Biological Sciences

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Program of Study

Biology is the study of organisms and their adaptations to the pressures of natural selection. The faculty of the College believe 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 students majoring in biological sciences, 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 many nonmajors.

The General Education Requirement in the Biological Sciences

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

1. an integrated Natural Sciences sequence for nonmajors, which meets all general education requirements for the physical and biological sciences; or

2. a two-quarter general education sequence for nonmajors; or

3. a Fundamentals Sequence required for students majoring in biological sciences and students preparing for the health professions.

Advanced Placement Credit. For students who do not plan to major in the biological sciences or prepare for the health professions, a score of 4 or 5 on the AP biology test confers credit for BIOS 10110. These students meet the general education requirement with either one or two topics courses in the biological sciences, depending on how the requirements in the mathematical and physical sciences are met; consult your College adviser for details.

Students with a score of 5 on the AP biology test who complete an AP 5 Fundamentals Sequence will be awarded a total of two quarters of credit to be counted toward the general education requirement for the biological sciences. This option is especially appropriate for students who plan to major in the biological sciences or prepare for the health professions, but it is open to all qualified students.

Biological Sciences Writing Program. The Biological Sciences Writing Program assists both professors and students in biology courses that are reading and writing intensive. The director of the program offers services to professors, such as help in selecting appropriate reading materials, designing challenging writing assignments, determining grading criteria, coordinating pedagogical support through the hiring of specially trained teaching assistants, and implementing writing workshops or discussion sections. Other workshops on research strategies and effective scientific writing are provided through a collaboration with the John Crerar Library. For more information, contact the program's director, Matthew Deming, at 702-7972 or *mjdeming@uchicago.edu.*

Requirements for the Biological Sciences Major

The goals of the biological sciences 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 program prepares 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 Courses for Biological Sciences Majors

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

Courses Required for the Biological Sciences Major

Courses in the Physical Sciences Collegiate Division

Students majoring in biological sciences must complete the third quarter of general chemistry (CHEM 11301/11302 or equivalent); two quarters of organic chemistry (CHEM 22000-22100/23100; 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 quantitative course from the following list: BIOS 26210, BIOS 28500, PHYS 12300 or higher, or STAT 22000 or higher.

Courses in the Biological Sciences

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

20200-level and Above Courses in Biological Sciences. Students **also** register for Introduction to Biochemistry (BIOS 20200) plus five additional 20200-level and above courses in biological sciences. These five courses are selected by the student unless the student chooses to complete a "specialization." (See sections that follow.) NOTE: BIOS 00290–00295 cannot be counted toward any of the five upper-level biological sciences courses required for the biological sciences major.

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

Summary of Requirements

General Education		CHEM 11101-11201/11102-11202 or equivalent† MATH 13100-13200, 15100-15200, or 16100-16200† BIOS 20181-20182 or 20191-20192, or completion of a three-quarter AP 5 sequence*
Major	3	completion of one of the following: BIOS 20180s sequence or BIOS 20190s sequence or a three-quarter AP 5* sequence
	1	CHEM 11301/11302 or equivalent†
	1	BIOS 20200 (Biochemistry)
	5	courses above 20200 in biological sciences (may include BIOS 00298) ‡
	2	CHEM 22000-221/23100
	2	PHYS 12100-12200 or higher†
	1	MATH 13300 or 15300 or 16300, or STAT 22000†
	1	additional quantitative course from the following: BIOS 26210 or BIOS 28500 or PHYS 12300 or higher or STAT 22000 or higher
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† *Credit may be granted by examination.*
* *Open only to students with a 5 on the AP biology test.*
‡ *BIOS 00290–00295 cannot be counted toward any of the five upper-level biological sciences courses required for the biological sciences major.*

Grading. Students must receive quality grades in all courses that meet requirements for the biological sciences major.

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 Division of the Biological Sciences to sponsor and supervise research on an individual tutorial basis. Students register for BIOS 00199 or 00299 for course credit. Consult the following course description section for information about procedures, grading, and requirements for registration in BIOS 00199 and 00299. For more information, see *http://bscd.bsd.uchicago.edu/research.html.* NOTE: Course credit cannot be given for work that is compensated by a salary.

Some financial support may be available to students for summer research through their research supervisors or through fellowships awarded competitively by the Biological Sciences Collegiate Division. The deadline for applications for fellowships is early March preceding the summer of the fellowship application.

Honors. Students may earn a bachelor's degree with honors 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 both overall and in courses in the major 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 undergraduate research and honors well before their senior year for guidance on meeting the requirements for honors.

Students who wish to be considered for honors rarely begin their research later than the summer before their fourth year; students pursuing honors typically begin their research in their third 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; two reviewers will evaluate the draft, which will be returned with comments. The final version, which will be due at the end of eighth week, must be approved by the director of undergraduate research and honors in consultation with the reviewers. For more information, see *http://bscd.bsd.uchicago.edu/honorsprogram.html.*

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. Students may complete only one specialization.

Specialization in Cellular and Molecular Biology. Students majoring in biological sciences 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 22200/23200)

2. three of the five 20200-level courses in the biological sciences that are required for the biological sciences major must be completed within the specialization, with one course each from three of the four following areas being selected:

    a. BIOS 21207. Cell Biology
    b. BIOS 21236. Genetics of Model Organisms
    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. For more information, consult Gayle Lamppa (702-9837, *gklamppa@uchicago.edu*).

Specialization in Ecology and Evolution. Students majoring in biological sciences who complete the course work indicated below and meet the requirements for writing a 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 select a faculty adviser, who then may recommend specific courses necessary to meet the specialization requirements (see following section). The faculty adviser may also help the student find an appropriate research lab in which to conduct an individual research project.

The following requirements must be met:

Courses	1. three quarters of calculus and three quarters of statistics (starting at the level of STAT 22000) in lieu of the physics requirement 2. three upper-level courses in the biological sciences, as recommended by the faculty adviser or the faculty member in whose lab the student does his/her research, from a menu of courses in behavior, ecology, evolution, or genetics
Laboratory or Field Research	completion of original research in the lab under the guidance of a member of the ecology and evolution faculty that will qualify the student to write an honors paper. NOTE: Students must complete field research by the end of the growing season (summer) of their third year.

The specialization in ecology and evolution is administered by the Department of Ecology and Evolution. For more information, consult Manfred Ruddat (702-8796, *mruddat@uchicago.edu).*

Specialization in Endocrinology. After taking the following three courses, students majoring in biological sciences will be recognized as having completed a specialization in endocrinology. Students who complete the specialization will be well versed in all aspects of endocrinology, ranging from basic cell signaling to the integration of endocrine systems and their dysregulation in human disease. Students will also have the option of participating in a hands-on

research component in an endocrinology lab. The prerequisite for these courses is completion of the Fundamentals Sequence.

Introductory Courses	BIOS 25226. Endocrinology I: Cell Signaling (Autumn) BIOS 25227. Endocrinology II: Systems and Physiology (Winter) BIOS 25228. Endocrinology III: Human Disease (Spring)

The specialization in endocrinology is administered by the Sections of Adult and Pediatric Endocrinology, and the Committee on Molecular Metabolism and Nutrition. For more information, consult Matthew Brady *(mbrady@medicine.bsd.uchicago.edu).*

Specialization in Genetics. Students majoring in biological sciences who meet the following requirements will be recognized as having completed a specialization in the area of genetics.

Introductory Courses	BIOS 20182 or 20192. Genetics (Winter) *(Credit may not be granted by examination.)* BIOS 20185. Ecology and Evolution (Winter) STAT 22000. Statistical Methods with Applications *(This section is focused on biological data.)*
Advanced Courses	BIOS 21200. Human Molecular Genetics (Winter) BIOS 21236. Genetics of Model Organisms (Autumn) *Choose one of the following:* BIOS 21208. Fundamentals of Molecular Biology (Winter) *or* BIOS 21209. Molecular Biology (Autumn) *or* BIOS 21306. Human Genetics and Evolution (Autumn) *or* BIOS 23256. Fundamentals of Molecular Evolution (Autumn) *Choose one of the following:* BIOS 21216. Introductory Statistical Genetics (Winter) *or* BIOS 21227. Advanced Developmental Biology (Autumn) *or* BIOS 23299. Plant Development and Molecular Genetics (Spring)

or
BIOS 25216. Molecular Basis of Bacterial Diseases (Spring)
or
BIOS 25307. Molecular Genetics of Bacteriophage (Spring)

Laboratory Research Completion of an independent research project.
The project must:
either qualify as a senior honors project;
or be approved by the director of the specialization.

Students must receive a *B* or better in all courses. The specialization in genetics is administered by the Committee on Genetics. Consult Jocelyn Malamy (702-4651, *jmalamy@bsd.uchicago.edu*) for more information.

Specialization in Immunology. After taking the three of the four courses listed below, students majoring in biological sciences will be recognized as having completed a specialization in immunology. The fourth course is available to students who wish further study.

Sudents are required to take both of the following two courses:
BIOS 25256. Immunobiology (Autumn)
BIOS 25258. Immunopathology (Spring)

Sudents are required to take one of the following two courses:
BIOS 25409. Immuno-logic: A Systems Approach (Spring)
or
BIOS 02370. Psychoneuroimmunology (Spring)

The following is an elective course:
BIOS 25260. Host Pathogen Interactions (Autumn)

For more information, consult Bana Jabri, Department of Pathology and the Committee on Immunobiology, (834-8670, *bjabri@bsd.uchicago.edu*).

Specialization in Microbiology. Students majoring in biological sciences who complete the following requirements will be recognized as having completed a specialization in microbiology. Students register for three required courses in the specialization (BIOS 25206, 25216, and 25287). 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 required courses.

Required Courses
BIOS 25206. Fundamentals of Bacterial Physiology (Autumn)
BIOS 25287. Introduction to Virology (Winter)

BIOS 25216. Molecular Basis of Bacterial Diseases (Spring)

Electives in the Committee on Microbiology
BIOS 25307. Molecular Genetic Analysis of Bacteriophage (Spring)

Honors in the Microbiology Specialization. Students who complete a research thesis have an opportunity to receive rigorous advanced training in microbiology and to 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 major, and (2) meet the lecture and lab 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 lab 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).

For more information, students should consult with Dominique Missiakas, undergraduate adviser of the Committee on Microbiology (834-8161, *dmissiak@bsd.uchicago.edu*).

Specialization in Neuroscience. Students majoring in biological sciences who complete the three required courses on the list that follows will be recognized as having completed a specialization in neuroscience. Students who elect to specialize should consult the faculty adviser, Philip Lloyd, who is available to advise on the choice of classes and to help identify labs in which individual research projects can be carried out. Students who plan to specialize are encouraged to begin the required sequence below in Autumn Quarter of their second year, carry out individual guided research, participate in the honors research program, and attend neurobiology/biopsychology-related seminars.

BIOS 24203. Introduction to Neuroscience (Autumn)
BIOS 24204. Cellular Neurobiology (Winter)
BIOS 24205. Systems Neuroscience (Spring)

For more information, students should consult with Philip Lloyd (702-6376, *plloyd@uchicago.edu*).

Minor Program in the Biological Sciences

The minor in the Biological Sciences, which is offered by the Biological Sciences Collegiate Division, requires completion of five upper-level (above

20200) BIOS courses. Students may choose courses from a specific area of the biological sciences (e.g., molecular and cell biology, genetics, evolutionary biology, developmental biology, organismal biology, ecology, neurobiology, immunobiology, microbiology). Alternatively, students may choose courses from related areas to construct a program that gives a more inclusive account of how different disciplines of biology interact. These areas could comprise, for instance, immunology and microbiology, organismal biology and evolution, genetics and genomics, developmental biology and evolution, or ecology and evolution. Other combinations are also possible. One of the courses either must be a research course or must have a lab or field study component. Only one course from the Fundamentals Sequence (BIOS 20181–20185 or 20191–20194) may be counted for one of the upper-level courses.

Students must meet general education requirements for the biological sciences and the physical sciences before entering the program. Biological Sciences courses at the 10000-level, Natural Sciences (NTSC) courses, and MATH 11200-11300 or 13100-13200 are the minimal general education requirements for the minor. General Chemistry and Organic Chemistry are not specifically required. These courses would, however, allow for a greater variety of upper-level biological sciences courses, especially those in the areas of molecular and cellular biology; chemistry and/or biochemistry are usually prerequisites for those courses.

No course in the minor can be double counted with the student's major(s) or with other minors; nor can they be counted toward general education requirements. More than half of the requirements for the minor must be met by registering for courses with University of Chicago course numbers.

Students who elect the minor program must meet with the master of the Biological Sciences Collegiate Division by the end of Spring Quarter of their third year. Students must obtain formal approval from the master to complete the minor program on a form obtained from their College adviser and returned to the adviser by the deadline. To schedule an appointment with the master, students should contact Kirsten Cole *(kcole@uchicago.edu).*

Minor Program in Computational Neuroscience

The minor in computational neuroscience is offered by the Biological Sciences Collegiate Division. Computational neuroscience is a relatively new interdisciplinary area of inquiry that is concerned with how components of animal and human nervous systems interact to produce behaviors. It relies on quantitative and modeling approaches to understand the function of the nervous system and to design human-made devices that duplicate behaviors. Course work in computational neuroscience can prepare students for graduate studies in neurobiology or psychology, in the mathematical or engineering sciences, or in areas of medicine such as neurology or psychiatry. It can lead to either traditional academic careers or to opportunities in the corporate world. For more information, visit *http://cns.bsd.uchicago.edu.*

This minor is a good option for students who are majoring in biological sciences and are interested in mathematical approaches to biology; or for students who are majoring in computer science, mathematics, physics, psychology, or statistics and have an interest in neuroscience. Students electing this minor must have completed, or placed out of, the equivalent of a year of collegiate-level calculus and must have completed the general education requirement for the biological sciences. Students with an interest in computational neuroscience are encouraged, but not required, to take the Mathematical Methods for Biological Sciences sequence (BIOS 26210-26211-26212). The minor requires completion of the following two (three-course) sequences: BIOS 24221, 24222, 24223 (Computational Neuroscience I, II, and III) and BIOS 29405, 29406, and 29407 (Mathematical and Statistical Methods for Neuroscience I, II, and III). Students who elect the minor program are required to meet with the Chair of the Committee on Computational Neuroscience (Philip Ulinski) by the end of Spring Quarter of their third year. Students must obtain formal approval from the chair to complete the minor program on a form obtained from their College adviser and returned to the adviser by the deadline. No courses in the minor can be double counted with the student's major(s) or with other minors; nor can they be counted toward general education requirements. More than half of the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers. Students must earn a *B-* average or above in courses counted toward the minor.

Minor Program in Interdisciplinary Quantitative Studies in the Natural Sciences

Offered by the Biological Sciences Collegiate Division, the minor in Interdisciplinary Quantitative Studies in the Natural Sciences is designed for third- and fourth-year majors in biology, chemistry, computer science, mathematics, and physics. The minor requires five courses: Computational Biology and four courses chosen from the list that follows.

Computational Biology, a course that carries 200 units of credit, introduces the interdisciplinary research and training expected of scientists in the twenty-first century. The other four required courses, which are chosen in consultation with the master of the Biological Sciences Collegiate Division, allow students to pursue either a specific area of interest or a range of interests. Students are required to meet with the master by the end of Spring Quarter of their third year to discuss a program of study. The master's approval for the minor program should be submitted to a student's College adviser by Spring Quarter of his or her third year on a form obtained from the adviser. To schedule an appointment with the master, students should contact Kirsten Cole *(kcole@uchicago.edu)*.

No course in the minor can be double counted with the student's major(s), with other minors, or with general education requirements. More than half of

the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers.

In addition to registering for the required introductory course described previously, students choose four courses from the following list. The list is subject to change.

BIOS 21216. Introductory Statistical Genetics
BIOS 21317. Topics in Biological Chemistry
BIOS 21318. Molecular Biophysics
BIOS 21319. RRP: Ribosomes, RNA, and Protein
BIOS 22242. Biological Fluid Mechanics
BIOS 22243. Biomechanics of Organisms
BIOS 24211. Neuroethology
BIOS 24221-24223. Computational Neuroscience
BIOS 26210-26212. Mathematical Methods for Biological Sciences
BIOS 26400. Introduction to Bioinformatics
BIOS 28500. Biological Physics

Faculty

Y. Amit, C. Andrews, J. Bates, A. Bendelac, J. Bergelson, R. Bieler, D. Bishop, S. Boyle-Vavra, M. Brady, K. Cagney, M. Casadaban, L. Casalino, M. Caserta, B. Chernoff, Z. Chi, K.-S. Chiang, A. Chong, T. Christianson, P. Cluzel, M. Coates, R. Cohen, C. Correll, N. Cox, J. Coyne, J. Crispino, E. DeSombre, H. de Wit, J. Dignam, A. DiRienzo, W. Du, V. Dukic, S. Dulawa, G. Dwyer, T. Emonet, R. Esposito, W. Epstein, M. E. Feder, E. Ferguson, B. Fineschi, J. Flynn, M. Foote, A. Fox, G. Franzoso, H. C. Friedmann, T. Gajewski, G. Getz, M. Giger, D. Gillen, B. Glick, M. Glotzer, J. Goldberg, L. Goldman, P. Goldstein, C. Gomez, W. Green, J. Greenberg, G. Greene, E. Grove, M. Hale, K. Hamann, D. Hanck, R. Haselkorn, N. Hatsopoulos, L. Heaney, A. Heller, R. Ho, M. Hobert, R. Hudson, A. Hunter, A. Imamoto, N. Issa, D. Jablonski, B. Jabri, R. Josephs, L. Kay, M. Kearney, S. Kent, S. Koide, M. Kreitman, S. Kron, V. Kumar, J. Kyle, M. LaBarbera, B. Lahey, B. Lahn, G. Lamppa, E. Larsen, D. Lauderdale, C. Lese-Martin, D. Levine, W.-H. Li, Y. Li, S. Liao, A. Lin, P. Lloyd, R. E. Lombard, M. Long, C. Lowe, K. Macleod, D. Maestripieri, A. Mahowald, C. Maki, M. W. Makinen, P. Makovicky, J. Malamy, D. Margoliash, S. Margulis, R. Martin, T. E. Martin, P. Mason, J. Mateo, M. McClintock, R. McCrea, J. McElwain, D. McGehee, S. C. Meredith, L. Mets, K. Millen, J. Milton, D. Missiakas, A. Montag, J. Moss, G. Mueller, P. Mueller, M. Musch, J. Nachman, T. Nagylaki, P. Nash, D. Nelson, M. Nishimura, M. Nobrega, A. Noronha, C. Ober, M. Osadjan, C. Palfrey, A. Palmer, T. Pan, S. Patel, B. Patterson, I. Pavlova, R. Perlman, M. Peter, C. Pfister, J. Piccirilli, D. Preuss, T. Price, V. Prince, J. Pritchard, S. Pruett-Jones, J. Quintans, C. Ragsdale, J.-M. Ramirez, P. Rathouz, I. Rebay, T. Regier, P. Rice, B. Roizman, M. Rosner, L. F. Ross, L. Rothman-Denes, M. D. E. Ruddat, U. Schmidt-Ott, O. Schneewind, C. Schonbaum, M. Schreiber, P. Schumacker, J. Schwab, E. Schwartz, P. Sereno, J. Shapiro, K. Sharma, M. Sherman, N. Shubin, P. Sierwald, J. C. Silverstein, H. Singh, S. Sisodia, 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, J. Sun, W.-J. Tang, E. W. Taylor, G. Thinakaran, K. Thompson, A. Turkewitz, R. Tuttle, P. Ulinski, L. M. Van Valen, M. Verp, P. Vezina, M. Villereal, P. Wagner, C.-R. Wang, C. Wardrip, G. Webb, M. Weigert, M. Westneat, W. Wimsatt, A. Winter, A. Wolfe, T.-W. Wong, I. Wool, J. T. Wootton, C. Wu, S. Yang, R. Zaragoza, X. Zhuang

Courses: Biological Sciences (BIOS)

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.*

Biological Sciences Sequences for Nonmajors

Students choose from the following options to meet the biological sciences requirement. The requirement should be completed by the end of the second year.

1. Students may choose to take Biological Issues and Paradigms (BIOS 10110) as their first course. For their second quarter, students choose from a menu of topics courses (BIOS 10111-19999) that are comprehensive reviews of specialized topics in the biological sciences (descriptions follow). Nonmajors are encouraged to enroll in additional biological sciences courses that cover topics of interest to them.

BIOS 10110. Biological Issues and Paradigms. *PQ: Concurrent registration in one section of BIOS 10900. Students must also confirm their registration in BIOS 10110 with their instructors by the second class meeting or their registration may be canceled.* 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 this course develop a broad common core of understanding of the nature of life through lectures, small group discussions, writing, and lab investigations. Lab fees apply. A second biology course (listed in the Topics Courses section that follows) builds on this core knowledge, focusing on a specialized topic of biological inquiry. *Autumn, Winter, Spring. L.*

Multiple sections of this course are offered each quarter. Each section is taught from a different perspective by one of six faculty members based upon the specialty of the instructor. To register for the version that best suits their interests, students should visit *timeschedules.uchicago.edu* and look for a "key descriptive word" in the notes for each section. Courses are listed in order based on prior knowledge of biology that students should have, from least to most.

A. "From Molecules to Ecosystems" (key word: "comprehensive") emphasizes how biological systems work, from macromolecules through cells and organisms to ecosystems. *T. Christianson. Winter, Spring.*

B. "Current Issues in Biology" (key word: "current") comprehensively covers modern biology. Subjects explored include current issues in genomics (the Human Genome Project) and stem cell biology. *B. Fineschi. Autumn, Winter.*

C. "Microbes and Infections I" (key word: "infections") provides a solid foundation in the basic concepts in biology: molecular and cellular biology, genetics, and ecology and evolution. Students learn about the diversity of microbes (e.g., viruses, bacteria, protists, fungi), as well as how the combination of microbial genetics and changes in the environment drive the evolution of microbes and the emergence of disease. Hands-on activities include using microbiological and microscopic methods to analyze the diversity of microbes in the environment and applying clinical and genetic tests to determine levels and mechanisms of antibiotic resistance. Microbes and Infections is the first course in a two-quarter sequence that meets the gene ral education requirement for the biological sciences. The content of the second quarter (BIOS 10210) builds on what is covered in the first quarter. *I. Pavlova. Autumn.*

D. "Ecology and Evolution" (key word: "E and E") emphasizes ecology, evolution, and physiology with the use of readings from popular scientific publications and the primary scientific literature. *A. Hunter. Winter.*

E. "Pharmacology Perspective" (key word: "pharmacology") describes how drugs work at the cellular and organismal level, as well as covers advanced topics in cellular, molecular, and organismal biology. *R. Zaragoza. Spring.*

F. "Accelerated Biology" (key words: "analytical, organisms, evolution") integrates critical thinking and methods of statistical analysis as applied to current issues in biology. This section is intended for nonmajors with advanced standing and pre-med students who wish to prepare for the required Fundamentals Sequence. *E. Larsen. Autumn, Winter.*

2. BIOS 20184 (Biological Diversity) and 20185 (Ecology and Evolution) constitute an alternative sequence, albeit a more intensive one, to BIOS 10110 and a topics course. It is appropriate for students who are interested in an in-depth, quantitative approach to the biological sciences. Before enrolling in BIOS 20185, students should have completed one quarter of calculus and should have familiarity with genetics. NOTE: These courses have limited enrollment because of laboratory requirements and preference will be given to students majoring in biological sciences.

20184. Biological Diversity. 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, A. Hunter, C. Andrews. Autumn. L.*

20185. Ecology and Evolution. This course surveys the basic 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, 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. *G. Dwyer, J. Coyne, C. Andrews. Winter. L.*

10900. Writing in the Biological Sciences. *PQ: Concurrent registration in BIOS 10110. This course will be listed as* P/F *on transcripts. Register for one section.* Drawing upon a wide range of scientific communications from *New York Times* and *Scientific American* articles to original research papers published in professional journals such as *Science and Nature,* this course aims to address a selection of contemporary biological issues and to acquaint students with their arguments and the evidence presented. Dialogue is created about them through in-class discussion and short, focused writing assignments. *M. Deming. Autumn, Winter, Spring.*

Topics Courses for Nonmajors

The courses that follow have a prerequisite of BIOS 10100 or 10110, or a score of 4 or 5 on the AP biology test. Attendance is required at the first class to confirm enrollment.

10210. Microbes and Infections II. *PQ: BIOS 10100 or 10110.* Students in this course apply the basic concepts of biology to learn about the amazing metabolic activities of microbes which allow them to live in places unimaginable by humans and to have a variety of influences ranging from foods to energy sources to global climate. We also cover pathogen tactics and the human immune response with representative diseases. Hands-on activities include an investigation into the causative agents of disease and an independent group project related to the metabolic diversity of microbes. *I. Pavlova. Winter*.

11104. Genetically Modified Food: Calamity or Cornucopia? *PQ: BIOS 10100 or 10110.* This course examines the nature of genetically modified food. We first provide background in plant biology and basic gene regulation and then discuss in detail the construction of modified plant varieties. With this knowledge, we finally explore the implications of the broad adoption of genetically modified crops for agriculture, ecology, and our lives. *J. Mach. Autumn.*

11105. Ancestry, Genetics, and Medicine. *PQ: BIOS 10110.* This lecture/discussion course focuses on genetic variation among humans, its evolutionary causes, and the potential implications for disease susceptibility. Topics include human evolution, population and quantitative genetics, observed health differences, and the search for disease-susceptibility loci. Readings are drawn from a combination of primary sources, popular science magazines, and newspapers. *M. Przeworski. Spring.*

11106. Molecular and Cellular Nature of Life. *PQ: BIOS 10100 or 10110.* This course is for students with an interest in the more chemical and molecular aspects of biology. We examine the principles underlying the universal processes on which all forms of life 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 with a look at the rapidly advancing field of genetic engineering and its implications for our lives. *K.-S. Chiang. Spring.*

11108. Human Heredity. *PQ: BIOS 10100 or 10110.* 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 a political, social, economic, or ethical issue. *B. Strauss. Winter.*

11109. Molecules to Cells and Back. *PQ: BIOS 10100 or 10110.* Selected topics of current medical and/or environmental interest are used to illustrate basic principles of cell and molecular biology. *T. Martin. Spring.*

11114. The Growth of Science. *PQ: BIOS 10100 or 10110.* This course attempts to show how the interdependence of observations and ideas leads to the development of scientific disciplines. Because the instructor is a biochemist, some examples are selected from developments in this field, which has vagaries that provide opportune material for instructive generalizations that radiate into other biological and chemical areas. An attempt is made to determine reasons for the development, and the lack of development, of scientific disciplines at different times and in different places. *H. Friedmann. Autumn.*

11116. Genetic Engineering. *PQ: BIOS 10100 or 10110.* 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 required to sites where the work of genetic engineers is on display. L. Mets. Spring*.

11119. The Biology of Gender. (=GNDR 12000) *PQ: BIOS 10100 or 10110.* This course explores the biological evidence and theories that seek to explain gender in humans. This course relies on current research in neuroscience, physiology, and cell biology to address topics such as the genetics of gender; sexual differentiation of the fetus; sexually dimorphic brain regions; the biology of gender identity and gender preference; and hormonal/environmental contributions to gender. *M. Osadjan. Autumn*.

11120. Behavior Genetics. PQ: BIOS 10110. This course addresses the basic biological mechanisms of inheritance and the role of genetic influences on human behavior. We also study aspects of behavior (e.g., cognitive abilities, personality, attitudes, affiliation, sexual behavior, mental health problems). We emphasize the complex interplay between genetic and environmental influences (e.g., gene-environment correlation, gene-environment interaction, gene regulation and expression). Strategies for studying such influences using non-human animal models and humans are described (e.g., selective breeding, gene knock-out and knock-down methods; overexpression for non-human animals; adoption studies, twin studies, half-sibling studies; molecular genetic studies of linkage and association in humans). The emerging field of pharmacogenetics is surveyed. Ethical issues and misuses of behavior genetics in the past are discussed. *B. Lahey, A. Palmer, S. Dulawa. Spring.*

11121. The Chemistry of Biology. *PQ: BIOS 10110.* This course considers the chemical properties of amino acids and the nucleotide constituents of DNA and RNA. Based on these properties, we look at the way in which genetic information is transferred both within a generation and from generation to generation. We also discuss how proteins, which are the the ultimate products of genes, interact to provide all cellular functions. *R. Haselkorn. Autumn.*

11123. The X-Chromosome and Its Degenerate Counterpart: The Y. *PQ: BIOS 11108 or equivalent.* Simplistic explanations of the biological basis of human sexuality rely on the qualitative/quantitatively different chromosomal constitution of males and females. Current biological research indicates that the situation is much more complex. This course considers the molecular structure of X and Y chromosomes and the control mechanisms that govern their function. Social consequences considered range from the use of the Y chromosome for the study of human history to the supposed roles of genes in homosexuality and in behavioral characteristics. *B. Strauss. Spring.*

11124. Molecular Approaches in Zoology. *PQ: BIOS 10100 or 10110.* The impact of DNA technology on our understanding of biology has been profound. Molecular biology, developmental biology, and genomics have all been a major part of the new synthesis. This course provides an overview of these fields of biology and examines how these new tools are being applied to evolutionary biology. The textbook, classical view of zoology has been fundamentally challenged by some of these new advances. This course examines the outstanding controversies in zoology and how DNA technology is helping to refine our understanding of animal relationships. *C. Lowe. Winter.*

11125. Life through a Genomic Lens. (=ENST 12402) *PQ: BIOS 10100 or 10110.* The implications of the double helical structure of DNA triggered a revolution in cell biology. More recently, the technology to sequence vast stretches of DNA has offered new vistas in fields ranging from human origins to the study of biodiversity. This course considers a set of these issues, including the impact

of a DNA perspective on the legal system, on medicine, and on conservation biology. *A. Turkewitz, M. Nobrega. Winter.*

12107. Cell Biology of Physio-logical Stress. *PQ: BIOS 10100 or 10110.* 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.*

12112. Animal Locomotion. *PQ: BIOS 10100 or 10110.* What makes animals so successful? A simple but critical piece of the puzzle is movement, which animals use to forage, find mates, and escape. Evolution has produced a broad array of locomotor styles, some of which are surprising and unexpected. This course explores the diversity of animal movement from a mechanical design perspective, as well as answers how demands of form and function have shaped the many styles of locomotion. Topics include swimming, terrestrial locomotion, gliding and powered flight, and biologically inspired robots. *J. Socha. Spring.*

12114. Nutritional Science. *PQ: BIOS 10100 or 10110.* This course examines the underlying biological mechanisms of nutrient utilization in humans and the scientific basis for setting human nutritional requirements. The relationships between food choices and human health are also explored. Students consider how to assess the validity of scientific research that provides the basis for advice about how to eat healthfully. Class assignments are designed to help students apply their knowledge by critiquing their nutritional lifestyle, nutritional health claims, and/or current nutrition policy issues. *P. Strieleman. Spring.*

12115. Responses of Cardiopulmonary Systems to Stress. *PQ: BIOS 10100 or 10110.* This course discusses basic concepts involved in the functioning of the cardiopulmonary system, followed by various types of patho-physiological stresses experienced by the lungs and heart. We discuss how these systems adapt to stress conditions by turning on "emergency response" mechanisms at the molecular, cell, tissue, and organ levels. We will also discuss current strategies and drugs designed to treat maladaptive changes taking place in the heart and lungs under stress. *M. Gupta, K. Birukov. Spring.*

13106. The Hungry Earth: Light, Energy, and Subsistence. (=ENST 13106) *PQ: BIOS 10100 or 10110.* This course considers 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. Winter.*

13107. Environmental Ecology. (=ENST 12404, NTSC 10400) *PQ: BIOS 10100 or 10110.* 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. T. Price. Winter.*

13109. Ecology. *PQ: BIOS 10100 or 10110.* 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.*

13111. Natural History of North American Deserts. *PQ: BIOS 10100 or 10110.* This lecture/laboratory course focuses on the ecological communities of the Southwest, primarily on the four subdivisions of the North American Desert, the Chihuahuan, Sonoran, Mohave, and Great Basin Deserts. Lecture topics include climate change and the impact on the flora and fauna of the region; adaptations to arid landscapes; evolutionary, ecological, and conservation issues in the arid Southwest, especially relating to isolated mountain ranges; human impacts on the biota, land, and water; and how geological and climatic forces shape deserts. *E. Larsen. Spring.*

13112. Natural History of North American Deserts: Field School. *PQ: Consent of instructor.* This lab course is a two-week field trip at end of Spring Quarter, specific dates to be announced. Our goal is to prepare proposals for field projects in the field portion of this course. Field projects are conducted at Organ Pipe Cactus National Monument in Arizona where we compare patterns of plant and animal distribution along an elevation gradient. We then take a driving tour of the Mohave and Great Basin before returning to Chicago. *Field conditions are rugged. Travel is by twelve-passenger van. Lodging during most of this course is tent camping on developed campsites. E. Larsen. Spring. L.*

13113. Prairie Ecosystems: Lessons of Sustainability in the Past, Present, and Future. *PQ: BIOS 10110.* This course looks at the Midwest prairie as a model ecosystem. How and when did grasslands evolve? And where and when did they become established? How many species and biotrophic levels are interconnected in a regularly disturbed environment? Are there keystone species? What are the ecological forces that maintain, destroy, and restore balance? Glacial retreat, fire, deep-rooted perennial grasses, large herbivores, deforestation, industrial agriculture, and biofuels are covered. We then apply what we have we learned from the grasslands to live sustainably. *J. Borevitz. Spring.*

13115. From So Simple A Beginning: Evolution. *PQ: BIOS 10110.* This course discusses a wide range of biological and geological phenomena in the light of evolutionary theory. The material is presented in the form of scientific inquiry

to provide insight into how we know what we know. Concepts are presented using examples relevant to the human condition and human evolution. *Practical part in the Evolving Planet exhibit of the Field Museum required. P. Sierwald, R. Bieler. Winter.*

13124. Learning about Reasoning from the Evolutionary Debate. *PQ: BIOS 10100 or 10110. Open only to nonmajors.* How we think about the evolution of life profoundly affects how we see ourselves and our roles in the world, both on a global and personal level. Using the current knowledge and debates of evolutionary models, this lecture/discussion course explores the psychology and philosophy of human knowledge; how humans build models of reality; and the relationship between models, beliefs, and actions, including those with ethical dimensions. This exploration prompts students to reassess their own worldview, with regard to evolutionary issues and reasoning as well as to decision making. *I. Pavlova. Spring, 2008.*

14107. Workings of the Human Brain. *PQ: BIOS 10100 or 10110.* 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. Winter, Spring.*

14108. Introduction to the Nervous System. *PQ: BIOS 10100 or 10110. Basic knowledge of biology recommended.* This course is designed for students with an interest in the biology of the nervous system. Lectures cover the basic principles and discussion sessions illustrate specific examples. We discuss 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, X. Zhuang, G. Thinakaran. Autumn.*

14111. Introduction to Brain and Behavior. *PQ: BIOS 10100 or 10110. Enrollment preference given to students who are not majoring in biological sciences.* This course introduces the structure of the nervous system. Using examples such as the visual system, students learn how external stimuli are transferred into chemical signals and how the resulting information is used to initiate or modify behavior. Other topics covered (e.g., addiction, Parkinson's disease, traumatic brain injury) illustrate how the brain optimally works and how different factors can negatively alter behavior. Students also gain an appreciation for the techniques employed in neurobiological research. *T. Brink. Spring.*

15106. Plagues: Past and Present. *PQ: BIOS 10100 or 10110.* This course explores selected examples of ancient, re-emerging, and emerging pathogens in the context of biology, as well as epidemiology and the selective pressures that influence the spread and control of epidemics. Emphasis is placed on the

biological basis of how microbes gain access to and cause damage in their hosts and the struggle between the pathogen and the host's immune system. Students also gain an understanding of the basis for diagnostic procedures, treatments, and immunization. *Discussion sessions required in addition to lectures. S. Boyle-Vavra. Winter.*

15108. Immune System in Health and Disease. *PQ: BIOS 10100 or 10110.* This course introduces basic concepts of molecular biology and immunology. Subjects 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, 2008.*

15109. The Origins of Cancer. *PQ: BIOS 10100 or 10110.* 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. Autumn.*

15111. Epithelium and Intestinal Flora. *PQ: BIOS 10100 or 10110.* This lecture/discussion course introduces the symbiotic relationship between humans and their intestinal flora on a cellular and molecular level. Special emphasis is given to understanding the benefits derived from normal gut flora as well as the molecular mechanisms responsible for diarrhea, inflammatory bowel disease, and cancer. Students discuss recent original experimental work in related fields. *J. Sun, M. Hobert. Spring, 2007.*

15112. Biological Poisons and Toxins. *PQ: BIOS 10110 or 10100.* This course explores biological poisons and toxins found throughout our environment. Toxins can originate from bacteria (anthrax, tetanus, botulinum, cholera); plants (ricin, curare, opiates); marine organisms (tetrodotoxin and saxitoxin); mushrooms (amanitin); frogs (batrachotoxin); and other organisms. Emphasis is placed on toxins that provide insight into the workings of the nervous, cardiovascular, and gastrointestinal systems. We also address current topics (e.g., weaponization of toxins in biowarfare and bioterrorism) and explore examples of therapeutic (i.e., Botox) and commercial uses of toxins. *J. Kyle. Spring.*

Biological Sciences Sequences for Majors and Students Preparing for the Health Professions

Five-Quarter Fundamentals Sequences

BIOS 20181 through 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. The final two quarters of this sequence must be completed by choosing two of the following three courses: BIOS 20184, 20185, or 20194. 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. *Students who completed the first three courses in this sequence prior to Autumn 2004 must take two of the following courses: BIOS 20184 (Biodiversity), 20185 (Ecology and Evolution), or either 20183 (Physiology) or 20193 (Physiology), but not both.*

Students interested in Ecology and Evolution are encouraged to begin the sequence with BIOS 20184 and 20185. These students should then discuss their further options with their undergraduate adviser. They typically take STAT 22000 in the third quarter and complete the Fundamentals Sequence in the following year.

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, A. Imamoto, C. Maki, 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. *L. Mets, G. Webb, P. Strieleman, Staff. Winter. L.*

20183. Physiology. *PQ: BIOS 20181 and 20182.* This course focuses on the physiological problems that animals (including humans) face in natural environments; solutions to these problems that the genome encodes; and the emergent physiological properties of the molecular, cellular, tissue, organ, and organismal levels of organization. Lectures and labs emphasize physiological reasoning, problem solving, and current research. *M. Feder, M. Osadjan. Spring. L.*

20184. Biological Diversity. 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, A. Hunter, C. Andrews. Autumn. L.*

20185. Ecology and Evolution. This course surveys the basic 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, 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. *G. Dwyer, J. Coyne, C. Andrews. Winter. L.*

BIOS 20191 through 20195

This integrated 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. The final two quarters of this sequence must be completed by choosing two of the following three courses: BIOS 20184, 20185, or 20194. Completing or placing out of general or honors chemistry is a prerequisite for BIOS 20191, unless the instructor gives prior consent. *Students who completed the first three courses in this sequence before Autumn 2004 must take two of the following courses: BIOS 20184 (Biodiversity), 20185 (Ecology and Evolution), or either 20183 (Physiology) or 20193 (Physiology), but not both.*

Students interested in Ecology and Evolution are encouraged to begin the sequence with BIOS 20184 and 20185. These students should then discuss their further options with their undergraduate adviser. They typically take STAT 22000 in the third quarter and complete the Fundamentals Sequence in the following year.

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. *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. *D. Bishop, B. Lahn, C. Schonbaum. Winter. L.*

20193. Organismal Physiology. *PQ: BIOS 20191 and 20192.* 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. *D. McGehee, M. Osadjan. Spring. L.*

20194. Developmental Biology. *PQ: First three quarters of either BIOS 20180s or 20190s.* 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. *J. Crispino, R. Ho, C. Schonbaum. Spring. L.*

Three-Quarter AP 5 Fundamentals Sequence

This sequence is open only to students who (1) have a score of 5 on the AP biology test; and (2) have first- or second-year standing, with enrollment preference given to first-year students.

A score of 5 on the AP biology test, together with a sufficiently high score on the biology diagnostic exam, allows students to register for the three-quarter accelerated sequence below. This sequence meets requirements for the biological sciences major. Upon completion of the three-quarter AP 5 sequence, students will have three credits in the major and they will have met the general education requirement for the biological sciences. Students preparing for the health professions will have met the general education requirement and will have credit for two electives. All students must register for BIOS 20234 (Autumn Quarter) and BIOS 20235 (Winter Quarter). Students register for a third course chosen from the following list: BIOS 20243, 20244, 20245, 20249, 20256, 20257, or 20260.

20234. Molecular Biology of the Cell. *PQ: Score of 5 on the AP biology test.* This course covers the fundamentals of molecular and cellular biology. Topics include protein structure and function; DNA replication, repair, and recombination; transcription, translation, and control of gene expression; cellular structure; organelles; cell cycle; cellular communication; and cell movement. *V. Prince, M. Glotzer, R. Zaragoza. Autumn. L.*

20235. Biological Systems. *PQ: BIOS 20234.* This course builds upon molecular cell biology foundations to explore how biological systems function. Topics include classical and molecular genetics, developmental signaling networks, genomics, proteomics, transcriptomics, and biological networks. *I. Rebay, V. Prince, R. Zaragoza. Winter. L.*

20243. From Neurons to Behavior: The Morphological and Physiological Basis of Movement. *PQ: BIOS 20235 and first-year standing, or consent of*

instructor. This course meets requirements for the biological sciences major. This course examines movement systems at multiple levels of design and function—integrating neurobiology, muscle morphology and physiology, skeletal mechanics, and the interaction of organisms with the physical environment. These topics are examined through lectures, readings from the primary literature, and labs. Lectures provide basic information on each subject and examples of recently published work. Readings complement the lectures and cover current issues in the relevant fields. Labs involve exposure to methodological approaches and work on a class research project that combines data collected with several of these techniques. *M. Hale. Spring. L.*

20244. The BIO 2010 University of Chicago Initiative: Biophysics and Chemical Biology. *PQ: BIOS 20234 and first-year standing.* This interdisciplinary seminar course is designed to prepare students for research at the interface of physical and biological sciences. Papers are selected from those recently published by colleagues at the University of Chicago, allowing students to meet and interact with authors and to explore examples of approaches drawn from the physical sciences and applied as powerful tools to understand biological systems. Working in groups, the students master the contents of each paper. They then conduct critical reviews, both in class and by writing essays. Through lab demonstrations and visits, students are introduced to key research methods and the shared research labs that provide access to key technologies to scientists at the University of Chicago. *S. Kron. Spring.*

20245. Immersive Virtual Anatomy. *PQ: Consent of instructor.* This course is an intensive introduction to human anatomy in a unique lab without cadaveric materials. Students and instructors collaborate in systematically revealing and learning fine anatomic details of the human body systems and regions from high-resolution clinical volumetric data (e.g., computed tomography and magnetic resonance) via high-performance interactive full-color stereo visualization systems based upon parallel computer gaming boards. This captivating, larger-than-life "dissection" experience is complemented by our study of textbooks and other virtual anatomic materials. *J. C. Silverstein. Spring.*

20249. Genome Informatics: Genome Organization, Expression, and Transmission. *PQ: BIOS 20235.* This seminar course examines how genomes are organized for coding sequence expression and transmission to progeny cells. The class discusses a series of key papers in the following areas: bacterial responses to external stimuli and genome damage, control of eukaryotic cell differentiation, complex loci regulating developmental expression in animals, centromere structure and function, position effect variegation, chromatin domains, chromatin remodeling, RNAi, and chromatin formatting. *J. Shapiro. Spring.*

20250. Programming for Modern Biological Science Research. *PQ: BIOS 20182/20192.* In the era of "omics" (e.g., genomics, proteomics), many modern biological studies require the automation of lab procedures and the processing of massive data. This course helps students acquire basic programming skills to face the challenge. We introduce basic concepts about computing and programming,

as well as describe daily computing environment. We discuss the use of basic Perl, C++, Java, and other programming for biological research needs (i.e., repetitive or massive calculations, formating or reformating of text data, sequence manipulation). *C. Liu. Spring. L.*

20256. Developmental Genetics and Evolution. (=EVOL 33700, ORGB 33700) *PQ: BIOS 20235.* The purpose of this course is to provide a developmental genetic perspective on evolutionary questions that have emerged in various disciplines (e.g., developmental biology, paleontology, phylogenetic systematics). Topics range from the evolution of gene regulation to the origin of novelties (e.g., eyes, wings). Although these subjects are introduced in lectures, the focus of this course is on reading, presenting, and discussing original research papers. *U. Schmidt-Ott. Spring.*

20257. Experimental Biophysical Chemistry. *PQ: BIOS 20235.* This is an introductory, lab-based course directed towards studying binding interactions of macromolecules with metal ions, small molecule ligands, and other macromolecules. The strength of binding interactions of proteins and enzymes are measured using different physical methods to evaluate and compare quantitative limits of precision and accuracy in determining equilibrium binding constants and steady-state kinetic parameters. Emphasis is placed on error analysis. We apply state-of-the-art physical methods, including fluorescence, circular dichroism, isothermal titration calorimetry, and surface plasmon resonance. The results of experiments are coordinated with examination of pertinent macromolecular structures through use of computer controlled molecular graphics. The theory underlying physical methods used for experimental observation of macromolecular binding interactions is introduced in lectures. *M. Makinen, M. Yousef. Spring. L.*

20260. Chordate Evolutionary Biology. Chordate biology emphasizes the diversity and evolution of modern vertebrate life, drawing on a range of sources (from comparative anatomy and embryology to paleontology, biomechanics, and developmental genetics). Much of the work is lab-based, with ample opportunity to gain firsthand experience of the repeated themes of vertebrate bodyplans, as well as some of the extraordinary specializations manifest in living forms. The instructors, who are both actively engaged in vertebrate-centered research, take this course beyond the boundaries of standard textbook content. *N. Shubin, M. Coates. Spring. L.*

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 Fundamentals Sequences. Courses listed under the headings *Specialized Courses* and *Independent Study and Research* may not be counted toward the courses required for the major 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) Fundamentals Sequence; (M) Minor Program in Interdisciplinary Sciences; (MIV) Microbiology, Immunology, or Virology; (N) Neuroscience; (O) Organismal; and (S) Specialized. *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)**
20200. Introduction to Biochemistry. *L.* **(F)**
20234. Molecular Biology of the Cell. *L.* **(F)**
21207. Cell Biology. **(C)**
21209. Molecular Biology. **(C)**
21227. Advanced Developmental Biology. **(C)**
21236. Genetics of Model Organisms. **(C)**
21306. Human Genetics and Evolution. **(C)**
22233. Comparative Vertebrate Anatomy. *L.* **(O)**
22257. Darwinian Medicine. **(O)**
23248. Primate Behavior and Ecology. **(E&E)**
23256. Fundamentals of Molecular Evolution. *L.* **(E&E)**
23261. Invertebrate Paleobiology and Evolution. **(E&E)**
23351. Ecological Applications to Conservation Biology. **(E&E)**
23403. Systematic Biology. *L.* **(E&E)**
24203. Introduction to Neuroscience. **(N)**
24208. Vertebrate Neural Systems. **(N)**
24221. Computational Neuroscience I: Single Neuron Computation. *L.* **(N)**
24246. Neurobiology of Disease I. **(N)**
25136. Fundamentals of Clinical Research.
25206. Fundamentals of Bacterial Physiology. **(MIV)**
25226. Endocrinology I: Cell Signaling. **(MIV)**
25256. Immunobiology. **(MIV)**
25260. Host Pathogen Interactions. **(MIV)**
26210. Mathematical Models for Biological Sciences I. **(CI)**
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)**
20235. Biological Systems. *L.* **(F)**
21200. Human Molecular Genetics. *L.* **(C)**

21208. Fundamentals of Molecular Biology. **(C)**
21216. Introductory Statistical Genetics. **(C)**
21229. Genome Informatics: How Cells Reorganize Genomes. **(C)**
22226. Human Developmental Biology. **(O)**
22242. Biological Fluid Mechanics. *L.* **(O)**
23100. Dinosaur Science. **(E&E)**
23240. The Diversity and Evolution of Plants. *L.* **(E&E)**
23246. The Diversity and Evolution of Plants. **(E&E)**
23249. Animal Behavior. **(E&E)**
23280. The Science Behind Genetically Modified Organisms. **(E&E)**
23289. Marine Ecology. **(E&E)**
23406. Biogeography. **(E&E)**
24204. Cellular Neurobiology. *L.* **(N)**
24207. Developmental Neurobiology. **(O)**
24217. Conquest of Pain. **(N)**
24222. Computational Neuroscience II: Vision. *L.* **(N)**
24247. Neurobiology of Disease II. **(N)**
25108. Cancer Biology. **(MIV)**
25227. Endocrinology II: Systems and Physiology. **(MIV)**
25258. Immunopathology. **(MIV)**
25287. Introduction to Virology. **(MIV)**
25407. Organ Transplantation. **(MIV)**
26100. Quantitative Topics in Biology II: Physiology and Biochemistry. *L.* **(CI)**
26211. Mathematical Models for Biological Sciences II. **(CI)**
26400. Introduction to Bioinformatics. *L.* **(CI)**
28400. Introduction to Systems Biology I. *L.* **(M)**
28500. Biological Physics. **(M)**
29281. Introduction to Medical Ethics. **(S)**
29296. Biological and Cultural Evolution. **(S)**
29300. Biological Psychology. **(S)**
29310. Medicine and Society: Things, Bodies and Persons. **(S)**
29406. Mathematical and Statistical Methods for Neuroscience II. **(N)**

Spring Quarter

20183. Organismal Physiology. *L.* **(F)**
20193. Organismal Physiology. *L.* **(F)**
20194. Developmental Biology. *L.* **(F)**
20200. Introduction to Biochemistry. *L.* **(F)**
20242. Physiology. (AP 5) *L.* **(F)**
20243. From Neurons to Behavior. (AP 5) *L.* **(N)**
20244. The BIO2010 U of C Initiative: Biophysics and Chemical Biology. (AP 5) *L.* **(F)**
20245. Immersive Virtual Anatomy. *L.* **(F)**
20249. Genome Informatics: Genome Organization, Expression, and Transmission. **(F)**
20250.Programming for Modern Biological Science Research. **(F)**
20256. Developmental Genetics and Evolution. (AP 5) **(F)**
20257. Experimental Biophysical Chemistry. (AP 5) *L.* **(F)**
20260. Chordate Evolutionary Biology. (AP 5) *L.* **(F)**
21304. Photosynthesis. *L.* **(C)**
21317. Topics in Biological Chemistry. **(C)**
21318. Molecular Biophysics. **(C)**
21319. RRP: Ribosomes, RNA, and Protein. **(C)**
21326. Molecular Biophysics: Theory and Application. **(C)**
21356. Vertebrate Development. **(O)**
21407. Image Processing In Biology. **(C)**
22244. Introduction to Invertebrate Biology. *L.* **(O)**

22247. Principles of Pharmacology. **(N)**
22248. Physiology of Vision. **(N)**
22260. Vertebrate Structure and Function. **(O)**
23124. Learning About Reasoning from the Evolutionary Debate. (BIOS majors) **(E&E)**
23232. Ecology and Evolution in the Southwest. **(E&E)**
23233. Ecology and Evolution in the Southwest: Field School. **(E&E)**
23241. Primate Evolution. **(E&E)**
23250. Research in Animal Behavior. **(E&E)**
23252. Field Ecology. *L.* **(E&E)**
23253. Apes and Human Evolution. **(E&E)**
23254. Mammalian 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)**
23408. Modeling and Computer Simulation of Evolution. **(E&E)**
24204. Cellular Neurobiology. *L.* **(N)**
24218. Molecular Neurobiology. **(N)**
24223. Computational Neuroscience III: Cognitive Neuroscience. *L.* **(N)**
25109. Topics in Reproductive Biology and Cancer. **(MIV)**
25126. Animal Models of Human Disease. **(MIV)**
25216. Molecular Basis of Bacterial Disease. **(MIV)**
25228. Endocrinology III: Human Disease. **(MIV)**
25307. Molecular Genetic Analysis of Bacteriophage. **(MIV)**
25406. Translational Biomedical Research: From Bench to Patient Bedside. **(MIV)**
26212. Mathematical Models for Biological Sciences III. **(CI)**
26317. Molecular Mechanisms of Cell Signaling. **(C)**
28401. Introduction to Systems Biology II. *L.* **(M)**
28406. Systems Biology, Self-Assembly, and Complexity. **(M)**
29285. Evolution and Medicine: Brain and Sex. **(S)**
29288. Genetics in an Evolutionary Perspective. **(S)**
29291. The History of U.S. Public Health. **(S)**
29326. Introduction to Medical Physics and Medical Imaging. **(S)**
29407. Mathematical and Statistical Methods for Neuroscience III. **(N)**

General Courses

Most general and specialized courses that are at the 20000-level and above assume mastery of the material covered in the Fundamentals Sequences. Students who have not yet completed the Fundamentals Sequence should consult with the individual instructor and the BSCD senior adviser before registering for the following courses. *Students must confirm their registration with their instructors by the second class meeting or their registration may be canceled.*

20200. Introduction to Biochemistry. *PQ: BIOS 20181-20182 or 20191-20192, and CHEM 22000-22100/23100. This course meets the biochemistry requirement for the biological sciences major.* This course examines the chemical nature of cellular components, enzymes, and mechanisms of enzyme activity, energy interconversions, and biosynthetic reactions. Strong emphasis is given to control and regulation of metabolism through macromolecular interactions. *P. Strieleman, M. Makinen, Autumn; P. Strieleman, H. Friedmann, Winter, Spring; P. Strieleman, Summer. L.*

21200. Human Molecular Genetics. *PQ: Completion of BIOS 20182, 20192, or 20235.* This course considers the different types of variation in the human genome and the tools that are used to characterize human genetic variation at the individual and population levels. We further explore how this variability is utilized to: (1) understand the molecular pathology of human disease, (2) aid in the diagnosis of human disease, (3) reconstruct human evolutionary origins and population history, and (4) unravel the evolutionary history of human genes and gene families. Throughout this course, we consider the social and ethical implications of human genetic research and medical applications. *C. Ober, A. Di Rienzo. Winter. L.*

21207. Cell Biology. *PQ: BIOS 20200 or equivalent. Third- or fourth-year standing.* This course covers fundamental concepts in gene expression and RNA processing, and then focuses on ribosome dynamics, regulation of protein synthesis and turnover, chaperone and proteasome functions, RNA and protein shuttling in and out of the nucleus, trafficking to different cellular compartments, cytoskeleton structures, movement through the endoplasmic reticulum and golgi, mitochondrial and chloroplast biogenesis, signaling pathways from the cell surface to the nucleus, cell-cell interactions, and apoptosis. Experimental approaches in cell biology are emphasized. Students participate in discussions on specialized topics based on original research reviews. *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 course covers the structure of genetic material, replication, recombination, and transcription and its regulation. Other topics include 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 course 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, S. Kron. Autumn.*

21216. Introductory Statistical Genetics. *PQ: BIOS 21200, college-level statistics course, and consent of instructor.* The goal of this course is to provide students with an understanding of genetic models for complex human disorders and quantitative traits. Students also learn how to conduct parametric and nonparametric linkage analyses, as well as linkage disequilibrium mapping using transmission/disequilibruim tests (TDT) and decay of haplotype sharing (DHS). *N. Cox. Winter.*

21227. Advanced Developmental Biology. (=DVBI 35400, GENE 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, D. Preuss. Autumn.*

21229. Genome Informatics: How Cells Reorganize Genomes. *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.*

21236. Genetics of Model Organisms. *PQ: BIOS 20182 or 20192.* A small number of organisms have been chosen for extensive study by biologists. The popularity of these organisms derives largely from the fact that their genomes can be easily manipulated, allowing sophisticated characterization of biological function. This course covers modern methods for genetic analysis in budding yeast, Drosophila, C. elegans, Arabidopsis, and the mouse. Case studies demonstrate how particular strengths of each system have been exploited to understand such processes as genetic recombination, pattern formation, and epigenetic regulation of gene expression. *D. Bishop, J. Malamy, E. Ferguson, M. Glotzer. Autumn.*

21304. Photosynthesis. *PQ: BIOS 20200 and 20180s, or 20190s.* This course covers 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. We also consider 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, 2007. L.*

21306. Human Genetics and Evolution. *PQ: BIOS 20180s or 20190s, or consent of instructor. Open only to students with advanced standing who are majoring 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. We stress 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, R. Hudson. Autumn, 2007.*

21317. Topics in Biological Chemistry. *PQ: BIOS 20200. Required of biological chemistry majors.* 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. Computer graphics exercises complement the lecture topics. *P. Rice, Staff. Spring.*

21318. Molecular Biophysics. (=BCMB 32400) *PQ: CHEM 22000-22100/ 23100 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. We focus 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. Spring.*

21319. RRP: Ribosomes, RNA, and Protein. *PQ: General chemistry, organic chemistry, and BIOS 20200*. This 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. Spring.*

21326. Molecular Biophysics: Theory and Application. (=BCMB 32200) *PQ: General chemistry, organic chemistry, and BIOS 20200. Third- or fourth-year standing, or consent of instructor.* This course exposes students to modern biophysical methods and provide background for use of existing facilities at the University of Chicago. Topics include the measurement of physical properties of biological molecules (e.g., structure, thermodynamics, kinetics). We focus on practical aspects but also cover a sufficient amount of theoretical background to develop the proper understanding of the technique. *T. Sosnick. Spring.*

21327. Structural Basis of Enzyme Action. *PQ: BIOS 2020 or CHEM 22000, and CHEM 22100. Advanced standing.* This course emphasizes structure, mechanism, and kinetics of enzyme catalyzed reactions. We discuss protein sequence alignment, allostery, three-dimensional structure of proteins, steady-state kinetics, molecular dynamics, and molecular motors. A laboratory component consists of molecular graphics stereo viewing and analysis of enzyme-

substrate complexes, and a discussion session is held each week for analysis of current research publications. *M. Makinen. Spring.*

21356. Vertebrate Developmental Biology. (=DVBI 35600) *PQ: BIOS 20180s or 20190, or AP 5 sequence.* 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). *K. Millen. Spring.*

21407. Image Processing in Biology. (=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. We also deal 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.*

22233. Comparative Vertebrate Anatomy. *PQ: Fundamentals or AP 5 sequence.* This course covers the structure and function of major anatomical systems of vertebrates. Lectures focus on vertebrate diversity, biomechanics, and behavior (from swimming and feeding to running, flying, seeing, and hearing). Labs involve detailed dissection of animals (muscles, organs, brains) and a focus on skull bones in a broad comparative context from fishes to frogs, turtles, alligators, mammals, birds, and humans. *Field trip to Field Museum and visit to medical school lab for human dissection required. M. Westneat. Autumn. 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 introduces 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, 2007. L.*

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, 2009. L.*

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, 2008. L.*

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.*

22248. Physiology of Vision. (=PSYC 25000/35000) *PQ: Prior physics and calculus courses, and one of the following: BIOS 24236 or 24204, or PSYC 28000.* This advanced course on primate visual physiology covers in detail cortical systems for object recognition, visual motion perception, depth perception, and heading (self-motion) perception. We also discuss basic components of visual computation, including frequency analysis, computational mapping, gain normalization, and population coding. *D. Bradley. 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, 2007.*

22260. Vertebrate Structure and Function. *PQ: BIOS 22233 or consent of instructor.* This course is devoted to vertebrate bones and muscles, with a focus on some of the remarkable functions they perform. The first part takes a close comparative look at the vertebrate skeleton via development and evolution, from lamprey to human. The major functional changes are examined as vertebrates adapted to life in the water, on land, and in the air. The second part takes a close look at muscles and how they work in specific situations, including gape-

feeding, swimming, leaping, digging, flying, and walking on two legs. Dissection of preserved vertebrate specimens required. *P. Sereno. Winter, 2007. L.*

23100. Dinosaur Science. *PQ: Consent of instructor and a prior course in general science, preferably geology or biology.* This introductory-level (but intensive) class includes a ten-day expedition to South Dakota and Wyoming (departing just after graduation). We study basic geology (e.g., rocks and minerals, stratigraphy, Earth history, mapping skills) and basic evolutionary biology (e.g., vertebrate and especially skeletal anatomy, systematics and large-scale evolutionary patterns). This course provides the knowledge needed to discover and understand the meaning of fossils as they are preserved in the field, which is applied to actual paleontological sites. Participants fly from Chicago to Rapid City, and then travel by van to field sites. There they camp, prospect for, and excavate fossils from the Cretaceous and Jurassic Periods. *Field trip required. P. Sereno. Winter. L.*

23124. Learning about Reasoning from the Evolutionary Debate. *PQ: Completion of the general education requirement for the biological sciences. Open only to biological sciences majors.* How we think about the evolution of life profoundly affects how we see ourselves and our roles in the world, both on a global and personal level. Using the current knowledge and debates of evolutionary models, this lecture/discussion course explores the psychology and philosophy of human knowledge; how humans build models of reality; and the relationship between models, beliefs, and actions, including those with ethical dimensions. This exploration prompts students to reassess their own worldview, with regard to both evolutionary issues and reasoning and decision making. *I. Pavlova. Spring, 2008.*

23232. Ecology and Evolution in the Southwest. *PQ: Completion of the general education requirement for the biological sciences, BIOS 20185, or consent of instructor.* This lecture/laboratory course focuses on the ecological communities of the Southwest, primarily on the four subdivisions of the North American Desert, the Chihuahuan, Sonoran, Mohave, and Great Basin Deserts. Lecture topics include climate change and the impact on the flora and fauna of the region; adaptations to arid landscapes; evolutionary, ecological, and conservation issues in the arid Southwest, especially relating to isolated mountain ranges; human impacts on the biota, land, and water; and how geological and climatic forces shape deserts. *E. Larsen. Spring.*

23233. Ecology and Evolution in the Southwest: Field School. *PQ: Consent of instructor.* Students in this course compare patterns of plant and animal distribution along an elevation gradient in two deserts. Our goal is to prepare proposals for field projects in the field portion of this course. *This lab course is a two-week field trip at end of Spring Quarter, specific dates to be announced. Field projects are conducted at Organ Pipe Cactus National Monument in Arizona. We then take a driving tour of the Mohave and Great Basin. Field conditions are rugged. Travel is by twelve-passenger van. Lodging during most of this course is tent camping on developed campsites. E. Larsen. Spring. L.*

23240. The Diversity and Evolution of Plants. *PQ: Completion of the general education requirement for the biological sciences.* Lectures in this course 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.*

23241. Primate Evolution. This course, which is the first of three in the Primate Biology and Human Evolution sequence (see also BIOS 23248 and 23253), introduces the evolution of nonhuman primates and humans. We focus on taxonomic classification; the use of fossil and genetic evidence for phylogenetic reconstructions; the evolution of primate morphological and physiological characteristics (e.g., body and brain size, skull and skeleton, sense organs, and dietary and reproductive adaptations); the adaptive radiation of Prosimians, New World Monkeys, Old World Monkeys, and apes into their current areas of geographic distribution; and an overview of the hominid fossil record. *R. Martin. Spring.*

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 21800/34300) *PQ: Completion of the general education requirement for the biological sciences. This course is the second of three in the Primate Biology and Human Evolution sequence (see also BIOS 23241 and BIOS 23253).* This course explores the behavior and ecology of nonhuman primates with emphasis on their natural history and adaptation to the environment. Specific topics include methods for the study of primate behavior, history of primate behavior research, foraging, predation, demography and dispersal, evolution of social and mating systems, affiliation, aggression, sexual behavior, parenting, development, communication, and cognition. *D. Maestripieri. Autumn.*

23249. Animal Behavior. (=HDCP 41650, HUDV 23249, PSYC 23249) *PQ: Completion of the general education requirement for the biological sciences.* For course description, see Human Development. *S. Pruett-Jones (even years), J. Mateo (odd years=PSYC 23249). Winter.*

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. Discussion with the instructor and T.A. 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.

All behavioral observations are conducted at Lincoln Park Zoo. S. Margulis. Spring, even years.

23252. Field Ecology. *PQ: Consent of instructor. Open only to students planning to pursue graduate research.* This course introduces 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. A two-week field trip to southern Florida during the Winter/Spring Quarter break 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. *Field trip required. S. Pruett-Jones. Spring. L.*

23253. Apes and Human Evolution. (=ANTH 28600/38600, EVOL 38600, HIPS 23700) *BIOS 23241 recommended.* For course description, see Anthropology. *Visits to local zoos, films, and demonstrations with casts of fossils and skeletons required. R. Tuttle. Spring, 2007.*

23254. Mammalian Ecology. *PQ: Completion of the general education requirement for the biological sciences and third-year standing; or BIOS 20184 or 20185.* This course introduces the diversity and classification of mammals and their ecological relationships. Lectures cover natural history, evolution, and functional morphology of major taxonomic groups. Lab sessions focus on skeletal morphology, identifying traits of major taxonomic groups, and methods of conducting research in the field. *Participation in field trips, occasionally on Saturday, is required. E. Larsen. Spring. L.*

23255. Introductory Paleontology. (=EVOL 32300, GEOS 22300) *PQ: GEOS 13100-13200, or PHSC 10900/11000, 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. (=ECEV 44000, EVOL 44000, GENE 44000) *PQ: Prior calculus course or consent of instructor.* 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. We also provide 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. L.*

23261. Invertebrate Paleobiology and Evolution. (=EVOL 32400, GEOS 22400/32400) *PQ: Completion of the general education requirement for the biological sciences.* For course description, see Geophysical Sciences. *Labs and fieldtrips required. M. Webster. Autumn. L.*

23266. Evolutionary Adaptation. *PQ: BIOS 20184 or 20185, or AP 5 sequence.* 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.*

23280. The Science behind Genetically Modified Organisms. *PQ: BIOS 20185.* The focus of this lecture/discussion course is the production of genetically modified organisms. We begin by understanding what genetic manipulation entails and how genetic manipulation can enhance agriculture and medicine. We then critically evaluate the scientific basis of health and environmental concerns. Readings from the primary literature and government reports are supplemented with background information on genetic technologies. *J. Bergelson. Winter.*

23281. Evolutionary Aspects of Gene Regulation. (=ECEV 32500, EVOL 32600, DVBI 32500, GENE 32500) *PQ: BIOS 23256 or consent of instructor.* Using primary research literature, this course examines recent advances in understanding of evolution of gene regulation. Topics include patterns and forces of evolutionary change in regulatory DNA and transcription factors, genetic changes that are responsible for phenotypic evolution, and discovery and evolutionary of implications of gene control by microRNAs. *I. Ruvinsky. Spring.*

23289. Marine Ecology. (=ENST 23289) *PQ: Prior introductory course in ecology or consent of instructor.* This course provides an introduction into the physical, chemical, and biological forces controlling the function of marine ecosystems and how marine communities are organized. The structures of various types of marine ecosystems are described and contrasted, and the lectures highlight aspects of marine ecology relevant to applied issues such as conservation and harvesting. *T. Wootton. Winter.*

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 this course. *M. Ruddat, J. Greenberg. Spring.*

23351. Ecological Applications to Conservation Biology. (=ECOL 31300, ENST 25100) *PQ: Completion of the general education requirement for the biological sciences and consent of instructor.* We focus on the contribution of ecological theory to the understanding of current issues in conservation biology. We emphasize quantitative methods and their use for applied problems in ecology (e.g., design of natural reserves, risk of extinction, impact of harvesting, dynamics of species invasions, role of species interaction). Course material is drawn mostly from the

current primary literature. *One Saturday field trip and computer modeling labs are in addition to scheduled class time. J. Bergelson, C. Pfister. Autumn. L.*

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.*

23403. Systematic Biology. (=EVOL 35400) *PQ: Completion of the general education requirement for the biological sciences.* This course carefully explores the concepts of homology, relationships, species, and higher taxa. We also cover modern methods of phylogeny reconstruction including morphological and molecular approaches. We consider the central role of systematic biology in the biological sciences and its connection to the fossil record, ontogeny, biogeography, taxonomy, and conservation. *M. Kearney. Autumn. L.*

23406. Biogeography. (=ENST 25500, EVOL 45500, GEOG 25500/35500) *PQ: Completion of the general education requirement for the biological sciences and a course in either ecology, evolution, or earth history; 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 (e.g., design and effectiveness of nature reserves). *B. Patterson (odd years, lab); L. Heaney (even years, discussion). Winter.*

23408. Modeling and Computer Simulation of Evolution. (=HGEN 47200) *Basic computer programming skills or willingness to learn some programming recommended.* This course introduces the creation of theoretical models to describe and predict biological processes. Students learn how to implement these models on a computer and how to explore the properties of the models by computer simulation. The class draws from examples in evolutionary biology that describe the evolution of organisms within and between species. We may also consider models from ecology or infectious disease epidemiology. *R. Hudson, J. Pritchard. Spring.*

24203. Introduction to Neuroscience. *PQ: A Fundamentals Sequence (BIOS 20180s or 20190s, or AP 5 sequence). This course is required for the neuroscience specialization.* This course is designed to provide a comprehensive introduction to the structure and function of the mammalian brain. *K. Sharma, M. Sherman, E. Grove. Autumn.*

24204. Cellular Neurobiology. (=PSYC 31100) *PQ: BIOS 24203. This course meets one of the requirements of the neuroscience specialization.* This course is concerned with the structure and function of the nervous system at the cellular level. It describes the cellular and subcellular components of neurons and their basic membrane and electrophysiological properties. We study cellular and molecular aspects of interactions between neurons, which leads to functional analyses of the mechanisms involved in the generation and modulation of behavior in selected model systems. *P. Lloyd. Winter.*

24205. Systems Neuroscience. (=PSYC 24000/31200) *PQ: BIOS 24204 or 24236, or consent of instructor. This course meets one of the requirements of the neuroscience specialization.* This course introduces 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, R. McCrea, M. Osadjan. Spring. L.*

24207. Developmental Neurobiology. *PQ: BIOS 24204 and 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. Winter.*

24208. Vertebrate Neural Systems. (=NURB 31600) *PQ: Consent of instructor.* This lab-centered course teaches students the fundamental principles of vertebrate nervous system organization. Students learn the major structures and the basic circuitry of the brain, spinal cord, and peripheral nervous system. Early sensory processing and the motor system are presented in particular depth. A highlight of this course is that students become practiced at recognizing the nuclear organization and cellular architecture of the rodent, cat, and primate brain. *C. Ragsdale. Autumn. L.*

24217. Conquest of Pain. *PQ: CHEM 22000-22100-22200 or BIOS 20200 required; 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. We discuss the role of opiates and enkephalins. Central theories of anesthesia, including the relevance of sleep proteins, are also examined. *J. Moss. Winter, 2008.*

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. Spring.*

24221. Computational Neuroscience I: Single Neuron Computation. *PQ: Prior college-level course in calculus required; some background in neurobiology and concurrent registration in BIOS 29405 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, Staff. Autumn. L.*

24222. Computational Neuroscience II: Vision. *PQ: BIOS 24221 required; concurrent registration in BIOS 29406 recommended.* This course considers computational approaches to vision. We cover the basic anatomy and physiology of the retina and central visual pathways, emphasizing computational approaches based on control theory, linear and nonlinear systems theory, and information theory. *P. Ulinski, Staff. Winter. L.*

24223. Computational Neuroscience III: Cognitive Neuroscience. (=CPNS 33200, ORGB 34600) *PQ: BIOS 24222.* This course is concerned with the relationship of the nervous system to higher order behaviors (e.g., perception, action, attention, learning, memory). Modern methods of imaging neural activity are introduced. Mathematical and statistical methods (e.g., dynamical systems theory, information theory, pattern recognition for studying neural encoding in individual neurons and populations of neurons) are discussed. *N. Hatsopoulos. Spring. L.*

24246. Neurobiology of Disease I. (=CPNS 34600) *PQ: NURB 31800 or BIOS 24203.* This seminar course is devoted to basic clinical and pathological features and pathogenic mechanisms of neurological diseases. The first semester is devoted to a broad set of disorders ranging from developmental to acquired disorders of the central and peripheral nervous system. Weekly seminars are given by experts in the clinical and scientific aspects of the disease under discussion. For each lecture, students are given a brief description of clinical and pathological features of a given set of neurological diseases followed by a more detailed description of the current status of knowledge of several of the prototypic pathogenic mechanisms. *C. Gomez, Staff. Winter.*

24247. Neurobiology of Disease II. (=CPNS 34700) *PQ: BIOS 24246.* This seminar course is devoted to understanding pathogenic mechanisms of neuronal death, neurodegenerative disease, and neuronal repair. Weekly seminars are given by experts in the basic and clinical aspects of neurodegenerative diseases. For each lecture, students are provided with a brief description of clinical and pathological features of a given set or mechanistic category of neurodegenerative diseases that

is followed by a more detailed description of the current status of knowledge of several of the prototypical pathogenic mechanisms. *C. Gomez, Staff. Spring.*

25108. Cancer Biology. *PQ: Completion of the general education requirement for the biological sciences.* This course covers the fundamentals of cancer biology with a focus on the story of how scientists identified the genes that cause cancer. The 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. We stress the role that cellular subsystems (e.g., signal transduction, cell cycle) play in cancer biology, as well as evolving themes in cancer research (e.g., ongoing development of modern molecular therapeutics). *M. Rosner, P. Nash, K. MacLeod. Winter.*

25109. Topics in Reproduction 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. We also discuss 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.*

25126. Animal Models of Human Disease. *PQ: BIOS 20181, 20191, or 20239/20234; or consent of instructor.* This course introduces 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, as well as on the use of large animal surgical models. University veterinarians also provide information regarding humane animal care. *C. L. Wardrip, Staff. Spring.*

25136. Fundamentals of Clinical Research. *PQ: General chemistry and biology.* This is an elective course designed for students with an interest in conducting clinical research to develop new treatment for diseases and/or to develop new drugs. Students learn how drugs function/act in a human body, clinical research techniques, and data interpretation. This comprehensive course also covers federal regulations, types of clinical studies, clinical study designs, and writing a clinical research grant proposal. *S. Yang. Autumn.*

25206. Fundamentals of Bacterial Physiology. (=MICR 30600) *This course meets one of the requirements of the microbiology specialization. BIOS 25256 (after 2007).* This course introduces bacterial diversity, physiology, ultra-structure, envelope assembly, metabolism, and genetics. In the discussion section, students review recent original experimental work in the field of bacterial physiology. *Biweekly lab required. D. Missiakas, T. Christianson. Autumn. L.*

25216. Molecular Basis of Bacterial Diseases. (=MICR 31600) *This course meets one of the requirements of the microbiology specialization.* 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. *J. Martinez. Spring.*

25226. Endocrinology I: Cell Signaling. (=CPHY 33600, NPHP 33600) *PQ: BIOS 20200.* The subject matter of this course considers the wide variety of intracellular mechanisms that, when activated, change cell behavior. We cover aspects of intracellular signaling, the latter including detailed discussions of receptors, G-proteins, cyclic nucleotides, calcium and calcium-binding proteins, phosphoinositides, protein kinases, and phosphatases. *M. Brady*, *C. Palfrey, M. Roe, J. Sun*. *Autumn.*

25227. Endocrinology II: Systems and Physiology. *PQ: A Fundamentals Sequence (BIOS 20180s or 20190s, or AP 5 sequence).* Endocrinology is the study of hormones, which are chemical messengers released by tissues that regulate the activity of other cells in the body. This course covers the classical hormone systems, including hormones regulating metabolism, energy mobilization and storage, calcium and phosphate metabolism, reproduction, growth, "fight or flight," and circadian rhythms. We focus on historical perspective, the mechanisms of action, homeostatic regulation, and relevant human diseases for each system. *M. Brady, R. Cohen. Winter.*

25228. Endocrinology III: Human Disease. *A Fundamentals Sequence (BIOS 20180s or 20190s, or AP 5 sequence) and BIOS 25227 recommended but not required.* This course is a modern overview of the patho-physiologic, genetic, and molecular basis of human diseases with nutritional perspectives. We discuss human diseases (e.g., hypertension, cardiovascular diseases, obesity, diabetes, osteoporosis, alopecia). *Y. C. Li, M. Musch. Spring.*

25246. Infections and Immunity. *PQ: Completion of the general education requirement for the biological sciences. Not open to students specializing in microbiology or immunology.* Approximately 25 percent of annual deaths in the world result from infectious diseases. Pathogens and their hosts are involved in a constant battle, leading to the recent emergence and re-emergence of deadly infections. This course explores the interplay between pathogen's strategies and the host's immune system. AIDS, tuberculosis, the flu, and the bubonic plaque are among some of the diseases covered. *J. Quintans, B. Fineschi, I. Pavlova. Spring.*

25256. Immunobiology. *PQ: BIOS 20180s or 20190s, and consent of instructor. BIOS 25206 will be required after 2007; in 2006, enrollment preference will be given to students who have completed or are concurrently taking BIOS 25206.* This survey course presents an integrated and comprehensive coverage of the tactics and logistics of innate and adaptive immune phenomena and conveys the elegance and complexity of the biological solutions evolved by multicellular organisms in their on going fights against infectious agents. *J. Quintans. Autumn.*

25258. Immunopathology. (=IMMU 30010, PATH 30010) *PQ: Consent of instructor.* Five examples of diseases are selected each year among the following categories: autoimmune diseases, inflammatory bowel diseases, infection immunity, immunodeficiencies and gene therapy, and transplantation and tumor immunology. Each disease is studied in depth with general lectures that include, where applicable, histological analysis of diseased tissue samples and discussions of primary research papers on experimental disease models. Special emphasis is placed on understanding immunopathology within the framework of general immunological concepts and on experimental approaches to the study of immunopathological models. *B. Jabri. Winter.*

25259. Fundamental Issues in Immunology. *PQ: Consent of instructor.* This course is based on the study of fundamental areas of immunology, using exclusively the primary literature. Topics, which rotate yearly over a five-year cycle, may include immunological tolerance, immunological memory, regulation of the class of immune responses, innate and adaptive immune recognition, and lymphocyte development (hemopoiesis excluded). Our aim is to grasp the conceptual and technological milestones in a historical perspective, from classics up to recently published work. We emphasize the detailed analysis and discussion of experimental data and concepts. *A. Bendelac. Autumn.*

25260. Host Pathogen Interactions. *PQ: Consent of instructor.* This course explores the basic principals of host defense against pathogens and pathogens' strategies to overcome host immune mechanisms. We address evolutionary aspects of innate and adaptive immune responses, while also studying specific examples of viral and bacterial interactions with their hosts. The reviews of relevant immunological mechanisms necessary for appreciation of host/pathogen interactions are incorporated in the studies of specific cases. *S. Chevronsky. Autumn.*

25287. Introduction to Virology. (=GENE 34600, MICR 34600, VIRO 34600) This class on animal viruses considers the major families of the viral kingdom with an emphasis on the molecular aspects of genome expression and virus-host interactions. Our goal is to provide students with solid appreciation of basic knowledge, as well as instruction on the frontiers of virus research. *E. Pilipenko. Winter.*

25307. Molecular Genetic Analysis of Bacteriophage. (=GENE 33000, MGCB 33000, MICR 33000) *PQ: BIOS 20200. This course meets one of the requirements of the microbiology specialization.* Phage are the most abundant and fastest growing biological entities, and they are involved in many natural microbiological processes. This course examines a series of bacteriophage that have been instrumental in our understanding of genetics and molecular biology, with an emphasis on their properties and the methods for which they are used in current and potential biological studies and in biotechnology. *M. Casadaban. Spring.*

25406. Translational Biomedical Research: From Bench to Patient Bedside. *PQ: A Fundamentals Sequence (BIOS 20180s or 20190s, or AP 5 sequence). Suggested for students planning postgraduate study in medicine or in biological sciences.* This course focuses on translational research in biomedical sciences with an emphasis on cancer research. In the scientific world, translation is the application of fundamental discoveries in basic science to clinical medicine, with the goal of developing new treatments for debilitating diseases. This course uses specific examples to cover the relationship between basic and translational research, the process of drug discovery, preclinical development and clinical testing, and choice of animal models for translational research. *H. R. Xing. Spring.*

25407. Organ Transplantation. *PQ: BIOS 25256.* This course presents biological, technical, ethical, and economic issues associated with organ transplantation. We sharply focus the immunologic knowledge from BIOS 25256 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 (i.e., kidney, liver, heart, lung, pancreas, islet, intestinal) are covered. The social, economic, and ethical issues raised in transplantation (i.e., allografts, xenografts, living donation) are also discussed. *A. Chong. Winter.*

25409. Immuno-logic: A Systems Approach. *Prior knowledge of computer programming not required.* This course begins with information about immunology and continues with research on current issues in immunology. Experiments are carried out "in silico" using IMMSIM (an immune system simulation developed at IBM's research labs). Lectures cover issues such as the nature and the development of autoimmune diseases (e.g., lupus, diabetes); the development of optimal organ transplantation strategies; the development of vaccines for viruses (e.g., the immune response to flu); and HIV drug holidays. Students with special interests have the opportunity to develop their own projects. *M. Weigert. Spring.*

26210-26211-26212. Mathematical Methods for Biological Sciences I, II, III. *PQ: MATH 15300 or equivalent*. This sequence is intended for students with an interest in quantitative approaches to biology. It provides a basic foundation in applied mathematics that serves as basis for upper-level biology courses that take quantitative approaches.

26210. Mathematical Methods for Biological Sciences I. *PQ: MATH 15300 or equivalent*. This course covers linear algebra, ordinary differential equations, numerical solutions to ordinary differential equations, and dynamical systems theory. Examples from biology are used throughout the sequence. Labs introduce computational approaches and visualization methods. *T. Baker. Autumn. L.*

26211. Mathematical Methods for Biological Sciences II. *PQ: BIOS 26210.* This course covers partial differential equations, vector spaces, Fourier and Laplace transforms, and Fourier analysis. Examples from biology are used throughout the sequence. Labs introduce computational approaches and visualization methods. *T. Baker. Winter. L.*

26212. Mathematical Methods for Biological Sciences III. This course covers basic mathematical probability, probability distributions, correlation, principal and independent component analysis, and stochastic processes. Examples from biology are used throughout the sequence. Labs introduce computational approaches and visualization methods. *T. Baker. Spring. L.*

26317. Molecular Mechanisms of Cell Signaling. (=CPHY 31900, NURB 31900) *PQ: BIOS 20181-20183 or 20191-20193, 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, with an emphasis on the structural basis of cell signaling. *W.-J. Tang. Spring.*

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. *W. Li. Winter.*

28400. Introductions to Systems Biology I. *PQ: Third- or fourth-year standing.* This is the first course of a two-quarter sequence. It covers how an organism emerges and evolves from the instructions embedded in its genome sequence. The available genome sequences from bacteria to man revolutionized how this question is addressed. Which, when and why molecules, both large (e.g., transcriptomics for RNA, proteomics for proteins) and small (e.g., metabolomics for metabolites), are there? What are the integrated effects these molecules have on cell behavior and evolution? This course introduces ideas and concepts and high-throughput, as well as large scale methods and techniques that are applied to analyze and understand the current genomics revolution. This course consists of lectures and literature discussions, as well as lab sessions. *T. Pan. Winter. L.*

28401. Introductions to Systems Biology II. *PQ: BIOS 28400.* This is the second course of a two-quarter sequence. Lectures in this course focus on the related graphic theories that address random connections of components in a

system and the role of these theories in interpretation of observed data. Lab experiments teach computational visualization of interaction maps and databases of interactions from available genomes. Students analyze a typical molecular system to ask and solve pertinent biological questions. We emphasize how a system changes over evolutionary time and how a new component can invade the old system. Instruction consists of a combination of lectures, experiments, and discussion. *M. Long, T. Nagylaki. Spring. L.*

28406. Systems Biology, Self-Assembly, and Complexity. (=CPHY 35000) *PQ: Consent of instructor. Advanced standing and background in cell biology, genetics, protein chemistry, mathematics, physics, and chemistry.* Among the most challenging concepts in biology involve understanding the fundamental mechanisms that underlie self-assembly and complexity in systems that vary from simple multi-protein molecular machines to cellular systems (e.g., signal transduction) to multi-cellular systems (e.g., immune system) or even whole organism (e.g., development). Systems biology aims at a holistic understanding of the dynamics of biological systems by combining approaches from system sciences, life sciences, and information sciences. Fundamental concepts and cutting-edge approaches are introduced at the interface of the biological and physical sciences. *P. Nash. Spring.*

28500. Biological Physics. (=PHYS 25500) *PQ: PHYS 19700 or CHEM 26200.* This course introduces the physics of living matter. Our goal is to convey an understanding of the design principles from physics that characterize the condensed and organized matter of living systems. In particular, we first focus on the physics of molecular motors, the dynamics of single molecules, and the mechanical properties of individual DNA molecules. In the second part of the class, we study examples of stochastic processes in intracellular regulatory networks. *P. Cluzel, T. Emonet. Winter.*

Big Problems Courses

02370. Psychoneuroimmunology: Links between the Nervous and Immune Systems. (=BPRO 24200, PSYC 24150) *PQ: Third- or fourth-year standing, and BIOS 20180s or 20190s. This course meets requirements for the biological sciences major and the immunology specialization.* This course covers all aspects of neuroimmunoendocrinology at the molecular, cellular, and organismal and social levels. *M. McClintock, J. Quintans. Spring.*

02490. Biology and Sociology of AIDS. (=BPRO 24900) *PQ: Third- or fourth-year standing.* This interdisciplinary course deals with current issues of the AIDS epidemic. Readings are based primarily on *AIDS Update 2006*. *J. Quintans, H. Pollack. Winter, 2007.*

02810. The Complex Problem of World Hunger. (=BPRO 24800, ENST 24800, SOSC 26900) *PQ: Third- or fourth-year standing. This course does not*

meet requirements for the biological sciences major. For course description, see Big Problems. *J. Malamy, D. Levine. Spring. Offered 2007-08; not offered 2006-07.*

02927. Perspectives on Imaging. (=ARTH 26900/36900, BPRO 27000, CMST 27300/37300, HIPS 24801) *PQ: Third- or fourth-year standing. This course does not meet requirements for the biological sciences major.* For course description, see Big Problems. *B. Stafford, P. La Riviere. Autumn, 2006.*

Specialized Courses

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

29281. Introduction to Medical Ethics. (=HIPS 21400) *PQ: Second-year standing or higher. This course does not meet requirements for the biological sciences major.* 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.*

29285. Evolution and Medicine; Brain and Sex. (=ECEV 30900, EVOL 30900, GNDR 26601) *PQ: Completion of the general education requirement for the biological sciences. This course does not meet requirements for the biological sciences major.* This course on medical implications uses lectures, readings, and discussions to cover a variety of areas in the evolutionary half of biology, with a focus on the brain and on sex. We consider such topics as hormones and behavior, what use are males, evolution of immunity, ghosts of environments past, and mating strategies. *L. Van Valen, M. Stoller. Spring.*

29286. Biological and Cultural Evolution. (=BPRO 23900, CHSS 37900, HIPS 23900, LING 11000, PHIL 22500/32500) *PQ: Third- or fourth-year standing or consent of instructor required; core background in genetics and evolution strongly recommended. This course does not meet requirements for the biological sciences major. For information on when course will be offered, call Margot Browning at 702-5657.* For course description, see Big Problems. *W. Wimsatt, S. Mufwene. Winter. Offered 2007-08; not offered 2006-07.*

29288. Genetics in an Evolutionary Perspective. (=BIOS 29288, CHSS 34210, HIPS 21401, PHIL 32201) *PQ: Completion of the general education requirement for the biological sciences and prior course in pre-calculus mathematics. This course does not meet requirements for the biological sciences major.* This course covers the historical development of theories of heredity and evolution. We begin before Darwin and Mendel; and proceed through the development of cytology and classical genetics, population genetics, and neo-Darwinism. We also discuss evolutionary developmental biology and "eco-evo-devo," as well as the relation

between macro-evolution and micro-evolution. This course includes computer simulations for historical and modern simpler models in population biology, as well as the strategy and tactics of mathematical model building. *W. Wimsatt. Spring.*

29291. The History of U.S. Public Health. (=HIPS 21701) *This course does not meet requirements for the biological sciences major.* This discussion-based course explores changes in public responsibility for health in the United States from 1800 to the later part of the twentieth century. Primary and secondary readings address how public health has responded to disease, knowledge of disease processes, social conditions, politics, and the medical profession. Topics include the public health response to epidemics, the sanitary movement, immigration concerns, public health research, private foundation initiatives, disease surveillance, vaccine policies, and risk factor epidemiology. *D. Lauderdale. Spring, 2008.*

29299. History of Public Health in Latin America. (=LACS 24700/34900) This course provides a broad and introductory overview of Latin America and the History of Public Health. We discuss (1) historical epidemiology and the impact of the introduction of European and African diseases in Latin America from 1492 to 1770; (2) maritime trade with Latin America, the demographic transition, and the development of public health, sanitation, and hygiene movements in the nineteenth century; and (3) international development and public health interventions in Latin America in the twentieth century. *K. Jones. Spring.*

29300. Biological Psychology. (=PSYC 20300/30300) *PQ: Some background in biology and psychology. This course does not meet requirements for the biological sciences major.* What are the relations between mind and brain? How do brains regulate mental, behavioral, and hormonal processes; and how do these influence brain organization and activity? This course introduces the anatomy, physiology, and chemistry of the brain; their changes in response to the experiential and sociocultural environment; and their relation to perception, attention, behavioral action, motivation, and emotion. *L. Kay, B. Prendergast. Winter.*

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

29307. Biotechnology and the Human Future. (=ISHU 23605) *PQ: Completion of general education requirements in biological sciences and humanities, or equivalent.* Where is biotechnology taking us? How far do we wish to go? What will this "journey" mean for humanity? These large questions are the subject of this interdisciplinary seminar, where they are pursued largely by examining and discussing several works published by the President's Council on Bioethics (of which the instructor was for four years the chairman): *Beyond Therapy:*

Biotechnology and the Pursuit of Happiness; Human Cloning and Human Dignity; and *Being Human. L. Kass. Spring.*

29310. Medicine and Society: Things, Bodies, and Persons. (=BPRO 22500, HIPS 22501, HIST 22501, PHIL 22501) *This course does not meet requirements for the biological sciences major*. For course description, see Big Problems. *D. Brudney, J. Lantos, F. Curlin. Winter, 2008.*

29311. Autonomy and Medical Paternalism. (=BPRO 22600, HIPS 21901, HIST 25102, PHIL 22601) *PQ: Third- or fourth-year standing. This course does not meet requirements for the biological sciences major.* For course description, see Big Problems. *This course is offered in odd years. D. Brudney, J. Lantos, A. Winter. Winter, 2007.*

29312. Social Behavior and Health. (=SOCI 20160/30160) *PQ: Introduction to Sociology or Epidemioliogy. This course does not meet requirements for the biological sciences major.* This course surveys research literature in several core areas of medical sociology from the perspective of social behavior and health. It first introduces the theoretical orientations focusing on social construction of illness, medicine as an institution of social control, and labeling theory and stigma. This is followed by discussion of empirical studies in three dominant research arenas: social epidemiology, social stress and illness, and organization of health care and health care utilization. *Y. Yang. Winter.*

29326. Introduction to Medical Physics and Medical Imaging. *PQ: PHYS 23500. This course does not meet requirements for the biological sciences major.* This course covers the interaction of radiation with matter and the exploitation of such interactions for medical imaging and cancer treatment. Topics in medical imaging include X-ray imaging and radionuclide imaging, as well as advanced technologies that provide three-dimensional images, including X-ray computed tomography (CT), single photon emission computed tomography (SPECT), positron emission tomography (PET), magnetic resonance imaging (MRI), and ultrasonic imaging. *S. Armato, P. La Riviere, C. Pelizzari. Spring.*

29405. Mathematical and Statistical Methods for Neuroscience I. (=CPNS 32000) *PQ: Some background in linear algebra and ordinary differential equations. This course meets requirements for the biological sciences major 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 the analysis of data obtained from physiological and imaging experiments using methods from signal processing. Signal averaging, continuous and discrete Fourier methods, Laplace and z-transforms, basic properties of filters, and applications of linear systems theory to physiological signals are considered. *W. van Drongelen. Autumn.*

29406. Mathematical and Statistical Methods for Neuroscience II. *PQ: BIOS 29405 or consent of instructor. This course meets requirements for the biological sciences major only for students specializing in neuroscience.* This is the second course of a three-quarter sequence that deals with analysis of data obtained from physiological and imaging experiments using methods from nonlinear systems dynamical systems theory. *W. van Drongelen. Winter.*

29407. Mathematical and Statistical Methods for Neuroscience III. (=CPNS 32200) *PQ: BIOS 29405 and 29406, or consent of instructor. This course meets requirements for the biological sciences major only for students specializing in neuroscience.* This is the third course of a three-quarter sequence that deals with applications of linear and nonlinear control theory. The goal of this course is to help students understand physiological systems, particularly the nervous system. *D. Mogul, P. Ulinski. Spring.*

Independent Study and Research

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

00290-00291-00292-00293-00294-00295. Interdisciplinary Research Seminar I, II, III, IV, V, VI. *PQ: Consent of instructor. These courses cannot be counted toward any of the five upper-level biological sciences courses required for the biological sciences major.* This seminar course for advanced research students serves as a curricular component of the PCBio program that complements their experience in their mentor's lab. Students participate in critical analyses of scientific literature and formal presentations of their ongoing research, as well as writing and revising reviews, research reports, and theses. *S. Kron, J. Quintans, Staff, Autumn (00290); S. Kron, J. Quintans, Staff, Winter (00291); S. Kron, J. Quintans, Staff, Spring, (00292); S. Kron, J. Quintans, Staff, Autumn (00293);*

S. Kron, J. Quintans, Staff, Winter (00294); S. Kron, J. Quintans, Staff, Spring (00295).

00298. Undergraduate Research Seminar. *PQ: Fourth-year standing and consent of director of undergraduate research and honors. Course must be taken for a quality grade and may be counted toward requirements for the biological sciences major. This seminar course is required of fourth-year students who are pursuing honors.* 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 director of undergraduate research and honors. Students are required to submit the College Reading and Research Course Form. This course is available for quality grades or for* P/F *grades. This course does not meet requirements for the biological sciences major. In the first quarter of registration, students must submit Supplementary Information Forms to their research sponsor and the director of undergraduate research and honors. 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.