: BIOS 10100.* This lecture/discussion class deals with topics of human physiology. The subject matter is divided into three main categories: relationship between form and function; biological order, regulation, and homeostasis; and unity within diversity and human perspective. *S. Patel. Spring.*

12107. Cell Biology of Physiological Stress. *PQ: BIOS 10100.* This course studies the application of cell biology principles to physiological stress. We use paradigms such as fasting to talk about organ interactions (e.g., the Cori cycle). This includes discussions of receptors, kinases, and other cellular biology. *M. Musch. Autumn.*

12108. Biology and the Human Condition. *PQ: BIOS 10100.* We discuss the insights that biology offers into some perennial human questions. Do the biological imperatives for reproduction and population growth inevitably conflict with the goals of a civilized society? Why do disease and suffering persist? In what ways are all people similar and in what ways is each individual unique? How do our genetic inheritances and our individual experiences interact in development? Is there a "human nature?" *R. Perlman. Winter, Spring.*

13106. The Hungry Earth, Light, Energy, and Subsistence. *PQ: BIOS 10100.* The theme of the class includes a consideration of the continuing erosion of the resources of the Earth by the persisting pressures of a growing human population, which makes a broad knowledge and appreciation of biology essential. Discussion includes the principles of energy conversion by plants as primary producers, the evolution of the structures and mechanisms involved in energy conversion, the origin of crop plants, improvements of plants by conventional breeding and genetic engineering, and the interactions of plants with pathogens and herbivores. *M. Ruddat. Spring.*

13107. Environmental Ecology. (=ENST 10400, NTSC 10400) *PQ: BIOS 10100.* This course emphasizes basic scientific understanding of ecological and evolutionary principles that relate most closely to the ways humans interact with their environments. Topics include population growth, adaptation, and ecosystem structure and function. We also discuss the regulation and consequences of biodiversity. *Discussion required. M. Leibold. Winter.*

13109. Ecology. *PQ: BIOS 10100.* Ecology is the study of the distribution and abundance of organisms. This course highlights key themes in ecology (e.g., how the environment affects species, evaluating the viability of populations, the implications for interactions among species, and the function of ecosystems). Emphasis is placed on how ecological information is being applied in the area of conservation biology. *C. Pfister. Autumn.*

13118. Genetically Modified Organisms. *PQ: BIOS 10100.* In this course, we discuss issues surrounding the production of genetically modified organisms. We begin by understanding genetic manipulation and how it can enhance agriculture and medicine. We then focus on critically evaluating the scientific basis of health and environmental concerns. Readings from the primary literature are supplemented with background information on genetic technologies and with presentations from the media. *The class includes lectures, videos, student presentations, and extensive discussions. J. Bergelson. Winter.*

14106. From Neuron to Brain. *PQ: BIOS 10200 or 10100. College-level calculus (a total of two quarters are required; one quarter may be taken concurrently). Consent of instructor.* This course is an introduction to the structure and function of the nervous system that is intended for non-biological science concentrators. It deals with the cellular structure of the nervous system, membrane properties of neurons, synapses and voltage gated channels, and a survey of important neural systems. *J. Foss. Spring.*

14107. Workings of the Human Brain. *PQ: BIOS 10100.* This course is designed to give students an overview of the many functions of the brain, including perception, movement, language, emotion, memory, and sleep. We use a model of disease or dysfunction in an area of the brain to understand its normal functioning. This approach is complemented by presenting modern methods such as functional MRI and by reviewing historical milestones in neuroscience. *Attendance required at each class meeting including lectures, labs, review sessions, and screenings of videotapes and imaging sessions.* A. Noronha. Spring.

14108. Introduction to the Nervous System. *PQ: BIOS 10100. Extensive biology background not required but some knowledge of the field is helpful.* This course is designed for students who are interested in learning the biology of the nervous system. Information is disseminated in the form of lectures that cover the basic principles and discussion sessions that illustrate specific examples. We cover compartments within the nervous system, development of different neuronal subtypes, neuronal connectivity, and neural activity in embryos and its role in sculpting neuronal connectivity. K. Sharma, Y. Zou. Autumn.

15106. Plagues: Past and Present. *PQ: BIOS 10100.* Plagues and epidemics of infectious diseases have played roles in influencing the course of civilization throughout the ages. We explore examples while we also learn to understand various types of infectious agents that have threatened men from both a biological and historical perspective. To this end, the student studies the impact of selected plagues and the biological basis behind modern methods of diagnosing, treating, and preventing them. Students learn the biological basis of how microbes gain access to their hosts and how the immune system tries to resist infection. S. Boyle-Vavra. Winter.

15108. Immune System in Health and Disease. *PQ: BIOS 10100.* This class introduces basic concepts of molecular biology and immunology. Subjects discussed include principles and applications of genetic engineering; defense mechanisms against infection and cancer; and various disorders of the immune system (e.g., allergy, autoimmunity, AIDS). C.-R. Wang. Winter.

15109. The Origins of Cancer. *PQ: BIOS 10100.* In this lecture/discussion course, the molecular biology and clinical aspects of cancer are considered in tandem. In particular, the most prevalent malignant tumors (e.g., those arising in the breast, prostate, colon, and lung) are used as examples. T. W. Wong. Spring.

16178. Introduction to the Biological Bases of Psychiatry. *PQ: BIOS 10100.* This course is an introduction to the bases of biological psychiatry, designed to enable interested students from various concentrations to acquire current knowledge of biological aspects of mental illness and pertinent research methods. Several main lines of inquiry into contemporary biological psychiatry are discussed, including hypotheses on the etiology of mental illness (and the current controversies), the basis for the classification of mental diseases, principles of brain neurotransmission, genetics of mental illness and behavioral traits, animal models of behavior, brain correlates of psychiatric symptoms, and several major psychiatric disorders and their treatment. P. Gejman, A. Sanders. Spring.

Five-Quarter Fundamental Sequences

BIOS 20181-20185

This five-course sequence is an integrated introduction to the breadth of biology as a modern scientific discipline. It is designed for students who are preparing for a career in the biological sciences or medical professions. The material in this sequence is largely the same as that in the BIOS 20190s sequence. Topics include cell and molecular biology, genetics, developmental biology, organismal biology, and ecology and evolution. Students registering for this sequence must have completed or placed out of General or Honors Chemistry or be enrolled concurrently in General or Honors Chemistry.

20181. Cell and Molecular Biology. This course is an introduction to molecular and cellular biology that emphasizes the unity of cellular processes amongst all living organisms. Topics are the structure, function, and synthesis of nucleic acids and protein; structure and function of cell organelles and extracellular matrices; energetics; cell cycle; cells in tissues and cell-signaling; altered cell functions in disease states; and some aspects of molecular evolution and the origin of cells. *T. Martin, D. Nelson, C. Schonbaum. Autumn. L.*

20182. Genetics. *PQ: BIOS 20181.* The goal of this course is to integrate recent developments in molecular genetics and the human genome project into the structure of classical genetics. Topics include Mendelian inheritance, linkage, tetrad analysis, DNA polymorphisms, human genome, chromosome aberrations and their molecular analysis, bacterial and virus genetics, regulatory mechanisms, DNA cloning, mechanism of mutation and recombination, and transposable elements. *J. Malamy, P. Strieleman, G. Webb. Winter. L.*

20183. Developmental Biology. *PQ: BIOS 20181 and 20182.* This course covers both the classical experiments that contributed to our understanding of developmental biology and the recent explosion of information about development made possible by a combination of genetic and molecular approaches. Examples from both vertebrate and invertebrate systems are used to illustrate underlying principles of animal development. *R. Ho, J. Crispino, C. Schonbaum. Spring. L.*

20184. Biological Diversity. *PQ: BIOS 20181-20183 or consent of instructor.* An overview of the diversity of living organisms, both prokaryotes and eukaryotes, is presented. We emphasize the major groups of organisms, their evolutionary histories and relationships, and the biological and evolutionary implications of the characteristic features of each group. We discuss how the biosphere transformed to its present state over the past four billion years. *M. LaBarbera, E. Larsen. Autumn. L.*

20185. Ecology and Evolution. *PQ: BIOS 20181 and 20182.* This course surveys the major principles of ecology and evolutionary biology. Topics in evolutionary biology include the evidence for evolution, the history of life, the mechanisms of evolution (e.g., mutation, selection, and genetic drift), adaptation, speciation, the origin of evolutionary

novelties, the origin of life, and human evolution. Topics in ecology include demography and life histories, competition, predation, and the interspecific interactions that shape the structure of ecological communities. *T. Wootton, J. Coyne, C. Andrews. Winter. L.*

BIOS 20191-20195

This integrated five-quarter sequence examines the fundamental biological processes that are the basis of all life. Topics include cell and molecular biology, genetics, developmental biology, ecology and evolution, and organismal biology. Before registering for BIOS 20191, students must have completed or placed out of General or Honors Chemistry or they must have consent of instructor.

20191. Cell and Molecular Biology. *PQ: CHEM 11300 or 12300, or consent of instructor.* The fundamental molecular processes of cells are examined using evidence from biochemical, physiologic, and microscopic analyses. Topics include the logical, spatial, and temporal organization and regulation of metabolism; the formation and function of proteins, RNA, and DNA; generation and function of cellular structures and compartments; regulation of gene expression; the organization and regulation of cell growth and division; and cell-environment and cell-cell interactions. *Discussion section required. L. Mets, B. Glick, C. Schonbaum. Autumn. L.*

20192. Genetics. *PQ: BIOS 20191.* The goal of this course is to integrate recent developments in molecular genetics and the human genome project into the structure of classical genetics. Topics include Mendelian inheritance, linkage, tetrad analysis, DNA polymorphisms, human genome, chromosome aberrations and their molecular analysis, bacterial and virus genetics, regulatory mechanisms, DNA cloning, mechanisms of mutation and recombination, and transposable elements. *L. Mets, C. Schonbaum, Staff. Winter. L.*

20193. Developmental Biology. *PQ: BIOS 20191 and 20192.* This course covers both the classical experiments that contributed to our understanding of developmental biology and the recent explosion of information about development made possible by a combination of genetic and molecular approaches. Examples from both vertebrate and invertebrate systems are used to illustrate underlying principles of animal development. *V. Prince, C. Schonbaum. Spring. L.*

20194. Ecology and Evolution. *PQ: BIOS 20191 and 20192.* This course surveys the major principles of ecology and evolutionary biology. Topics in evolutionary biology include the evidence for evolution, the history of life, the mechanisms of evolution (e.g., mutation, selection, and genetic drift), adaptation, speciation, the origin of evolutionary novelties, the origin of life, and human evolution. Topics in ecology include demography and life histories, competition, predation, and the interspecific interactions that shape the structure of ecological communities. *R. Hudson, G. Dwyer, C. Andrews. Autumn. L.*

20195. Organismal Physiology. *PQ: BIOS 20191 and 20192, or consent of instructor.* This course is concerned with fundamental

physiological functions and their relation to structure. In multicellular organisms the responsibilities for preservation of an appropriate cellular milieu, substrate intake and metabolite excretion, circulation of substrates and metabolites, locomotion, and integration of function are achieved by specializations of cells into organs. The biological principles of organ development, interaction, regulation, and coordination to mediate survival of the organism are examined using models from simple multicellular organisms to humans. *P. Schumacker, D. McGehee, E. Larsen. Spring. L.*

Two-Quarter "AP 5" Fundamental Sequence

(for students with a score of 5 on the AP biology test)

A score of 5 on the AP biology test places a concentrator or a student preparing for the health professions out of the biological sciences general education requirement and into a two-quarter sequence in the concentration. These students register for BIOS 20239 and either BIOS 20240, 20246, or 20247. NOTE: As this catalog went to press, this sequence was being reviewed with the intent of adding laboratory content to the courses.

20239. Molecular Biology I. *PQ: A score of 5 on the AP biology test, and prior or concurrent registration in General or Honors Chemistry.* This course introduces the concepts and fundamentals of molecular biology. The instruction includes central features and model systems of molecular biology, cellular macromolecules and their chemical structures, enzymes, protein structure and function, DNA structure and function, transcription, protein synthesis, gene regulation, and DNA technology. *T. Pan. Winter.*

20240. Molecular Biology II. *PQ: BIOS 20239 or consent of instructor. First-year standing and a score of 5 on the AP biology test. Intention to concentrate in biological sciences recommended.* This seminar course examines the experimental basis for understanding the biology of the eukaryotic cell. We focus on specific examples of scientific discovery as described in research papers taken from primary literature. Students critique each paper, both in class and in essays. A lab section allows students to form and examine their own hypotheses by observing simple biological phenomena and manipulating conditions of experiments. *S. Kron. Spring. L.*

20246. Photons to Consciousness. *PQ: BIOS 20239 or consent of instructor.* This course uses the visual system as a model to explore how the brain works. The course begins by considering the physical properties of light. We then proceed to consider the mechanism of sensory transduction, cellular mechanisms of neuron to neuron communication, the operation of small neural networks, strategies of signal detection in neuron networks, and the hierarchical organization of cortical function. We conclude with visually guided behavior and consciousness. *Spring.*

20247. Animal Models of Human Disease. *PQ: BIOS 20180s or 20190s, or 20239, or consent of instructor.* This course provides an introduction to the use of animals in biomedical research for the purposes of understanding, treating, and curing human disease. Particular emphasis is placed on rodent models in the context of genetic, molecular, and immunologic manipulations. *K. Hamann, A. Sperling. Spring.*

20248. Foundations of Scientific Investigation. *PQ: First-year standing and a score of 5 on the AP biology test.* An introduction to the scientific approach. A historical overview of how modern science has developed will be followed by studies of a number of papers. Both classical (Mendel and Garrod) and more recent examples will illustrate how scientists identify and study problems. Course requirements include class discussions, oral presentations and written papers. *W. Epstein. Autumn.*

Advanced-Level Courses

There are three types of advanced courses. In courses listed under the heading *General Courses*, instructors present the general principles and recent developments for broad areas within the biological sciences. Such courses are usually offered on a regular basis, either annually or biennially. In courses listed under the heading *Specialized Courses*, the focus is on either a topic of particular interest to the instructor or on topics that are examined at a more advanced level than in *General Courses*. Such courses are offered less regularly, as warranted by student and faculty interest. Unless otherwise stated, most *General Courses* and *Specialized Courses* assume mastery of the material covered in the Fundamental Sequences. Courses listed under the headings *Specialized Courses* and *Independent Study and Research* may not be counted toward the courses required for the concentration with the exception of BIOS 00298.

The following list provides information for students who are planning programs of study. Letters after course titles refer to the subject matter presented in the course: (C) Cell and Molecular, Genetics, or Developmental Biology; (CI) Computer Intensive; (E&E) Ecology and Evolution; (F) Fundamental Sequence; (M) Microbiology, Virology, and Immunology; (N) Neuroscience; (S) Specialized; and (O) Organismal. *L* indicates courses with laboratory.

Autumn Quarter

- 20181. Cell and Molecular Biology. *L.* (F)
- 20184. Biological Diversity. *L.* (F)
- 20191. Cell and Molecular Biology. *L.* (F)
- 20194. Ecology and Evolution. *L.* (F)
- 20200. Introduction to Biochemistry. *L.* (F)
- 21207. Cell Biology. (C)
- 21227. Advanced Developmental Biology. (C)
- 21306. Human Genetics and Evolution. (C)
- 21336. Cell Signaling. (C)
- 22232. Mammalian Biology. *L.* (O)
- 22257. Darwinian Medicine. (O)
- 23248. Primate Behavior and Ecology. (E&E)
- 23256. Fundamentals of Molecular Evolution. (E&E)
- 23260. Mammal Evolution. *L.* (E&E)
- 23270. Evolution: Genes to Groups. *L.* (E&E)
- 23351. Ecological Applications to Conservation Biology. (E&E)
- 23403. Systematic Biology. *L.* (E&E)
- 24205. Systems Neuroscience. *L.* (N)
- 24216. Neuropharmacology. (N)
- 24221. Computational Neuroscience I: Single Neuron Computation. *L.* (N)
- 24238. Scientific Approaches to Mental Illness. (N)
- 25206. Fundamentals of Bacterial Physiology. (M)
- 26099. Quantitative Topics in Biology I: Ecology. (CI)
- 29206. Introduction to Medical Physics. (S)

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- 29283. Neurology and Kant's Theory of Knowledge. (S)
- 29306. Evolutionary Processes. (S)
- 29405. Mathematical and Statistical Methods for Neuroscience I. (N)

Winter Quarter

- 20182. Genetics. *L.* (F)
- 20185. Ecology and Evolution. *L.* (F)
- 20192. Genetics. *L.* (F)
- 20200. Introduction to Biochemistry. *L.* (F)
- 20239. Molecular Biology I (AP 5). (F)
- 21208. Fundamentals of Molecular Biology. (C)
- 21209. Molecular Biology. (C)
- 21216. Introductory Statistical Genetics. (C)
- 21226. Advanced General Genetics. (C)
- 21319. RRP: Ribosomes, RNA, and Protein. (C)
- 22226. Human Developmental Biology. (O)
- 22234. Chordate Biology. *L.* (O)
- 22242. Biological Fluid Mechanics. *L.* (O)
- 22246. Physiology. (O)
- 23240. The Diversity and Evolution of Plants. *L.* (E&E)
- 23246. The Diversity and Evolution of Plants. (E&E)
- 23249. Animal Behavior. (E&E)
- 23406. Biogeography. (E&E)
- 24211. Neuroethology. *L.* (N)
- 24217. Conquest of Pain. (N)
- 24222. Computational Neuroscience II: Vision. *L.* (N)
- 24237. Biological Rhythms and Sleep. (N)
- 25107. Immunobiology. (M)
- 25108. Cancer Biology. (M)
- 25210. Laboratory in Bacterial Physiology. *L.* (M)
- 26100. Quantitative Topics in Biology II: Physiology and Biochemistry. *L.* (CI)
- 26400. Introduction to Bioinformatics. *L.* (CI)
- 29281. Introduction to Medical Ethics. (S)
- 29292. Medical Odysseys. (S)
- 29293. On Becoming a Doctor. (S)
- 29296. Biological and Cultural Evolution. (S)
- 29406. Mathematical and Statistical Methods for Neuroscience II. (N)

Spring Quarter

- 20183. Developmental Biology. *L.* (F)
- 20193. Developmental Biology. *L.* (F)
- 20195. Organismal Physiology. *L.* (F)
- 20200. Introduction to Biochemistry. *L.* (F)
- 20240. Molecular Biology II (AP 5). *L.* (F)
- 20246. Photons to Consciousness. (F)
- 20247. Animal Models of Human Disease. (F)
- 20248. Foundations of Scientific Investigation. (F)
- 21200. Human Molecular Genetics. *L.* (F)
- 21259. Development and Evolution. (C)
- 21304. Photosynthesis. *L.* (C)
- 21307. Bacterial Genomes. (C)
- 21316. Biochemistry. (C)
- 21318. Molecular Biophysics. (C)
- 21356. Vertebrate Development (O)
- 21406. Electron Microscopy and Image Processing. (C)
- 22244. Introduction to Invertebrate Biology. *L.* (O)
- 22247. Principles of Pharmacology. (N)
- 23250. Research in Animal Behavior *L.* (E&E)
- 23252. Field Ecology. *L.* (E&E)
- 23255. Introductory Paleontology. *L.* (E&E)
- 23266. Evolutionary Adaptation. (E&E)
- 23299. Plant Development and Molecular Genetics. (E&E)

23401. Mutualisms and Symbiosis. *L.* (E&E)
 23402. Diversity and Evolution of Arthropods. *L.* (E&E)
 24204. Cellular Neurobiology. *L.* (N)
 24218. Molecular Neurobiology. (N)
 24223. Computational Neuroscience III: Language. *L.* (N)
 24236. Cellular Neurobiology. (N)
 24207. Developmental Neurobiology. (O)
 24214. Cognitive Neuroscience. *L.* (N)
 25107. Immunobiology. (M)
 25109. Topics in Reproductive Biology and Cancer. (M)
 25216. Molecular Genetic Analysis of Bacterial Pathogenesis. (M)
 25239. Microbiology. (M)
 25286. Viruses of Eukaryotes. (M)
 25305. Microbes of Men and Beast. *L.* (M)
 25306. Microbes of Men and Beast. (M)
 25407. Organ Transplantation. (M)
 26317. Molecular Mechanisms of Cell Signaling. (C)
 26401. Evolutionary Genomics. *L.* (CI)
 29282. Advanced Medical Ethics. (S)
 29283. Neurology and Kant's Theory of Knowledge. (S)
 29290. Doctors as Guides and Helpers in the Healing Profession. (S)
 29407. Mathematical and Statistical Methods for Neuroscience III. (N)
 29293. On Becoming a Doctor. (S)
 29316. Molecular Dissection of the Gene and Genome. (M)

General Courses

Most general and specialized courses that are at the 20000-level and above assume mastery of the material covered in the Fundamental Sequences. Students who have not yet completed these sequences should consult with the individual instructor and the BSCD senior adviser before registering for the following courses.

20200. Introduction to Biochemistry. *PQ: BIOS 20181-20182 or 20191-20192, and CHEM 22000-22100. This course meets the biochemistry requirement for the concentration. This course examines the chemical nature of cellular components, enzymes, and mechanisms of enzyme activity, energy interconversions, and biosynthetic reactions, including template-dependent processes and some aspects of control mechanisms. P. Strieleman, Summer; H. Friedmann, P. Strieleman, Staff, Autumn, Winter, Spring. L.*

21200. Human Molecular Genetics. *PQ: BIOS 20239. The focus of this course is to study the basic principles of genetics in relation to human disease and human variations. Emphasis is placed on the molecular and analytical methods that are used to study human genetic diversity and evolution, as well as to map human disease genes. Lectures and labs are utilized to explore state-of-the-art approaches to a broad range of topics in human genetics. C. Ober, R. Potter. Spring. L.*

21207. Cell Biology. *PQ: BIOS 20200 or equivalent. This course surveys gene organization and expression; functions of the cell nucleus, cytoskeleton, and cytoplasmic structures; and cell-cell interactions and signaling. P. Mueller, G. Lamppa. Autumn.*

21208. Fundamentals of Molecular Biology. (=BCMB 31000, GENE 31000, MGCB 31000) *PQ: Basic knowledge of genetics and biochemistry. Third- or fourth-year standing. This comprehensive course covers structure*

of genetic material, replication, recombination, transcription and its regulation, and post-transcriptional regulation, chromatin and DNA repair (both after transcription), and protein synthesis. *U. Storb, J. Staley. Winter.*

21209. Molecular Biology. *PQ: BIOS 20200.* This class focuses on current concepts in gene regulation at both the transcriptional and post-transcriptional levels. Topics include regulation of transcription initiation and elongation, pre-mRNA splicing and processing, RNA export, mRNA turnover, translational controls, protein degradation, and protein modification. Emphasis is placed on eukaryotic examples, but prokaryotic models are discussed where appropriate. *H. Singh. Winter.*

21216. Introductory Statistical Genetics. (=HGEN 47100) *PQ: BIOS 21200 and college-level statistics course.* Our goal is that class members gain an understanding of genetic models for complex human disorders and quantitative traits. Students also learn how to conduct parametric and non-parametric linkage analyses, as well as linkage disequilibrium mapping using transmission/disequilibrium tests (TDT) and decay of haplotype sharing (DHS). *N. Cox. Winter.*

21226. Advanced General Genetics. *PQ: BIOS 20182 or 20192.* This course deals with the molecular and cellular basis of genetic change. We discuss DNA repair functions, mutator loci, induced mutation, mechanisms of homologous recombination and gene conversion, site-specific recombination, transposable elements and DNA rearrangements, reverse transcription and retrotransposons, transposable vector systems for making transgenic organisms, and genetic engineering of DNA sequences in antibody formation. *Discussion section required. J. Shapiro. Winter.*

21227. Advanced Developmental Biology. (=DVBI 35400, MGCB 35400) *PQ: BIOS 20182 or 20192.* This course is an overview of the field of developmental biology, emphasizing the origins of classical concepts in the field as well as the modern molecular and genetic approaches to the study of developmental processes. Underlying mechanisms are illuminated through discussion of key experiments. Examples are drawn from the literature on invertebrate and vertebrate embryology. Subjects include induction, embryonic pattern formation, cell and tissue interactions, and the control of gene expression in development. *E. Ferguson, J. Malamy. Autumn.*

21259. Development and Evolution. (=DVBI 35700, EVOL 33800, MGCB 35700, ORGB 33800) *PQ: BIOS 20180s or 20190s, or consent of instructor.* Over the last decade, genetic and molecular approaches in a few model systems (e.g., *Drosophila*, *C. elegans*, *Arabidopsis*, mouse) have led to a detailed understanding of several steps in pattern formation during the development of each respective organism. Our purpose is to evaluate how our knowledge of developmental mechanisms in model organisms can help us understand the evolution of development. *N. Patel. Spring.*

21304. Photosynthesis. *PQ: BIOS 20200 and 20180s, or 20190s.* Fundamental photosynthetic processes occur on time domains of femtoseconds, minutes, seasons, centuries, and eons. Critical photosynthetic events occur on molecular, sub-cellular, cellular, organismal, ecosystem, and global scales. This course considers photosynthesis as an integrated whole over both its temporal and spatial domains. Chemical, biophysical,

biochemical, genetic, developmental, physiologic, ecological, and evolutionary methods are employed to analyze the net processes and detailed mechanisms of photosynthesis. *L. Mets. Spring. L. Offered 2002-03; not offered 2003-04.*

21306. Human Genetics and Evolution. *PQ: BIOS 20180s or 20190s, or consent of instructor. Open to students with advanced standing who are concentrating in the biological sciences or preparing for the medical professions.* This course deals with issues in genetics of variations within, as well as between, modern human populations. Normal genetic variations and the genetic basis of human diseases are explored with an emphasis at the molecular level. The course stresses understanding the fundamental concepts of genetics and evolution using mainly, but not exclusively, human studies as examples. Genome organization, genetic mapping, population genetic theories, and molecular evolution of humans are covered. *C.-I. Wu. Autumn.*

21307. Bacterial Genomes. *PQ: BIOS 26400 and consent of instructor.* This course examines the information available from complete bacterial genome sequences. It addresses the usefulness of sequence databases and bioinformatics for answering questions of functional and comparative genomics. The genome sequences serve as the basis for addressing special topics in microbiology (e.g. communication, cellular differentiation, pathogenicity, vaccine development, bacterial evolution). The format is seminar-style discussions of specific genomes. *J. Shapiro. Spring.*

21316. Biochemistry. *PQ: BIOS 20200. Required of biological chemistry concentrators.* This course examines a variety of biological problems from a chemical and structural perspective. Topics include macromolecular structure-function relationships, DNA and protein synthesis and repair, RNA folding and catalysis, molecular motors, nitrogen fixation; photosynthesis; and mechanisms of signal transduction. Homework includes computer graphics exercises that complement the lecture topics. *W. Hoff, P. Rice. Spring.*

21318. Molecular Biophysics. (=BCMB 32400) *PQ: CHEM 22000-22100 and college-level physics, or consent of instructor.* This is an introductory course emphasizing concepts of physical chemistry important in the interactions of biological macromolecules, with emphasis on structure, dynamics, and kinetics. The course focuses on basic aspects of secondary and tertiary structure, the origin and basis of electrostatic and hydrophobic interactions, dynamical properties of proteins, and the structural basis of enzyme action. Problem sets, including use of molecular graphics workstations, are coordinated with lectures. *M. W. Makinen, W. Hoff. Spring.*

21319. RRP: Ribosomes, RNA, and Protein. *PQ: General Chemistry, Organic Chemistry, and BIOS 20200.* The course is devoted to RNA biochemistry and molecular biology and to RNA-protein interactions with special emphasis on ribosome structure and protein biosynthesis. Topics include the biochemistry of protein synthesis (i.e., the translation reactions such as initiation, elongation, and termination); tRNA structure and identity elements; rRNA (i.e., structure, processing, regulation of synthesis, function, and evolution); ribosomal proteins (i.e., structure, function, gene

organization, regulation of synthesis); ribosome assembly; ribosome structure from immuno-electron microscopy, neutron scattering, and x-ray defraction; RNA (i.e, protein interactions including tRNA-aminoacyl-tRNA syntase, rRNA-ribosomal proteins, and other examples); and, finally, regulation and translation. *I. Wool. Winter.*

21336. Cell Signaling. (=CPHY 30036, NPHP 30036) *PQ: BIOS 20200 and 20183, or 20193.* Cells in the body communicate with each other by a variety of extracellular signals (e.g., hormones, neurotransmitters) that are disseminated locally or in the bloodstream to distant targets. What happens when these signals are received by the target cells? The subject matter of this course considers the wide variety of intracellular mechanisms that, when activated, change cell behavior. Both general and specific aspects of intracellular signaling are covered in the course, the latter including detailed discussions of receptors, G-proteins, cyclic nucleotides, calcium and calcium-binding proteins, phosphoinositides, protein kinases, and phosphatases. *C. Palfrey. Autumn.*

21356. Vertebrate Development. (=DVBI 35600) *PQ: BIOS 20180s or 20190s and permission of course co-coordinator.* This advanced-level course combines lectures, student presentations, and discussion sessions. It covers major topics on the developmental biology of embryos (e.g., formation of the germ line, gastrulation, segmentation, nervous system development, limb patterning, organogenesis). We make extensive use of the primary literature and emphasize experimental approaches (e.g., classical embryology, genetics, molecular genetics). *V. Prince, K. Millen, R. Ho. Spring.*

21406. Electron Microscopy and Image Processing. (=MGCB 34300) *PQ: One year of calculus.* Whether one is trying to read radio signals from far-away galaxies or to understand molecular structures, it is necessary to understand how to read, interpret, and process the data that contain the desired information. In this course we learn how to process the information contained in images of molecules as seen in the electron microscope. This course deals with the principles involved in processing electron microscope images, including the underlying analytical methods and their computer implementation. *R. Josephs. Spring.*

22226. Human Developmental Biology. *PQ: Completion of the general education requirement for the biological sciences. Prior chemistry and organismal biology courses.* This course examines the physiologic, cellular, and biochemical functions of a series of organs and systems in their transition from fetal to newborn life in the human, and the implications of these changes for successful adaptation to independent life. Examples of failures of adaptation and disease states are presented and discussed. The organs and systems covered are brain, lung, heart, liver, immune system, blood-forming system, intestine, endocrine organs, and kidney. *M. Schreiber. Winter.*

22232. Mammalian Biology. *PQ: Completion of the general education requirement for the biological sciences.* This course covers the structure and function of major organ systems of the typical mammal with dissection, histological material, and lectures correlating function with gross and microscopic structure. There is a focus on the organ systems of man. *F.*

Straus, L. Straus. Autumn. L.

22234. Chordate Biology. *PQ: Completion of the general education requirement for the biological sciences.* This is a general consideration of the structure, evolution, phylogeny, and life history of vertebrates. We emphasize comparative morphology, as well as structural and functional evolution. *N. Shubin, M. Coates. Winter. L.*

22242. Biological Fluid Mechanics. *PQ: Completion of the general education requirement for the biological sciences. Prior physics course required; prior chemistry and calculus courses recommended.* This course is an introduction to fluid mechanics and the interactions between biology and the physics of fluid flow (both air and water). Topics range from the fluid mechanics of blood flow to the physics (and biology) of flight in birds and insects. *M. LaBarbera. Winter. L. Offered 2002-03; not offered 2003-04.*

22243. Biomechanics of Organisms. *PQ: Completion of the general education requirement for the biological sciences. Prior chemistry, physics, and calculus courses recommended.* This course examines how organisms cope with their physical environment, covering the properties of biological materials, mechanical analysis of morphology, and principles of design optimization. We emphasize support systems of organisms but also examine aspects of cardiovascular design. Mechanical properties of biomaterials are analyzed in relation to their underlying biochemical organization and biophysical properties, with mathematical treatment at an introductory level. The lab research project is optional. *M. LaBarbera. Winter. L. Offered 2004-05; not offered 2002-03 or 2003-04.*

22244. Introduction to Invertebrate Biology. *PQ: Completion of the general education requirement for the biological sciences or consent of instructor.* This is a survey of the diversity, structure, and evolution of the invertebrate phyla, with emphasis on the major living and fossil invertebrate groups. Structure-function relationships and the influence of body plans on the evolutionary history of the invertebrate phyla are stressed. *M. LaBarbera. Spring. L. Offered 2003-04; not offered 2002-03.*

22246. Physiology. *PQ: BIOS 20184 or 20195, or consent of instructor.* This course considers physiological mechanisms that operate at all levels, ranging from the subcellular to the whole organism, to support organismal function. The course emphasizes physiological reasoning, problem solving, and current research. We consider examples from molecular, cellular, human, comparative, and pathophysiology. We emphasize aspects of physiology other than neurophysiology, such as membrane transport, intracellular communication, respiration, circulation, thermoregulation, and osmoregulation. *M. Feder. Winter.*

22247. Principles of Pharmacology. *PQ BIOS 20200.* This course considers the physiological and biochemical bases of drug actions, common pharmacological methods, and a small set of specific drugs and their targets. *D. Hanck. Spring.*

22257. Darwinian Medicine. (=HIPS 25900) *PQ: Completion of the general education requirement for the biological sciences.* This course

discusses human health and disease in an evolutionary perspective and emphasizes how principles from evolutionary biology, ecology, and genetics can increase our understanding of the physiological mechanisms and populational processes that affect the maintenance of health and origin of disease. Topics include host-parasite interactions; the evolution of virulence and of host defenses; the ecology of emerging diseases, including AIDS; the cultural and social contexts of disease; and epigenetic mechanisms in health and disease. *R. Perlman, W. Wimsatt. Autumn.*

23240. The Diversity and Evolution of Plants. *PQ: Completion of the general education requirement for the biological sciences.* The lectures address the diversity in morphology, anatomy, reproduction, and evolutionary trends, beginning with cyanobacteria and progressing to flowering plants. The unifying aspects of cell structure and function are emphasized, along with the basic physiological and molecular mechanisms in plants. The lab is correlated with the lectures to examine representatives of the major taxonomic plant groups and basic physiological techniques. This course is identical to BIOS 23246 except that it has a lab. *M. Ruddat. Winter. L.*

23246. The Diversity and Evolution of Plants. *PQ: Completion of the general education requirement for the biological sciences.* This course is identical to BIOS 23240 except that it does not have a lab. *M. Ruddat. Winter.*

23248. Primate Behavior and Ecology. (=EVOL 37300, HUDV 21800) For course description, see Human Development. *D. Maestriperi. Autumn.*

23249. Animal Behavior. *PQ: Completion of the general education requirement for the biological sciences.* This course provides an introduction to the mechanism, ecology, and evolution of behavior, primarily in nonhuman species, at the individual and group level. Topics include the genetic basis of behavior, developmental pathways, communication, physiology and behavior, foraging behavior, kin selection, mating systems and sexual selection, and the ecological and social context of behavior. A major emphasis is placed on understanding and evaluating scientific studies and their field and lab techniques. *S. Pruett-Jones. Winter. Offered 2003-04; not offered 2002-03.*

23250. Research in Animal Behavior. (=EVOL 33200) *PQ: BIOS 23249 or consent of instructor.* Students develop and collect data on an independent research project of their choosing. Training in the methods of behavioral research precedes the initiation of the research projects. All behavioral observations are conducted at Brookfield Zoo. Discussion with the instructor and TA facilitates progress. Students analyze and interpret data, and present their findings orally or in poster form, as well as in written form, at the end of class. *S. Margulis. Spring.*

23252. Field Ecology. *PQ: Consent of instructor. Open to students planning to pursue graduate research.* This course is an introduction to habitats and biomes in North America and the methods of organizing and carrying out field research projects in ecology and behavior, focusing on questions of evolutionary significance. The course consists of a two-week field trip to southern Florida during the Winter/Spring Quarter break. The field trip

consists of informal lectures and discussions, individual study, and group research projects. During Spring Quarter there are lectures on the ecology of the areas visited and on techniques and methods of field research. *S. Pruett-Jones. Spring. L. Offered 2002-03; not offered 2003-04.*

23255. Introductory Paleontology. (=EVOL 32300, GEOS 22300) *PQ: GEOS 13100-13200, or PHSC 10800/10900-11000, BIOS 20195, or completion of the general education requirement for the biological sciences, or consent of instructor.* For course description, see Geophysical Sciences. *M. Foote. Spring. L.*

23256. Fundamentals of Molecular Evolution. *PQ: Prior calculus course or consent of instructor.* The comparative analysis of DNA sequence variation has become an important tool in molecular biology, genetics, and evolutionary biology. This course covers evolutionary forces governing molecular variation and divergence and genome organization. It explores the evolutionary assembly of genes, the origin of novel gene function, the population genetics of repetitive DNA variation, and the evolution of multigene families. The course also provides practical information on accessing genome databases, searching for homologous sequences, aligning DNA and protein sequences, calculating sequence divergence, producing sequence phylogenies, and estimating evolutionary parameters. *M. Kreitman, T. Nagylaki. Autumn.*

23260. Mammal Evolution. (=EVOL 31100) *PQ: Completion of the general education requirement for the biological sciences or consent of instructor.* This course is an introduction to the major features of mammalian evolution. It surveys major groups of mammals, including both living and fossil *taxa*. We focus on phylogeny, morphology, biogeography, and patterns of diversification and extinction, using illustrations from the Field Museum's world-class collections of fossil and living mammals. *Taught at Field Museum with transportation arranged as needed. J. Flynn. Autumn. Offered 2003-04; not offered 2002-03. L.*

23266. Evolutionary Adaptation. *PQ: BIOS 20185, 20194, or 20239; and BIOS 20240.* This course deals with the adaptation of organisms to their environments and focuses on methods for studying adaptation. Topics include definitions and examples of adaptation, the notion of optimization, adaptive radiations, and the comparative method in evolutionary biology. *C. Andrews. Spring.*

23270. Evolution: Genes to Groups. *PQ: BIOS 20180s or 20190s.* This course introduces evolutionary processes and patterns in present-day and fossil organisms and how they are shaped by biological and physical forces. Topics emphasize evolutionary principles and issues of "microevolution" versus "macroevolution" by comparing and contrasting evolution across various hierarchical levels (e.g., genes, individuals, populations, species). Specific topics include DNA and the genetic code; the genetics of populations; the origins of species; evolution above the species level and "trends"; and major events in the history of life (e.g., the origin of complex cells, the invasion of land, mass extinctions). *P. Goldstein, J. Flynn (2002-03); P. Goldstein, P. Wagner (2003-04). Autumn. L.*

23299. Plant Development and Molecular Genetics. (=DVBI 36100,

ECEV 32900, MGCB 36100) *PQ: Completion of the general education requirement for the biological sciences.* This course describes the growth, differentiation, and development of plants at the organismal, cellular, and molecular levels. Emphasis is placed on the regulatory function of plant hormones, particularly in response to environmental stimuli and in control of gene expression. Recent advances using molecular genetic approaches in *Arabidopsis* and maize are a central feature of the course. *M. Ruddat, J. Greenberg. Spring.*

23351. Ecological Applications to Conservation Biology. (=ECEV 31300, ENST 25100) *PQ: Completion of the general education requirement for the biological sciences.* We focus on the contribution of ecological theory to the understanding of current issues in conservation biology. The course emphasizes quantitative methods and their use for applied problems in ecology, such as the design of natural reserves, the risk of extinction, the impact of harvesting, the dynamics of species invasions, and the role of species interactions. Course material is drawn mostly from the current primary literature. *Two Saturday field trips and computer modeling labs are in addition to scheduled class time. J. Bergelson, C. Pfister. Autumn. L. Offered 2003-04; not offered 2002-03.*

23401. Mutualisms and Symbiosis. *PQ: Completion of the general education requirement for the biological sciences or consent of instructor.* Fungi, bacteria, and other microbes are often intimately associated with plants and animals in diverse mutualistic and other symbiotic relationships. This course focuses on the importance and intricacies of these associations. A survey of the variety of mutualisms with animals and plants is presented. Plant/fungus mutualisms highlighted include mycorrhizae, endophytes, and lichens. Morphological, physiological, and ecological aspects of these associations are treated. *G. Mueller. Spring. L. Offered 2002-03; not offered 2003-04.*

23402. Diversity and Evolution of Arthropods. *PQ: BIOS 20180s or 20190s.* This course focuses on arthropod systematics and evolution, with an emphasis on insects and spiders. Lectures focus on facets of arthropod evolution (i.e., theories of arthropod origins, the evolution of flight, and metamorphosis). Labs focus on comparative examination of diverse arthropod groups, and students are expected to achieve a general understanding of major arthropod groups. *P. Goldstein, P. Sierwald. Spring. L. Offered 2002-03; not offered 2003-04.*

23403. Systematic Biology. (=EVOL 35400) *PQ: Completion of the general education requirement for the biological sciences and knowledge of college algebra.* Systematic biology encompasses such activities as discovering and classifying biological diversity, estimating the phylogenetic relationships among species or larger lineages, and testing hypotheses about evolutionary processes. From the standpoint of the three schools of systematic biology (i.e., evolutionary, phenetic, and phylogenetic), the course carefully explores the concepts of homology, relationships, species, and higher *taxa*. We consider the central role of systematic biology in the biological sciences and use systematic hypotheses to test theories about evolutionary or biological processes. *B. Chernoff. Autumn. L.*

23406. Biogeography. (=ENST 25500, EVOL 45500, GEOG 25500/35500)

PQ: Completion of the general education requirement for the biological sciences or consent of instructor. This course examines factors governing the distribution and abundance of animals and plants. Topics include patterns and processes in historical biogeography, island biogeography, geographical ecology, areography, and conservation biology, such as the design and effectiveness of nature reserves. B. Patterson (odd years, lab); L. Heaney (even years, discussion). Winter.

24204. Cellular Neurobiology. (=PSYC 31100) *PQ: Completion of the general education requirement for the biological sciences. This course meets one of the requirements of the neuroscience specialization. This course is identical to BIOS 24236 except that it has a lab, which focuses on electrophysiological techniques used in analysis of issues fundamental to neural processing at the cellular level. These include monitoring membrane potential, carrying out voltage clamp of native and cloned ion channels, and investigating the control of synaptic transmission. D. Hanck, P. Lloyd. Spring. L.*

24205. Systems Neuroscience. *PQ: BIOS 24204 or 24236, or consent of instructor. This course meets one of the requirements of the neuroscience specialization. Students are introduced to vertebrate and invertebrate systems neuroscience with a focus on the anatomy, physiology, and development of sensory and motor control systems. The neural bases of form and motion perception, locomotion, memory and other forms of neural plasticity are examined in detail. We also discuss clinical aspects of neurological disorders. Labs are devoted to mammalian neuroanatomy and electrophysiological recordings from neural circuits in model systems. J. Ramirez, J. Goldberg. Autumn. L.*

24207. Developmental Neurobiology. (=NPHP 32500) *PQ: BIOS 24204, 24205, and consent of instructor. This course examines the development of the vertebrate nervous system. We trace the development of the brain from the first induction of neural tissue in the embryo to the refinement of synaptic connections late in development by emerging brain activity. We discuss the new synthesis of classical experimental embryology and modern techniques of molecular biology that have led to several recent breakthroughs in our understanding of neural development. E. Grove, Y. Zou, N. Issa. Spring.*

24211. Neuroethology. (=CPNS 30100, PSYC 31500) *PQ: BIOS 24204 or consent of instructor. Prior or concurrent registration in PHYS 14200. Prior knowledge of basic cellular mechanisms of neurons and basic anatomy of the vertebrate central nervous system. The design of this course considers the needs of advanced students who plan to pursue graduate work, particularly in neurobiology or experimental psychology. It covers topics in systems, computational, and behavioral neuroscience. There is a heavy emphasis on original literature, and oral and written scientific presentations. Labs include exposure to instrumentation and electronics, and involve work with live animals. Labs meet once a week and may require time beyond the posted schedule. D. Margoliash. Winter. L.*

24214. Cognitive Neuroscience. (=CPNS 30200, PSYC 34214) *PQ: One year of college-level calculus and prior course in systems neuroscience. This course meets one of the requirements of the neuroscience*

specialization. This course is concerned with the relationship of the nervous system to higher order behaviors such as perception, action, attention and learning and memory. Modern methods of imaging neural activity are introduced. Mathematical and statistical methods including dynamical systems theory, information theory, and pattern recognition for studying neural encoding in individual neurons and populations of neurons are discussed. *N. Hatsopoulos. Spring. L.*

24216. Neuropharmacology. (=NPHP 32700, NURB 32700) *PQ: BIOS 24204 and 24205, or consent of instructor.* This course explores the biochemical basis of neuropharmacology using the textbook of the same name by Cooper, Bloom, and Roth. Cellular and molecular foundations are explored through topics including neurotransmitter systems, synaptic transmission, and centrally-active agonist and antagonist drugs. *P. Vezina. Autumn.*

24217. The Conquest of Pain. *PQ: CHEM 22000-22100-22200 or BIOS 20200. Prior course in neurobiology or physiology recommended.* This course examines the biology of pain and the mechanisms by which anesthetics alter the perception of pain. The approach is to examine the anatomy of pain pathways both centrally and peripherally, and to define electrophysiological, biophysical, and biochemical explanations underlying the action of general and local anesthetics. The role of opiates and enkephalins is discussed in detail. Central theories of anesthesia, including the relevance of sleep proteins, are also examined. Additionally, mechanistic discussions of acupuncture and cutaneous nerve stimulation are included. *J. Moss. Winter.*

24218. Molecular Neurobiology. *PQ: BIOS 20200 and 24236 or 24204, or consent of instructor.* This is a lecture/seminar course that explores the application of modern cellular and molecular techniques to clarify basic questions in neurobiology. Topics include mechanisms of synaptic transmission, protein trafficking, exo- and endo-cytosis, and development and mechanisms of neurological diseases. *S. Sisodia, Staff. Spring.*

24221. Computational Neuroscience I: Single Neuron Computation. (=CPNS 30030, ORGB 34400) *PQ: Prior course in cellular neurobiology or consent of instructor required; prior or concurrent registration in MATH 20000 recommended.* This course briefly reviews the historical development of computational neuroscience and discusses the functional properties of individual neurons. The electrotonic structure of neurons, functional properties of synapses, and voltage-gated ion channels are discussed. *P. Ulinski, D. Hanck. Autumn. L.*

24222. Computational Neuroscience II: Vision. (=ORGB 34500) *PQ: BIOS 24221 and a prior course in systems neurobiology, or consent of instructor required; prior or concurrent registration in MATH 20100 recommended.* This course considers computational approaches to vision. It discusses the basic anatomy and physiology of the retina and central visual pathways and then examines computational approaches to vision based on linear and nonlinear systems theory, information theory and algorithms derived from computer vision. *P. Ulinski, Staff. Winter. L.*

24223. Computational Neuroscience III: Language. (=ORGB 34600,

PSYC 34400) *PQ: Consent of instructor.* This course discusses computational approaches to human language. It examines the learning, production, and comprehension of language, through neural network modeling of human linguistic behavior, and through brain imaging. *T. Regier, Staff. Spring. L.*

24236. Cellular Neurobiology. *PQ: Completion of the general education requirement for the biological sciences.* This course is identical to BIOS 24204 except that it does not have a lab. This course covers the cellular properties of neurons and glia (structure and function), membrane potential, action potential, properties of voltage-gated and ligand-gated ion channels, mechanism of synaptic transmission, the known cellular bases of memory, and cellular mechanisms of sensory transduction. *D. Hanck, P. Lloyd. Spring.*

24237. Biological Rhythms and Sleep. (=PSYC 34237) *PQ: Completion of the general education requirement for the biological sciences, including a course in neuroscience.* This course considers oscillatory process in human physiology and behavior and discusses their functional implications. The focus is on circadian rhythms (i.e., those with a near twenty-four hour period) and includes a consideration of molecular and genetic controls and their neuroanatomical basis. Sleep-wake homeostasis, reproducibility of diurnal variations in hormonal release, metabolism, cardiovascular function, cognitive function, and mood are discussed. This course includes an overview of sleep disorders and alterations of biological rhythms in aging, blindness, and effective illness, as well as a consideration of current therapies (e.g., melatonin, hypnotic drugs). *E. Van Cauter. Winter.*

24238. Scientific Approaches to Mental Illness. (=PSYC 34338) *PQ: Completion of the general education requirement in biology required; prior course in neurobiology recommended.* This course considers the biological bases of mental illness including pertinent research methods in psychiatry and culminating with a panel discussion of coming developments in biological psychiatry. *P. Gejman, A. Sanders. Autumn.*

25107. Immunobiology. *PQ: BIOS 20180s or 20190s, or consent of instructor.* This course presents an integrated coverage of the tactics and logistics of immune phenomena and conveys the elegance of the biological solutions evolved by multicellular organisms in their fights against infectious agents. Immune phenomena are presented as unique evolutionary adaptations of vertebrates operating in the context of ancillary defense mechanisms. The various types of countermeasures evolved by pathogens are also discussed, with particular emphasis on HIV and discussions on AIDS. *P. Ashton-Rickardt, Winter; J. Quintans, Spring.*

25108. Cancer Biology. *PQ: Completion of the general education requirement for the biological sciences.* This course covers the fundamentals of cancer biology but focuses on the story of how scientists identified the genes that cause cancer. Emphasis is on "doing" science rather than "done" science: how do scientists think, how do they design experiments, where do these ideas come from, what can go wrong, and what it is like when things go right. *M. Rosner. Winter.*

25109. Topics in Reproductive Biology and Cancer. *PQ: BIOS 20180s or*

20190s, or consent of instructor. This course focuses on several aspects of the molecular and cellular biology of human reproduction as well as the basis of chemical/viral carcinogenesis and the progression, treatment, and prevention of cancer. The role of steroid hormones and their receptors in the control of growth, development, and specialized cell function is discussed in the context of normal and abnormal gene expression in human development and disease. Key historical events, research approaches, utilization of knowledge, recent advances in drug design and herbal medicines, and philosophies of scientific research are also covered. *G. Greene. Spring.*

25206. Introduction to Bacterial Physiology. *This course meets one of the requirements for the specialization in microbiology.* This course introduces students to bacterial diversity, physiology, ultra-structure, envelope assembly, metabolism, and genetics. In the discussion section, students discuss recent original experimental work in the field of bacterial physiology. *D. Missiakas. Autumn.*

25210. Experimental Physiology of Bacteria. *This course meets one of the requirements for the specialization in microbiology.* This course teaches students experimental techniques in bacteriology and molecular genetic analysis of bacteria and phage. Students work at the laboratory bench under supervision of the instructor and assistants to learn experimental techniques and fundamentals of bacterial physiology. *T. Christianson, Staff. Winter. L.*

25216. Molecular Genetic Analysis of Bacterial Pathogenesis. *This course meets one of the requirements for the specialization in microbiology.* This lecture/discussion course involves a comprehensive analysis of bacterial pathogens, the diseases that they cause, and the molecular mechanisms involved during pathogenesis. Students discuss recent original experimental work in the field of bacterial pathogenesis. *O. Schneewind, Staff. Spring.*

25286. Viruses of Eukaryotes. (=GENE 34600, MGCB 34600, VIRO 34600) *PQ: Consent of instructor. This course meets one of the requirements for the specialization in microbiology.* This course is concerned with various aspects of the molecular biology of viruses of animal cells, including viruses that afflict man. Special emphasis is given to recent developments in the field related to viral nucleic acid replication, controls of viral gene expression, use of viruses as cloning vectors to amplify specific cellular genes, and the contribution of virus research to our understanding of mechanisms underlying eukaryotic gene expression. The course attempts to develop experimental thinking and knowledge of experimental approaches currently in use in related fields in molecular biology and cell biology. *B. Roizman. Spring.*

25305. Introduction to Microbes of Men and Beast. *PQ: First three quarters of BIOS 20180s or 20190s.* This course is intended to teach the fundamentals underlying the pathogenesis of disease caused by various types of microbes such as bacteria, viruses, and fungi. Students learn the fundamentals of the molecular interactions that occur between microbe and host that determine the outcome of an interaction between them. Intervention strategies used by humans, such as vaccination and antimicrobial therapy, and the corresponding microbial adaptive mechanisms are also covered. This course is identical to BIOS 25306 except

that it has a lab. *R. Daum, S. Boyle-Vavra, B. Fineschi. Spring. L.*

25306. Introduction to Microbes of Men and Beast. *PQ: First three quarters of BIOS 20180s or 20190s.* This course is identical to BIOS 25305 except that it does not have a lab. *R. Daum, S. Boyle-Vavra. Spring.*

25407. Organ Transplantation. *PQ: BIOS 25107.* This course presents biological, technical, ethical, and economic issues associated with organ transplantation. We sharply focus the immunologic knowledge from BIOS 25107 onto the biologic barriers to organ acceptance and the ultimate goal of immunologic tolerance. We also address principles of organ preservation and the mechanisms of ischemia/reperfusion injury. The technical aspects and physiology of organ transplantation (kidney, liver, heart, lung, pancreas, islet, and intestinal) are covered. The social, economic, and ethical issues raised in transplantation (allografts, xenografts and living donation) are also discussed. *A. Chong, D. Cronin, R. Harland, M. Garfinkel, M. Millis, R. Thistlethwaite, J. Willilams. Spring.*

26099. Quantitative Topics in Biology I: Ecology. *PQ: One quarter of calculus.* This course focuses on mathematical techniques for solving problems in ecology. The goal is to construct mathematical models that can explain ecological patterns and make predictions about how these patterns might be altered by changes in the environment. The emphasis throughout the course is on identifying interesting biological puzzles and solving them using the appropriate mathematical tools. *P. Amarasekare. Autumn.*

26100. Quantitative Topics in Biology II: Physiology and Biochemistry. *PQ: Prior introductory calculus course.* Quantitative techniques are becoming an increasingly significant tool in biological research. This introduction to biomathematics develops a basic toolbox of mathematical techniques (e.g., time series analysis, linear and nonlinear dynamics, stochastic processes, oscillator theory) and illustrates its usefulness through study of current biological problems. A computer lab provides hands-on experience in problem solving. *J. Foss. Winter. L.*

26317. Molecular Mechanisms of Cell Signaling. *PQ: BIOS 20181-20183 or 20191-2019, and 20200.* Cells in the body communicate with each other by a variety of extracellular signals (e.g., hormones, neurotransmitters) and processes such as vision and olfaction, as well as diseases such as cancer, all involve aspects of such signaling processes. The subject matter of this course considers molecular mechanism of the wide variety of intracellular mechanisms that, when activated, change cell behavior. Both general and specific aspects of intracellular signaling are covered in the course, with an emphasis on the structural basis of cell signaling. *W.-J. Tang. Spring. Offered 2002-03; not offered 2003-04.*

26400. Introduction to Bioinformatics. *PQ: BIOS 20182 or 20192, or MATH 15100, or consent of instructor.* This course introduces the concepts, purposes, tools, skills, and resources of bioinformatics. It includes a description of GenBank and other sequence databases; genetic and physical mapping databases; and structure databases. It also explains definitions such as homology, similarity, and gene families. Other topics include the basic principles and computational skills of comparative and phylogenetic analyses of DNA and protein sequence data; computer skills in database

searching and information retrieval; predictive methods using DNA sequences; predictive methods using protein sequences; and comparative genomics. Finally, cutting-edge developments such as DNA chips and other information technologies are discussed. *W. Li. Winter. L.*

26401. Evolutionary Genomics. The exponentially expanding sequence databases, in consequence of the human genome project and other molecular studies, provide an opportunity to investigate the makeup of genes and genomes in evolutionary perspectives. This course is an introduction to a new field in biological sciences: the evolutionary analysis of genomic data of various organisms. It covers important concepts of evolution of genes and genomes, introduces major accomplishments in the field, and teaches basic technical skills such as computer programming and simulation necessary for the data analysis. This course focuses on training the student's ability to access and analyze available genomic databases to study questions of biological interest. *M. Long. Spring. L.*

Big Problems Courses

02370. Psychoneuroimmunology: Links between the Nervous and Immune Systems. (=BPRO 24200, PSYC 34100) *PQ: Third or fourth-year standing, and BIOS 20180s or 20190s.* This course covers all aspects of neuroimmunoendocrinology at the molecular, cellular, and organismal and social levels. *M. McClintock, J. Quintans. Autumn. Offered 2002-03; not offered 2003-04.*

02800. Cultural Evolution and Dimensions of Globalization. (=BPRO 24000, CFSC 25000, HIPS 21500, LING 11200, NCDV 27500, PHIL 32600) *PQ: BIOS 29286 or consent of instructor. This course does not meet concentration requirements.* The focus of this two-quarter sequence is on cultural evolution and the globalization of culture. Relevant disciplines are evolutionary genetics, epidemiology, demography, economics, communications, science and technology, anthropology, history, and political science. We discuss issues such as the spread of new diseases, rise of multinational corporations, free trade, popular culture, the Internet, English as an emerging world language, and extinction of languages and cultures. *S. Mufwene, J. Sadock, W. Wimsatt, Staff. Winter. Offered 2003-04; not offered 2002-03.*

Specialized Courses

These courses may not be counted toward the courses required for the concentration.

29206. Introduction to Medical Physics. *PQ: Two years of college physics. This course does not meet concentration requirements.* This course covers basic radiation physics, including interactions with matter, dosimetry, and radiobiology. Topics in medical imaging include X-ray imaging with both analog screen/film and digital recording acquisition systems, and radionuclide imaging. Coverage of advanced technologies that provide three-dimensional images include X-ray computed tomography (CT), single photon emission computed tomography (SPECT), positron emission tomography (PET), and magnetic resonance imaging (MRI). *M. Giger, T. Pan, R. Hamilton. Autumn.*

29281. Introduction to Medical Ethics. (=HIPS 21400) *PQ: Second-year standing or higher. This course does not meet concentration requirements.* This course explores the ethical issues raised by modern medicine. We begin with an introductory examination of the foundations of medical ethics. We also discuss the doctor-patient relationship: how it evolved since World War II and how it should evolve in the twenty-first century. We examine moral issues raised by human experimentation, organ transplantation, and the human genome project. *L. Ross. Winter.*

29282. Advanced Medical Ethics. (=HIPS 21600) *PQ: BIOS 29281 or other prior ethics course. This course does not meet concentration requirements.* This course explores the ethical issues raised by genetics. We begin with an introductory examination of the ethics of family, and how modern medical ethics with its focus on the individual cannot easily accommodate the familial issues raised by genetics. We then consider particular issues such as predictive testing, the right to know versus the right to not know, genetic privacy, population screening, prenatal screening, and stem cells and cloning. *L. Ross. Spring. Offered 2003-04; not offered 2002-03.*

29283. Neurology and Kant's Theory of Knowledge. (=HIPS 28501) *PQ: Third- or fourth-year standing. This course does not meet concentration requirements.* In this course we cover most of the first half of Kant's *Critique of Pure Reason*, which contains his theory of perception and cognition. Our goal is to grasp the distinctively Kantian level of abstraction that he called "transcendental." When this is understood, the critique is transformed from an object of misinterpretation and uninformed criticism into a text which speaks intelligibly, and even helpfully, to present-day cognitive neurobiology (though Kant was not primarily analyzing, nor, much less, doing, empirical physiology or psychology). We also read several original, landmark papers from the related scientific literature subsequent to Kant's time. *S. Schulman. Autumn, Spring.*

29286. Biological and Cultural Evolution. (=BPRO 23099, CHSS 37900, HIPS 23900, LING 11100, NCDV 27400, PHIL 32500) *PQ: Third or fourth-year standing or consent of instructor. Core background in genetics and evolution is strongly recommended. This course does not meet concentration requirements.* For course description, see Big Problems. *W. Wimsatt, S. Mufwene. Winter.*

29290. Doctors as Guides and Helpers in the Healing Professions. *This course does not meet concentration requirements.* Physicians have been present in Western society since the time of the ancient Greeks, and most cultures have some form of doctors, yet the biologic approach to medicine has been used to alter the course of disease for less than a century. Using readings and discussion, this course explores the meaning of healing, ancient forms of healing, and aspects of present-day healing that supplement current biological approaches. Additional topics include personal inventory and preparation to become a healer, evolution and transformation of the healing role with regard to the changing concepts of interpersonal relationships, and challenges of becoming a healer. *L. Pottenger, H. Pokharna. Spring.*

29292. Medical Odysseys. *This course does not meet concentration*

requirements. Physicians and patients have new moral responsibilities because of changes in medical technology, economics, and public policy. Both physicians and patients must frame responses to the moral dilemmas of modern medicine: truth; conflict of interest; disparities in knowledge and power; allocation of scarce resources; and the meaning of life, disease, and death. This course studies works that present these and other dilemmas through the immediacy of lived personal experiences as documented in books of medical autobiography, essays, and poems. *J. Lantos. Winter.*

29293. On Becoming a Doctor. *This course does not meet concentration requirements.* The goal of this course is to help students explore their interest in a career in medicine, and provide potential applicants with the foundations for exploring key issues they will encounter in becoming a physician. Through peer presentations, visiting lecturers, and group discussion, we review the current legal, economic, and ethical climate for the practice of medicine. Using group discussions, readings, and seminars, we consider the obligations of the physician: to patients, to society, and to one's own family. *J. Saul. Winter, Spring.*

29306. Evolutionary Processes. (=CHSS 34800, ECEV 31000, EVOL 31000, HIPS 20800) *PQ: Consent of instructor. This course does not meet concentration requirements.* In this course we examine evolutionary aspects of ecology, genetics, biochemistry, paleontology, development, philosophy, and related subjects through readings, essays, and discussions. *L. Van Valen. Autumn.*

29316. Molecular Dissection of the Gene and Genome. *PQ: Consent of instructor. This course does not meet concentration requirements.* This course deals with the impact of molecular genetics on basic concepts of heredity and evolution. We discuss the theoretical significance of discoveries presented in *Scientific American* articles dealing with the classical view of the gene, genetic structure in the molecular era, transcriptional regulation in prokaryotes and eukaryotes, splicing and RNA processing, genetic engineering, mobile genetic elements, bacterial antibiotic resistance as an evolutionary case study, DNA repair systems and mutagenesis, and the action of the genome in development. *J. Shapiro. Spring. Offered 2002-03; not offered 2003-04.*

29405. Mathematical and Statistical Methods for Neuroscience I. (=CPNS 32000) *PQ: A college-level course in calculus and, preferably, some background in neurobiology. This course meets concentration requirements only for students specializing in neuroscience.* This is the first course of a three quarter sequence that introduces methods in applied mathematics and probability theory that are applicable to problems in neuroscience. It discusses ordinary differential equations, linear algebra, Fourier and Laplace methods, dynamical systems theory and introduces partial differential equations. *J. Foss. Autumn. L.*

29406. Mathematical and Statistical Methods for Neuroscience II. (=CPNS 32100, STAT 24700/31000) *PQ: BIOS 24245. This course meets concentration requirements only for students specializing in neuroscience.* For course description, see Statistics. *Y. Amit. Winter.*

29407. Mathematical and Statistical Methods for Neuroscience III.

(=CPNS 32200) *PQ: BIOS 29405 and 29406. This course meets concentration requirements only for students specializing in neuroscience. Spring.*

Independent Study and Research

00199. Undergraduate Research. *PQ: Consent of research sponsor and the director of the honors program in biological sciences. Students are required to submit the College Reading and Research Course Form. This course is graded P/F. This course does not meet concentration requirements. This course may be elected for up to three quarters. Students must submit a one-page summary of the research planned to their research sponsor and the director of the honors program before the Friday of the fifth week of the quarter in which they register. A detailed five- to ten-page report on the completed work must be submitted to the research sponsor and the director of the honors program before the Friday of examination week. D. Nelson. Summer, Autumn, Winter, Spring.*

00206. Readings in Biology. *PQ: Consent of faculty sponsor. Students are required to submit the College Reading and Research Course Form. This course is graded P/F. This course does not meet concentration requirements. Students may register for only one BIOS 00206 tutorial per quarter. Enrollment must be completed by the end of the second week of the quarter. This is a tutorial offering individually designed readings. Summer, Autumn, Winter, Spring.*

00207. Cholesterol and the Origin of Heart Disease and Alzheimers Disease. *PQ: BIOS 20180s and 20190s, and 20200. This course does not meet concentration requirements. This course is an overview of the control of cholesterol metabolism. We discuss the role of cholesterol metabolism in the origin of heart disease, how its control might modify the risk of heart disease, and how knowledge about the latter point has led to an appreciation of the role of cholesterol metabolism in Alzheimers disease. G. Getz. Spring.*

00276. Fundamentals of Clinical Research. *PQ: Completion of the general education requirement for the biological sciences. This course does not meet concentration requirements. This course has been designed to provide students in different stages of education and career development with the background to plan, manage, and communicate within the world of clinical research. The course introduces students to the fundamentals of all aspects of clinical research, which can lead to better understanding of safe and effective planning as well as implementation of patient oriented research. Based on availability, students may consult with the instructor on having a small project of their own for one summer. S. Patel. Winter.*

00298. Undergraduate Research Seminar. *PQ: Fourth-year standing and consent of the director of the honors program. Students will receive a letter grade and may count this course toward concentration requirements. This seminar course is required of graduating students in the honors program. The honors thesis is revised during the year and submitted third week of Spring Quarter. Students also participate in a poster session early in Spring Quarter. D. Nelson. Spring.*

00299. Advanced Research in the Biological Sciences. *PQ: Fourth-year*

standing. Consent of research sponsor and the director of the honors program in biological sciences. Students are required to submit the College Reading and Research Course Form. This course is graded P/F. This course does not meet concentration requirements. In the first quarter of registration students must submit a Supplementary Information Form to their research sponsor and to the director of the honors program. D. Nelson. Summer, Autumn, Winter, Spring.

Graduate-Level Courses

Many graduate-level courses in the Division of the Biological Sciences are open to qualified College students. Students should consult their advisers, the BSCD office, or the various departments and committees in the division to identify appropriate courses.