

# Biological Sciences

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## Program of Study

Biology is the study of life, past and present. Life operates within supportive ecosystems that generate selective pressures driving diversity and complexity through 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.

## Academic Honesty

Academic dishonesty is a matter of grave concern to the faculty of the Biological Sciences Collegiate Division and will not be tolerated. Students should become familiar with the guidelines presented in *Doing Honest Work in College* by Charles

Lipson and consult with each of their instructors to make sure they understand the specific expectations of each course. Consequences of academic dishonesty (including plagiarism) may result in suspension or expulsion from the University.

### 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 10130. 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.

### 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 BA 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 10100-10200 or 11100-11200 (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 20150-20151) 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. Students majoring in the Biological Sciences are encouraged to meet their general education humanities requirement in their first year with an autumn-winter, two-quarter sequence.

### 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 10300/11300 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, PHYS 12300 or higher, or STAT 22000 or higher.

#### *Courses in the Biological Sciences*

**Fundamentals Sequence.** Students register for an additional three quarters of Biology Fundamentals courses, selected from BIOS 20180s or BIOS 20190s, or for the three-quarter AP 5 Fundamentals sequence if they have a score of 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***For students who matriculated prior to Autumn 2010*

<b>General Education</b>		CHEM 10100-10200/11100-11200 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*
<b>Major</b>	3	completion of one of the following: BIOS 20180s sequence or BIOS 20190s sequence or a three-quarter AP 5* sequence
	1	CHEM 10300/11300 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 PHYS 12300 or higher or STAT 22000 or higher
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† Credit may be granted by examination. The Biology Fundamentals sequences require an average grade of C or higher in CHEM 10100-10200-10300 or CHEM 11100-11200-11300 or CHEM 12100-12200-12300, a 5 on the AP Chemistry exam, or consent of the department.

\* Open only to students with a 5 on the AP biology test (beginning with the 2010–11 entering class, open only to first-years).

**Summary of Requirements: AP 5***Beginning with Class of 2014*

<b>General Education</b>		CHEM 10100-10200/11100-11200 or equivalent† MATH 13100-13200, 15100-15200, or 16100-16200† BIOS 20150 and 20151, or completion of a three-quarter AP 5 sequence*
<b>Major</b>	1	CHEM 10300/11300 or equivalent†
	2	PHYS 12100-12200 or higher†
	1	additional quantitative course from the following: BIOS 26210 or PHYS 12300 or higher or STAT 22000 or higher
	1	BIOS 20234
	1	BIOS 20235
	2	MATH 13300, 15300, or 16300, and BIOS 20243, 20244, 20245, 20246, 20249, 20250, 20256, 20258, 20260, or 20184 (for students in E&E)
	1	BIOS 20200
	5	courses above BIOS 20200 (with lab) in biological sciences (may include BIOS 00298)
	2	CHEM 22000-221/23100
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† Credit may be granted by examination. The Biology Fundamentals require an average grade of C or higher in CHEM 10100-10200 or CHEM 11100-11200 or CHEM 12100-12200, or a 5 on the AP Chemistry exam, or consent of the department.

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

## Summary of Requirements: Variant A

*Beginning with Class of 2014*

<b>General Education</b>	CHEM 10100-10200/11100-11200 or equivalent† MATH 13100-13200, 15100-15200, or 16100-16200† BIOS 20150 and 20151, or completion of a three-quarter AP 5 sequence*	
<b>Major</b>	1	CHEM 10300/11300 or equivalent†
	2	PHYS 12100-12200 or higher†
	1	additional quantitative course from the following: BIOS 26210 or PHYS 12300 or higher or STAT 22000 or higher
	1	BIOS 20181
	1	BIOS 20182
	1	BIOS 20183
	1	BIOS 20200
	6	courses above BIOS 20200 in biological sciences (may include BIOS 00298)
	2	CHEM 22000-221/23100
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† Credit may be granted by examination. The Biology Fundamentals require an average grade of C or higher in CHEM 10100-10200 or CHEM 11100-11200 or CHEM 12100-12200, or a 5 on the AP Chemistry exam, or consent of the department.

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

## Summary of Requirements: Variant B

*Beginning with Class of 2014*

<b>General Education</b>	CHEM 10100-10200/11100-11200 or equivalent† MATH 13100-13200, 15100-15200, or 16100-16200† BIOS 20150 and 20151, or completion of a three-quarter AP 5 sequence*	
<b>Major</b>	1	CHEM 10300/11300 or equivalent†
	2	PHYS 12100-12200 or higher†
	1	additional quantitative course from the following: BIOS 26210 or PHYS 12300 or higher or STAT 22000 or higher
	1	BIOS 20181
	1	BIOS 20182
	1	BIOS 20194
	1	BIOS 20200
	6	courses above BIOS 20200 (with lab) in biological sciences (may include BIOS 00298)
	2	CHEM 22000-221/23100
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† Credit may be granted by examination. The Biology Fundamentals require an average grade of C or higher in CHEM 10100-10200 or CHEM 11100-11200 or CHEM 12100-12200, or a 5 on the AP Chemistry exam, or consent of the department.

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

**Summary of Requirements: Variant C*****Beginning with Class of 2014***

<b>General Education</b>	CHEM 10100-10200/11100-11200 or equivalent†	
	MATH 13100-13200, 15100-15200, or 16100-16200†	
	BIOS 20150 and 20151, or completion of a three-quarter AP 5 sequence*	
<b>Major</b>	1	CHEM 10300/11300 or equivalent†
	2	PHYS 12100-12200 or higher†
	1	additional quantitative course from the following: BIOS 26210 or PHYS 12300 or higher or STAT 22000 or higher
	1	BIOS 23351 (Autumn)
	1	BIOS 20185 (Winter)
	1	BIOS 20184 (Spring)
	6	courses above BIOS 20200 in biological sciences (may include BIOS 00298)
	3	additional quantitative courses chosen in consultation with the Ecology & Evolution adviser
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† Credit may be granted by examination. The Biology Fundamentals require an average grade of C or higher in CHEM 10100-10200 or CHEM 11100-11200 or CHEM 12100-12200, or a 5 on the AP Chemistry exam, or consent of the department.

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

**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 [bscd.bsd.uchicago.edu/research.html](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.

**Responsible Conduct in Research, Training Required by National Science Foundation.** All undergraduate students must complete training prior to being

hired on any NSF. Students will access the CITI RCR education module for training and provide certificate of successful completion to the principal investigator prior to participating in a project. Go to <https://www.citiprogram.org/default.asp?language=english> and then select “Biomedical Responsible Conduct of Research Course, Basic Course” for more information.

**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, visit [bscd.bsd.uchicago.edu/honorsprogram.html](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:

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| <i>Courses</i> | <ol style="list-style-type: none"> <li>1. third quarter of organic chemistry (CHEM 22200/23200)</li> <li>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:               <ol style="list-style-type: none"> <li>a. BIOS 21207. Cell Biology</li> <li>b. BIOS 21236. Genetics of Model Organisms</li> <li>c. BIOS 21237 or BIOS 23299. Developmental Biology</li> <li>d. BIOS 21208 Molecular Biology</li> </ol> </li> </ol> |
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| <i>Laboratory or Field Research</i> | completion of an independent research project that either: <ol style="list-style-type: none"> <li>a. qualifies as a senior honors project; or</li> <li>b. is approved by the director of the specialization.</li> </ol> |
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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](mailto: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:

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| <i>Courses</i> | <ol style="list-style-type: none"> <li>1. three quarters of calculus and three quarters of statistics (starting at the level of STAT 22000) in lieu of the physics requirement</li> <li>2. three upper-level courses in the biological sciences, as recommended by the faculty member in whose lab the student does his/her research or the ecology and evolution adviser, from a menu of courses in behavior, ecology, evolution, or genetics</li> </ol> |
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<i>Laboratory or Field Research</i>	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 a research paper. The research paper should be submitted before the end of third week in spring quarter. NOTE: Students must complete field research by the end of the growing season (summer) of their third year.
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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](mailto: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. It is strongly recommended that students complete a Biochemistry course before enrolling; however, the Specialization can be completed as Endocrinology I–III or Endocrinology II, III, I.

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| <i>Introductory Courses</i> | BIOS 25226. Endocrinology I: Cell Signaling (Autumn)<br>BIOS 25227. Endocrinology II: Systems and Physiology (Winter)<br>BIOS 25228. Endocrinology III: Human Disease (Spring) |
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The specialization in endocrinology is administered by the Institute for Endocrine Discovery & Clinical Care, the Committee on Molecular Metabolism & Nutrition, and the NIH funded Diabetes Research & Training Center. For more information, consult Matthew Brady ([mbrady@medicine.bsd.uchicago.edu](mailto:mbrady@medicine.bsd.uchicago.edu)).

**Specialization in Genetics.** Biological sciences majors who obtain a *B* or better in the following set of courses will be recognized as having completed a specialization in the area of genetics. For students graduating in 2010 or 2011, the Molecular Evolution I requirement can be replaced by any course from the



approved electives. Please consult Jocelyn Malamy ([jmalamy@bsd.uchicago.edu](mailto:jmalamy@bsd.uchicago.edu)) if you would like to request approval for any non-listed course with significant genetics content to satisfy this requirement.

**Introductory Courses** BIOS 20182 or 20192. Genetics (or BIOS 20235 for those with AP 5 credit) (Winter)  
BIOS 20185. Ecology and Evolution (Winter)  
STAT 22000. Statistical Methods with Applications (section focused on biological data)

**Advanced Courses** BIOS 21236. Genetics of Model Organisms (Autumn) *and either*  
BIOS 23258. Molecular Evolution I: Fundamentals and Principles (Winter)  
*or*  
BIOS 21206. Advanced Topics in Human Genetics (Winter)

*Choose two of the following:*

BIOS 20256. Developmental Genetics and Evolution (Spring)  
BIOS 21208. Fundamentals of Molecular Biology (Winter)  
BIOS 21216. Introductory Statistical Genetics (Winter)  
BIOS 21237. Developmental Mechanisms (Winter)  
BIOS 21229. Genome Informatics: How Cells Reorganize Genomes (Winter)  
BIOS 21306. Human Genetics and Evolution (Autumn)  
BIOS 23259. Molecular Evolution II: Genes and Genomes (Spring)  
BIOS 23286. An Introduction to Population Genetics (Spring)  
BIOS 23299. Plant Development and Molecular Genetics (Spring)  
BIOS 25216. Molecular Genetic Analysis of Bacterial Pathogenesis (Winter)  
BIOS 25287. Introduction to Virology (Spring)  
BIOS 28407. Genomics and Systems Biology (Spring)  
BIOS 29319. What Genomes Teach About Evolution (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.

The specialization in genetics is administered by the Committee on Genetics. Consult Jocelyn Malamy (702.4651, [jmalamy@bsd.uchicago.edu](mailto: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.

*Students are required to take both of the following three courses:*

BIOS 25256. Immunobiology (Autumn)  
BIOS 25258. Immunopathology (Winter)  
BIOS 25266. Molecular Immunology (Spring)

*The following is an elective course:*

BIOS 25260. Host Pathogen Interactions (Autumn)

For more information, students should consult with Bana Jabri, Department of Pathology and the Committee on Immunobiology (834.8670, [bjabri@bsd.uchicago.edu](mailto:bjabri@bsd.uchicago.edu)).

**Accelerated Program in Immunology.** The University of Chicago Graduate Program in Immunology permits undergraduate students who have demonstrated outstanding potential for graduate studies in biology to begin graduate school during their fourth year in the College. This is a competitive merit-award program.

Because of the accelerated nature of the curriculum, applicants must have outstanding academic credentials (i.e., GPA typically in the range of 3.7 and GRE scores typically not less than 1400). Eligible students also have a clear understanding of their motivation for immunology. Laboratory experience is not mandatory but highly encouraged.

Candidates will apply to the Graduate Program in Immunology at the University of Chicago during their third year in the College. Eligible students must have completed thirty-three credits (of the forty-two required for a degree in the College) by the end of their third year. These thirty-three credits must include all fifteen general education requirements and one-half of the requirements for their major.

For further information, contact Bana Jabri, Department of Pathology and the Committee on Immunobiology (834.8670, [bjabri@bsd.uchicago.edu](mailto: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. For more information, students should consult with Dominique Missiakas, undergraduate adviser of the Committee on Microbiology (834.8161, [dmissiak@bsd.uchicago.edu](mailto:dmissiak@bsd.uchicago.edu)).

*Students are required to take the following three courses:*

BIOS 25206. Fundamentals of Bacterial Physiology (Autumn)

BIOS 25216. Molecular Basis of Bacterial Diseases (Winter)

BIOS 25287. Introduction to Virology (Spring)

**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 Megan McNulty (834.7744, [mmcnulty@uchicago.edu](mailto:mmcnulty@uchicago.edu)), 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 third 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 Megan McNulty (834.7744, [mmcnulty@uchicago.edu](mailto:mmcnulty@uchicago.edu)).

## Minor Program in the Biological Sciences

Students who elect the minor program must meet with the master or senior adviser of the Biological Sciences Collegiate Division by the Spring Quarter of their second year in order to plan out the appropriate curriculum.

The minor in the Biological Sciences requires a total of six to seven BIOS courses depending on how the general education requirement for biological sciences has been met. Courses in the minor may be selected 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, courses may be selected 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. Depending on how the general education requirement is fulfilled, one to three courses must be Fundamentals Biology courses with a lab component (see sample minor programs below). Prior to taking the Fundamentals courses, students must complete the necessary prerequisites (BIOS 20150-20151) offered in the Spring Quarter. All courses must be chosen in consultation with the master or the senior adviser of the Biological Sciences

Collegiate Division.

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 or above, 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 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](mailto:kcole@uchicago.edu)). Alternatively, students can schedule an appointment with the senior adviser, Megan McNulty ([mmcnulty@uchicago.edu](mailto:mmcnulty@uchicago.edu)).

## Sample Minor Programs in the Biological Sciences

*Program for students who have met the general education biology requirements with two BIOS Fundamentals courses\**

1	Additional BIOS Fundamentals course
4–5	Upper-level (above 20200) BIOS courses

*Program for students who have met the general education biology requirements with courses for non-Biological Sciences majors*

3	*BIOS Fundamentals courses
4–5	Upper-level (above 20200) BIOS courses

*\* Prior to taking the Fundamentals Biology courses, students must complete the necessary prerequisites (BIOS 20150-20151) offered in the Spring Quarter.*

## 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 *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. The minor requires completion of the following six courses: BIOS 24221, 24222, and 24223 (Computational Neuroscience I, II, and III); BIOS 26210 and 26211 (Autumn and Winter Quarters of the Mathematical Methods for Biological Sciences sequence); and BIOS 29408 (Signal Analysis and Modeling for Neuroscientists). Students who elect the minor program are required to meet with the chair of the Committee on Computational Neuroscience (Nicholas Hatsopoulos) 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.

## Faculty

E. Adams, Y. Amit, C. Andrews, J. Bates, A. Bendelac, J. Bergelson, R. Bieler, K. Birukov, D. Bishop, J. Borevitz, S. Boyle-Vavra, M. Brady, A. Chervonsky, K.-S. Chiang, A. Chong, T. Christianson, M. Coates, R. Cohen, J. Collier, N. Cox, J. Coyne, W. Dobyns, W. Du, G. Dwyer, R. Esposito, W. Epstein, M. E. Feder, R. Fehon, E. Ferguson, B. Fineschi, M. Foote, A. Fox, H. C. Friedmann, G. Getz, M. Giger, Y. Gilad, B. Glick, M. Glotzer, J. Goldberg, C. Gomez, K. Goss, W. Green, J. Greenberg, G. Greene, E. Grove, M. Gupta, M. Hale, K. Hamann, D. Hanck, R. Haselkorn, N. Hatsopoulos, L. Heaney, A. Heller, R. Ho, R. Hudson, A. Hunter, A. Imamoto, D. Jablonski, B. Jabri, R. Jones, R. Josephs, L. Kay, K. Keenan, R. Keenan, S. Kent, S. Koide, D. Kondrashov, D. Kovar, M. Kreitman, S. Kron, V. Kumar, J. Kyle, P. La Riviere, M. LaBarbera, B. Lahey, B. Lahn, G. Lamppa, J. Lantos, E. Larsen, D. Levine, W.-H. Li, Y. Li, S. Liao, A. Lin, P. Lloyd, R. E. Lombard, M. Long, M. C. Lozada, Y. Lussier, K. Macleod, D. Maestriperi, A. Mahowald, M. W. Mäkinen, P. Makovicky, J. Malamy, D. Margoliash, J. Marks, R. Martin, T. E. Martin, J. Martinez, P. Mason, J. Mateo, M. McClintock, D. McGehee, M. McNulty, S. C. Meredith, L. Mets, D. Missiakas, A. Montag, C. Moreau, J. Moss, G. Mueller, M. Musch, T. Nagylaki, P. Nash, D. Nelson, D. Nicolae, M. Nobrega, A. Noronha, C. Ober, M. Osadjan, A. Palmer, T. Pan, B. Patterson, I. Pavlova, C. Pelizzari, R. Perlman, M. Peter, C. Pfister, J. Piccirilli, H. Pollack, B. Prendergast, D. Preuss, M. Prezworski, T. Price, V. Prince, J. Pritchard, S. Pruett-Jones, J. Quintans, C. Ragsdale, I. Rebay, R. Ree, P. Rice, B. Roizman, M. Rosner, L. F. Ross, L. Rothman-Denes, M. D. E. Ruddat, I. Ruvinsky, U. Schmidt-Ott,

O. Schneewind, C. Schonbaum, M. Schreiber, J. Schwab, E. Schwartz, P. Sereno, J. Shapiro, K. Sharma, M. Sherman, N. Shubin, P. Sierwald, 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, X. Sun, S. Szuchet, W.-J. Tang, E. W. Taylor, G. Thinakaran, A. Turkewitz, R. Tuttle, P. Ulinski, W. Van Drongelen, L. M. Van Valen, M. Verp, P. Vezina, M. Villereal, C. Wardrip, M. Webster, M. Westneat, W. Wimsatt, A. Wolfe, T.-W. Wong, I. Wool, J. T. Wootton, C. Wu, H. R. Xing, R. Zaragoza, Y. Zhao, 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 Core Biology 2010 (BIOS 10130) as their first course. For their second quarter, students choose from a menu of topics courses (BIOS 11000–19999) 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.

Multiple sections of BIOS 10130 are taught throughout the year. Sections are taught from a different perspective based upon the specialty of the instructor. The different descriptions are listed below. The student should register for the section that best suits their interests based upon the descriptions below.

### 10130. Core Biology 2010.

**A. Neurobiology.** The brain and being human: What does it mean to be human? What makes us unique and how have we evolved? Bridging the brain, the body, and biological behavior, this course uses inquiry-driven interactive learning activities, readings from the popular and scientific press, and directed writing exercises to explore the brain and the biological basis of being human. *M. McNulty. Autumn, Winter. L.*

**B. Microbes and Immunity.** These sections cover the most basic concepts in biology, such as life, macromolecules, cells, energy, metabolism, evolution, and genomics, as well as human anatomy and physiology. These particular sections draw examples from microbiology and immunology to tie these basic concepts together. The impact of our interactions with microorganisms in our evolution is highlighted in many ways. Hands-on laboratories, readings, and discussion sessions complement lectures. *B. Fineschi. Autumn, Winter, Spring. L.*

**C. Basic Biology.** What is life? How does it work and evolve? This course uses student-centered interactive learning in the lab, assigned readings from both the popular press and primary scientific literature, and directed writing exercises to explore the nature and functions of living organisms, their evolution, and their interactions with each other. *A. Hunter. Winter, Spring. L.*

**D. Biotechnology.** In the first half of this course, basic biology concepts related to biotechnology are covered. These include lectures on life, cells, macromolecules, metabolism, and genetics, complemented by hands-on laboratories. The second half of the course involves student-led topical research and presentations on various aspects of biotechnology, such as plant biotechnology, animal biotechnology, microbial biotechnology, response to bioterrorism, and examining the consequences of developments in these areas. *N. Bhasin. Spring. L.*

2. Students may choose one of the sequences below (BIOS 10450 and 10451 or BIOS 10500 and 10501) as an alternative to BIOS 10130. Taking BIOS 10500 and 10501 meets the general education requirement in biological sciences.

**10450. Pharmacological Perspectives in Cell and Molecular Biology.**

This course introduces concepts related to the use, pharmacodynamic properties, manner in which drugs act at the molecular and/or cellular level, and their effects at the organismal level. *R. Zaragoza. Winter. L.*

**10451. Pharmacological Perspectives II.** *PQ: BIOS 10450.* The goal of this course is to learn the pharmacological principals by which drugs act, at the molecular and cellular level, to affect an organ/organ systems of the human body. The pharmacodynamics, pharmacokinetic, pharmacotherapeutics and toxicology of a number of drugs are discussed. Drugs currently in the media, how these drugs affect different systems ranging from cardiovascular to the central nervous system, and the fundamental basis for the use of drugs are covered. *R. Zaragoza. Spring.*

**10500. Metabolism and Exercise.** *Must be taken in sequence with BIOS 10501.* This course examines the flow of energy through the human body—from what we eat to what we can do. Basic physiology, metabolism, and exercise concepts are covered from cells to systems. Students should be prepared to alter their diet and/or physical activity. This course is intended to be followed by BIOS 10501 (Metabolism and Nutrition). *M. Osadjan. Winter. L.*

**10501. Metabolism and Nutrition.** *Must be taken in sequence with BIOS 10500.* Taking a scientific approach to nutrition, this course covers nutritional requirements and why they are required for human health by exploring their function at the cellular and molecular level. Basic

physiology concepts related to nutritional health are covered, including digestive physiology and some aspects of endocrinology. As a continuation of the exercise concepts covered in BIOS 10501, the relationship between exercise and nutrition is considered. Students complete a dietary analysis of their food intake to critique their individual nutritional health. *P. Strieleman. Spring.*

*Topics Courses for Nonmajors*

The courses that follow have a prerequisite of BIOS 10130, or a score of 4 or 5 on the AP biology test. Attendance is required at the first class to confirm enrollment.

**10601. The Numbers on Drugs: A Quantitative Introduction to Pharmacology.** *PQ: BIOS 10130 and MATH 13300/15300/16300 or equivalent experience.* This topics course is intended for students with a quantitative background who are interested in learning about the molecular basis of drug action. Topics include the elimination of drugs (pharmacokinetics) as well as the mechanisms of drug action (pharmacodynamics), focusing on interactions with the nervous system. Quantitative aspects are emphasized, including assessing the results of clinical trials and the biophysics of molecular interactions. Students are expected to complete a final research project with a group and present it in a poster session. *D. Kondrashov. Winter.*

**11119. The Biology of Gender.** (=GNDR 12000) *PQ: BIOS 10130.* 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.*

**11125. Life through a Genomic Lens.** *PQ: BIOS 10130.* 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. This course is offered in alternate, even years.*

**11128. Introduction to Human Genetics.** *PQ: BIOS 10130.* This course covers both classical Mendelian human genetics and advances in molecular genetics. We discuss the inheritance of normal human traits and a variety of genetic diseases, including single gene traits and multifactorial, complex traits. Other topics include chromosome abnormalities, sex inheritance, human population genetics, and microevolution. *T. Christianson. Spring.*

**11129. Human Use and Abuse of Biological Molecules.** *PQ: BIOS 10130.* This course explores the science (molecular, microbial, and evolutionary) as well

as some environmental, medical, and ethical issues associated with our use of biological molecules. Antibiotics and pesticides serve as case studies. *S. Crosson, A. Fiebig, M. Marks. Spring.*

**11130. Molecules and Life.** *PQ: BIOS 10130.* This course considers the macromolecular machinery of life: proteins and enzymes, nucleic acids and genes. Topics include how the structure of DNA was discovered and how scientists currently seek to synthesize biomolecules and even cells (“synthetic biology”). We use simple computer programs and simulations to visualize and play with these macromolecules in order to appreciate their vital functions. *S. B. H. Kent. Spring.*

**12107. Cell Biology of Physiological Stress.** *PQ: BIOS 10130.* This course studies the application of cell biology principles to physiological stress. We use paradigms (e.g., fasting) to talk about organ interactions (e.g., the Cori cycle). This includes discussions of receptors, kinases, and other cellular biology. *M. Musch. Autumn.*

**12114. Nutritional Science.** *PQ: BIOS 10130.* 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. Winter, Summer.*

**12115. Responses of Cardiopulmonary System to Stress.** *PQ: BIOS 10130.* 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 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.*

**12117. The 3.5 Billion Year History of the Human Body.** *PQ: BIOS 10130.* This course looks at the structure, function, and deep history of the human body. Each major organ and system of the body is explored from perspectives of anatomy, paleontology, and developmental genetics to reveal the deep history of the body and our connections to the rest of life on the planet. *N. Shubin. Winter.*

**12118. The Descent of Man: Human Health across the Ages.** *PQ: BIOS 10130.* This course examines the relationship between human health, lifestyle, and environment. How have agriculture, urbanization, and industrialization affected human health? We discuss measures of health among hunting and gathering societies, after the development of agriculture and large settlements, at the dawn of the city, and in contemporary industrialized and developing societies. Topics

include diet, malnutrition, malaria, the bubonic plague, sanitation, pollution, the obesity epidemic, stress, and sleep. *K. Knutson. Winter.*

**13107. Environmental Ecology.** (=ENST 12404, NTSC 10400) *PQ: BIOS 10130.* This course emphasizes basic scientific understanding of ecological principles that relate most closely to the ways humans interact with their environments. It includes lectures on the main environmental pressures, notably human population growth, disease, pollution, climate change, habitat destruction, and harvesting. We emphasize the ongoing impacts on the natural world, particularly causes of population regulation and extinction and how they might feed back on to humans. *Discussion required. T. Price. Winter.*

**13109. Ecology.** *PQ: BIOS 10130.* 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 and global change research. *C. Pfister. Not offered 2010–11; will be offered 2011–12.*

**13111. Natural History of North American Deserts.** *PQ: BIOS 10130.* This lecture 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 lecture/lab course is the same course as BIOS 13111, but includes a lab section preparatory to a two-week field trip at end of Spring Quarter, specific dates to be announced. Our goal in the lab is to prepare proposals for research projects to conduct in the field portion of this course. *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.** (=ENST 13113) *PQ: BIOS 10130.* *Warm coat and ability to walk five miles required.* 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 learned from the grasslands to live sustainably. *J. Borevitz. Spring.*

**13115. From So Simple a Beginning: Evolution.** (=ANTH 28010) *PQ: BIOS 10130.* 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. The diversity of organisms is demonstrated throughout the course in the lectures, using living and preserved specimens. *Practical sessions in the Evolving Planet exhibit of the Field Museum required. P. Sierwald, R. Bieler. Winter.*

**13125. Ecology and the Environment.** This course introduces the principles of ecology and environmental biology. Focusing on both studies of wild populations of plants and animals as well as human ecology, we discuss population growth, the distribution and abundance of species, and conservation biology. Other topics include such current environmental issues as climate change, invasive species, and resource use. This course is intended for students who are not majoring in biological sciences or who are seeking an introductory understanding of ecology and environmental biology. *S. Pruett-Jones. Summer.*

**13126. Tropical Ecology: Biodiversity and Human Impacts.** *PQ: BIOS 10130.* This course covers the description of the geographic distribution of the tropics, the nature of biological communities found there in contrast with temperate communities, and the interrelations of those communities with human society, both indigenous and global. Conservation of tropical biodiversity and ecosystem services related to human populations and exploitation of resources is a major theme of the course. *E. Larsen. Winter.*

**13127. Evolution and Intelligent Design.** *PQ: BIOS 10130.* In recent years, there has been an explosion of genetic and other biological discoveries expanding our notions of evolution of life on Earth. At the same time, there has been a rise in the rejection of evolution, in particular of a movement supporting a group of ideas called intelligent design. We explore questions such as: Who is right? How do biological discoveries inform us? What is the role of science in helping us understand the world? Should intelligent design be taught along with evolution in public schools? *I. Pavlova. Autumn, Winter.*

**13128. Plant-Animal Interactions.** *PQ: BIOS 10130.* In this course we investigate the ecological interactions between plants and animals, and their evolution. Through readings and discussion we explore herbivory and mutualisms (pollination, seed dispersal). How do plants defend themselves against herbivores? How have plants and their seed dispersers, pollinators, and predators co-evolved? *A. Hunter. Winter.*

**13129. Environmental Science: A Microbiology Toolkit for the Modern Age.** *PQ: BIOS 10130.* This course covers broad themes such as the role of microbes in industrial processes, human health, and ecosystem function. We explore fundamental technologies and bioinformatics techniques used to explore the microbial world, covering statistical techniques often used by economists and

their application to the vast datasets currently being produced by researchers. We explore the new science of metagenomics and the many associated metagenomics techniques and how they can be used to generate metabolic models of whole ecosystems. We show how these models can be used to predict the impact of microbial communities on climate change and vice versa, as well as outlining how this will effect overall human endeavor. Finally, we explore the future and discuss the role of synthetic life and designer microbial communities on the continued exploitation and stewardship of planet Earth. *J. Gilbert, H. Shuman. Spring.*

**13140. The Public and Private Lives of Insects.** *PQ: BIOS 10130.* This course examines the ecology and evolution of insects, from their early evolution over 350 million years ago to their adaptations that allow them to exploit nearly every habitat on earth and become the most diverse animal group on the planet. We explore the basic biology of insects that have allowed them to become the largest group of animals on the planet, making up approximately 1.5 million of the 2 million described species. *E. Larsen. Autumn, Winter.*

**14107. Workings of the Human Brain.** *PQ: BIOS 10130.* This course is designed to give students an overview of the many functions of the brain, including perception, movement, language, emotion, memory, and sleep. We use a model of disease or dysfunction in an area of the brain to understand its normal functioning. This approach is complemented by presenting modern methods such as functional MRI and by reviewing historical milestones in neuroscience. *Attendance required at each class meeting, including lectures, labs, review sessions, and screenings of videotapes and imaging sessions. A. Noronha. Spring.*

**14112. From Brain to Behavior.** *PQ: BIOS 10130.* This course examines how the brain generates behavior. Topics include the organization of the nervous system; the mechanisms by which the brain translates external stimuli into electrical and chemical signals to initiate or modify behavior; and the neurological bases of learning, memory, sleep, cognition, drug addiction, and neurological disorders. *M. McNulty. Winter, Spring, Summer.*

**15106. Plagues: Past and Present.** *PQ: BIOS 10130.* 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.*

**15109. The Origins of Cancer.** *PQ: BIOS 10130 (no equivalency).* In this lecture/discussion course, the molecular biology and clinical aspects of cancer are considered in tandem. In particular, the most prevalent malignant tumors (e.g., those arising in the breast, prostate, colon, and lung) are used as examples. *T. W. Wong. Spring.*



**15112. Biological Poisons and Toxins.** *PQ: BIOS 10130.* 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, 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.*

**15114. Eliminating Infectious Disease.** *PQ: BIOS 10130.* Infectious diseases are a major cause of human deaths globally, yet many are preventable and curable. Why are people still dying? What would it take to prevent, cure, and ultimately eliminate infectious disease? By focusing on the major killers of our time (i.e., lower respiratory infections, AIDS, diarrheal diseases, tuberculosis, and malaria), we learn from past successes and failures, while exploring novel approaches and technologies. This course takes a multi-faceted approach, considering both biological (i.e., genetics, evolution, ecology) and nonbiological (i.e., sociological, economic) factors. *I. Pavlova. Autumn, Spring.*

**15115. Cancer Biology: How Good Cells Go Bad.** *PQ: BIOS 10130.* This lecture/discussion course examines the multi-step process by which normal cells become malignant cancer cells. Topics include how defects in the regulation of proliferation, differentiation, and apoptosis can occur in cancer cells, as well as how cancer cells can acquire the ability to attract blood vessels (angiogenesis) and to invade other organ systems (metastasis). We emphasize the study of signal transduction pathways and how they are altered in cancer cells. The concept of genes that cause cancer (oncogenes) and genes that deter cancer (tumor suppressor genes) is discussed. New disease treatments that target specific molecular defects within cancer cells are reviewed. *M. Villereal. Winter.*

**15119. Immunology: Light and Tasty.** *PQ: BIOS 10130.* The goal of this course is to familiarize students with the properties of the immune system, with a focus on responses to infections. The material is presented in a series of lectures, and learning is reinforced through reading and discussing relevant current literature. The first half of the course focuses on the cellular and molecular aspects of the immune system. The second half focuses on how the various components are integrated during the response to infectious agents. The flu (including H1N1) and HIV are used as examples. *B. Fineschi. Winter.*

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

### Fundamentals Sequences

Beginning with students matriculating in Autumn 2010, all first-year students who wish to major in Biological Sciences must take the following two courses

during Spring Quarter of their first year as prerequisites for the Fundamentals courses.

**20150. A Serious Introduction to Biology for Majors: From LUCA to the University of Chicago.** *PQ: CHEM 10100-10200 or CHEM 11100-11200 or CHEM 12100-12200.* Biology is the study of life, an emergent, ordered state of matter that evolved on planet earth some 3.5 billion years ago from prebiotic biomolecules that assembled into the last common ancestor of the three major branches of the tree of life (Bacteria, Archaea, and Eukaryotes) that gave rise under natural selection to all known organisms. Life exists and thrives in ecosystems that support the metabolic programs that generate the energy required to create and maintain cellular structure and function. Biologists study all forms of life both past and extant, and the ecosystems that support them, from unicellular microorganisms to the highly evolved human animal with infinitizing needs. Biological knowledge and its societal impact have increased dramatically in the last decades, making this an exciting, challenging, and rewarding time to be a biologist. This course prepares students for the rigorous and exciting curricular options available to them in the BSCD. It includes a scientific writing program. *J. Quintans, Staff. Spring. L.*

**20151. Introduction to Quantitative Modeling in Biology.** *PQ: CHEM 10100-10200 or CHEM 11100-11200 or CHEM 12100-12200.* The goal for this course is to give future biologists the quantitative tools to be informed consumers and producers of modern biological research. We build on the mathematical background of two quarters of calculus and learn to construct dynamical models for population growth, spread of epidemics, pharmacokinetics, and others. The students also learn statistical tools for quantifying uncertainty, such as estimation and hypothesis testing, to use for biological data analysis. Students use Excel to work with data and implement mathematical models. *D. Kondrashov. Spring. L.*

## BIOS 20181 through 20185

This 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 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.** *PQ: BIOS 20150 and BIOS 20151. Second- or third-year standing only; fourth-year by petition only. An average grade of C or higher in, and completion of, CHEM 10100-10200-10300 or CHEM 11100-11200-11300 or CHEM 12100-12200-12300, a 5 on the AP Chemistry exam, or consent of the department.* 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. *D. Kovar, T. Martin, A. Imamoto, T. Christianson. 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. *D. Bishop, J. Malamy, T. Christianson. 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. *D. McGehee, D. Hanck, M. Osadjan, C. Andrews. 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. *J. Coyne, S. Alessina, C. Andrews. Winter. L.*

## BIOS 20191 through 20194

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 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: BIOS 20150 and BIOS 20151. Second- or third-year standing only; fourth-year by petition only. An average grade of C or higher in, and completion of, CHEM 10100-10200-10300 or CHEM 11100-11200-11300 or CHEM 12100-12200-12300, a 5 on the AP Chemistry exam, or consent of the department.* 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. *I. Ruvinsky, 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, D. Hanck, C. Andrews. 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. *A. Imamoto, 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 (beginning with the 2010–11 entering class, enrollment will be open only to first-year students); it is most appropriate for students considering careers in biomedical sciences. In addition to topics listed below, courses will cover experimental design and interpretation.*

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 in the biological sciences. Nonmajors who are preparing for the health professions meet the general education requirement by completing the first two quarters of the AP Fundamentals Sequence. 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, 20246, 20249, 20250, 20256, 20257, 20258, 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; cell division; protein modification and stability; cellular signaling; and cell growth, cell death, and cancer biology. *M. Glotzer, M. Gupta, R. Zaragoza. Autumn. L.*

**20235. Biological Systems.** *PQ: BIOS 20234. Students preparing for the health professions must take BIOS 20235 and 20242 in sequence.* 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, E. Munro, 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. Seminar in Biophysics and Chemical Biology.** *PQ: BIOS 20234 and first-year standing.* This interdisciplinary freshman seminar is designed to prepare students for research at the interface of physical and biological sciences. The course focuses on papers recently published by colleagues at the University of Chicago that apply approaches drawn from the physical sciences to understand biological systems. Students meet and interact with authors, graduate students, and postdoctoral fellows who explain the scientific questions they pursue and describe their research methods. Working in groups, the students master the contents of each paper and offer critical reviews, both by presentation in class and writing essays. *S. Kron. Spring.*

**20246. Photons to Consciousness.** *PQ: BIOS 20235 or consent of instructor.* This course uses the visual system as a model to explore how the brain works. We begin by considering the physical properties of light. We then proceed to consider the mechanism of sensory transduction, cellular mechanisms of neuron to neuron communication, the operation of small neural networks, strategies of signal detection in neuron networks, and the hierarchical organization of cortical function. We conclude with visually guided behavior and consciousness. *E. Schwartz. 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.*

**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.*

**20258. From Atomic Coordinate to Protein Function.** *PQ: BIOS 20235 or consent of instructor.* The course uses the atomic coordinate of proteins to explore how molecular machinery works in the context of physiological functions and human diseases. We begin by considering the chemical and physical properties of proteins. We then proceed to explore protein components that make up the signal transduction pathway, their assembly for the various physiological functions, and the disease progression led by protein malfunctions. We conclude by discussing the protein-targeted therapeutics of human diseases. Computer graphic exercises and in-class journal clubs complement the lecture topics. *W-J. Tang. Spring.*

**20260. Chordate Evolutionary Biology.** (=EVOL 30200, ORGB 30260) 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, Developmental Biology, or Biochemistry; (CI) Computer Intensive; (E&E) Ecology and Evolution; (F) Fundamentals Sequence; (I) Integrative Biology; (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)
- 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)
- 23253. Apes and Human Evolution. (E&E)
- 23261. Invertebrate Paleobiology and Evolution. (E&E)
- 23351. Ecological Applications to Conservation Biology. (E&E)
- 23404. Reconstructing the Tree of Life: An Introduction to Phylogenetics. (E&E)
- 24203. Introduction to Neuroscience. (N)
- 24208. Survey of Systems Neuroscience. (N)
- 24221. Computational Neuroscience I: Single Neuron Computation. *L.* (N)
- 24205. Microbiology Laboratory. (MIV)
- 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)
- 27100. Personal Genomics and Translational Bioinformatics. (I)
- 29286. Biological and Cultural Evolution. (S)

### Winter Quarter

- 20182. Genetics. *L.* (F)
- 20185. Ecology and Evolution. *L.* (F)
- 20192. Genetics. *L.* (F)
- 20235. Biological Systems. *L.* (F)
- 21206. Advanced Topics in Human Genetics. (C)
- 21208. Fundamentals of Molecular Biology. (C)
- 21216. Introductory Statistical Genetics. (C)
- 21229. Genome Informatics: How Cells Reorganize Genomes. (C)
- 21237. Developmental Mechanisms. (C)
- 22226. Human Developmental Biology. (O)
- 22242. Biological Fluid Mechanics. *L.* (O)
- 22243. Biomechanics of Organisms. *L.* (O)
- 23100. Dinosaur Science. (E&E)
- 23246. The Diversity and Evolution of Plants. (E&E)
- 23247. Bioarchaeology and the Human Skeleton. (E&E)
- 23249. Animal Behavior. (E&E)
- 23258. Molecular Evolution I: Fundamentals and Principles. (E&E)
- 23281. Evolutionary Aspects of Gene Regulation. (C)
- 23289. Marine Ecology. (E&E)
- 23406. Biogeography. (E&E)

24204. Cellular Neurobiology. *L.* (N)  
 24222. Computational Neuroscience II: Information Processing in Neural Systems. (N)  
 24246. Neurobiology of Disease I. (N)  
 25108. Cancer Biology. (MIV)  
 25216. Molecular Basis of Bacterial Disease. (MIV)  
 25227. Endocrinology II: Systems and Physiology. (MIV)  
 25258. Immunopathology. (MIV)  
 25407. Organ Transplantation. (MIV)  
 25418. Systems Biology of Cancer. (MIV)  
 26211. Mathematical Models for Biological Sciences II. (CI)  
 29281. Introduction to Medical Ethics. (S)

### Spring Quarter

20183. Physiology. *L.* (F)  
 20193. Organismal Physiology. *L.* (F)  
 20194. Developmental Biology. *L.* (F)  
 20200. Introduction to Biochemistry. *L.* (F)  
 20243. From Neurons to Behavior. (AP 5) *L.* (N)  
 20244. Seminar in Biophysics and Chemical Biology. (AP 5) *L.* (F)  
 20245. Immersive Virtual Anatomy. *L.* (AP 5) (F)  
 20246. Photons to Consciousness. (AP 5) (F)  
 20249. Genome Informatics: Genome Organization, Expression, and Transmission. (AP 5) (F)  
 20251. Introduction to Systems Biology. (AP 5) (F)  
 20256. Developmental Genetics and Evolution. (AP 5) (F)  
 20258. From Atomic Coordinate to Protein Function. (AP5) (C)  
 20260. Chordate Evolutionary Biology. (AP 5) *L.* (F)  
 21207. Cell Biology. (C)  
 21317. Topics in Biological Chemistry. (C)  
 21328. Biophysics of Biomolecules. (C)  
 21356. Vertebrate Development. (O)  
 21357. Extracellular Matrices: Chemistry and Biology. (O)  
 21358. Simulation, Modeling, and Computation in Biophysics. (C)  
 21407. Image Processing In Biology. (C)  
 22244. Introduction to Invertebrate Biology. *L.* (O)  
 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)  
 23252. Field Ecology. *L.* (E&E)  
 23254. Mammalian Ecology. *L.* (E&E)  
 23255. Principles of Paleontology. *L.* (E&E)  
 23259. Molecular Evolution II: Genes and Genomes. (E&E)  
 23266. Evolutionary Adaptation. (E&E)  
 23286. An Introduction to Population Genetics. (C)  
 23299. Plant Development and Molecular Genetics. (E&E)  
 24205. Systems Neuroscience. *L.* (N)  
 24207. Developmental Neurobiology. (O)  
 24218. Molecular Neurobiology. (N)  
 24223. Computational Neuroscience III: Cognitive Neuroscience. *L.* (N)  
 24247. Neurobiology of Disease III. (N)

25109. Topics in Reproductive Biology and Cancer. (MIV)  
 25126. Animal Models of Human Disease. (MIV)  
 25228. Endocrinology III: Human Disease. (MIV)  
 25246. Infections and Immunity. (MIV)  
 25266. Molecular Immunology. (MIV)  
 25287. Introduction to Virology. (MIV)  
 25406. Translational Biomedical Research: From Bench to Patient Bedside. (MIV)  
 26212. Mathematical Models for Biological Sciences III. (CI)  
 26400. Introduction to Bioinformatics. *L.* (CI)  
 28407. Genomics and Systems Biology. (M)  
 29285. Evolution and Medicine: Brain and Sex. (S)  
 29288. Genetics in an Evolutionary Perspective. (S)  
 29308. Pharmacogenomics. (S)  
 29313. Medical Ethics: Who Decides and on What Basis? (S)  
 29317. Issues in Women's Health. (S)  
 29318. Principles of Epidemiology. (S)  
 29319. What Genomes Teach about Evolution. (S)  
 29320. Introduction to History and Philosophy of Biology. (S)  
 29321. The Problem of Evil: Disease? (S)  
 29326. Introduction to Medical Physics and Medical Imaging. (S)  
 29408. Signal Analysis and Modeling for Neuroscientists. (C)

### 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 in the biological sciences major. This course examines the chemical nature of cellular components, enzymes, and mechanisms of enzyme activity, energy interconversion, and biosynthetic reactions. Strong emphasis is given to control and regulation of metabolism through macromolecular interactions. *M. Makinen, P. Strieleman, Autumn, Spring. L.; P. Strieleman, Summer. L.*

**21206. Advanced Topics in Human Genetics.** *PQ: Second-year standing; BIOS 20182, 20192, or 20235.* The goal of this course is to provide an evolutionary perspective on the molecular genetic bases of human diseases and non-clinical human traits. The course covers fundamental concepts and recent progress in Mendelian and complex trait mapping, as well as evolutionary principles as they apply to genomics analyses of DNA sequence variation in human populations. These topics are introduced through lectures and are complemented by discussion and student presentations of original research papers. *A. Di Rienzo. Winter.*

**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. Spring.*

**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, 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.*

**21216. Introductory Statistical Genetics.** (=GENE 47100, HGEN 47100) *PQ: MD or PhD student or 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/disequilibrium tests (TDT) and decay of haplotype sharing (DHS). *N. Cox. Winter.*

**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 (*Saccharomyces cerevisiae*), fruit flies (*Drosophila melanogaster*), plants (*Arabidopsis thaliana*), and mice (*Mus musculus*). 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, A. Palmer. Autumn.*

**21237. Developmental Mechanisms.** (=MGCB 36400, DVBI 36400) *PQ: BIOS 20182, 20192, or 20235.* This course provides both an overview of

developmental biology and an in-depth coverage of selected topics, emphasizing the origins of classical concepts in the field as well as modern molecular and genetic approaches to the study of developmental processes. Subjects include cell fate determination, growth control, stem cells, signal transduction, neurogenesis, and cell polarity in developing systems. Underlying mechanisms are illuminated through discussion of key experiments. Discussion sections cover selected papers from the developmental biology literature, with emphasis on critical evaluation of experimental evidence. *E. Ferguson, R. Fehon. Winter.*

**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. Autumn.*

**21317. Topics in Biological Chemistry.** *PQ: BIOS 20200. Required of students who are majoring in biological chemistry.* This course examines a variety of biological problems from a chemical and structural perspective, with an emphasis on molecular machines. Topics include macromolecular structure-function relationships, DNA synthesis and repair, RNA folding and function, protein synthesis, targeting and translocation, molecular motors, membrane proteins, photosynthesis, and mechanisms of signal transduction. Computer graphics exercises and in-class journal clubs complement the lecture topics. *P. Rice, R. Keenan. Spring.*

**21328. Biophysics of Biomolecules.** (=BCMB 32200) *PQ: Consent of instructor.* This course covers the properties of proteins, RNA, and DNA, as well as their interactions. We emphasize the interplay between structure, thermodynamics, folding, and function at the molecular level. Topics include cooperativity, linked equilibrium, hydrogen exchange, electrostatics, diffusion, and binding. *T. Sosnick. Spring.*

**21329. Protein Post-Translational Modifications.** (=CABI 40300) *PQ: BIOS 20200.* Protein Post-translational Modification (PTM) represents a major vehicle to expand genetic codes and a cellular proteome (the inventory of all protein species in a cell). PTMs play crucial roles in the major cellular pathways and diseases. This course cover concepts that include biochemistry, proteomics/ systems biology, molecular biology, and bioinformatics, as well as practical techniques for PTMs. The goals are for students to learn fundamental chemistry, biochemistry, and enzymology of protein post-translational modifications; learn molecular mechanisms underlying functions of protein post-translational modifications through case studies; and gain basic and practical knowledge of



common techniques for characterizing protein post-translational modifications and function. *Y. Zhao, R. Jones, P. Nash. Spring.*

**21338. Epithelial Cell Biology.** (=CABI 34000, CPHY 34000) *PQ: A Fundamentals Sequence (BIOS 20180s or 20190s, or AP 5 sequence).* This course provides a fundamental understanding of epithelial cell biology and pathobiology. Topics include the molecular mechanisms that drive polarization, apical and basolateral sorting, cell-cell and cell-matrix interactions, and disease states of epithelial cells (e.g., cancer, ischemia). *K. Goss, K. Matlin, M. Zegers, M. ter Beest, J. Collier, P. Bouyer, E. Beyers. Spring.*

**21356. Vertebrate Developmental Biology.** (=DVBI 35600, MGCB 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). *V. Prince, K. Sharma. Spring.*

**21357. Extracellular Matrices: Chemistry and Biology.** (=MPMM 33000) *PQ: BIOS 20180s or 20190s, AP 5 sequence, or consent of instructor.* This course covers advanced topics dealing with the biology and chemistry of the extracellular matrix, cell-matrix interactions, and current methodologies for engineering these interfaces. *J. Collier, M. Mrksich, M. Gardel, K. Matlin. Spring.*

**21358. Simulation, Modeling, and Computation in Biophysics.** *PQ: BIOS 20200 and BIOS 26210-26212, or consent of instructor.* This course develops skills for modeling biomolecular systems. Fundamental knowledge covers basic statistical mechanics, free energy, and kinetic concepts. Tools include molecular dynamics and Monte Carlo simulations, random walk and diffusion equations, and methods to generate random Gaussian and Poisson distributions. A term project involves writing a small program that simulates a process. Familiarity with a programming language or Matlab would be valuable. *B. Roux. Spring.*

**21407. Image Processing in Biology.** (=MGCB 34300) *PQ: One year of calculus.* Whether one is trying to read radio signals from faraway 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.*

**22222. Exercise Physiology.** *PQ: BIOS 20182 or BIOS 20192. This course may substitute for BIOS 20183 or 20193 in fulfilling Pre-Med requirements and/or the Biology Fundamentals Sequence.* This course is a rigorous exploration of how the cells and systems of the human body function at times of rest and during activity.

The ability of an individual to maintain a stable internal environment during exercise is central to physical endurance and to survival. This course elucidates many of the physiological adaptations that afford such control. Students should be prepared to serve as test subjects and to alter their diet and/or physical activity. *M. Osadjan. Summer.*

**22226. Human Developmental Biology.** *PQ: BIOS 20183, 20193, 20194, 20235, or 20242.* This course covers the anatomic and physiologic development of the human from conception to birth, on an organ-by-organ basis. Special attention is paid to the profound physiologic events that take place in the transition from intra-uterine to extra-uterine life. Examples of clinical conditions due to specific errors in development are presented in context. Genetic regulation of organogenesis with reference to mouse models are discussed where the data are available. *J. Marks. 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. Winter. L. This course will be offered in 2011–12.*

**22242. Biological Fluid Mechanics.** (=EVOL 34200, ORGB 34200) *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. L. Not offered in 2010–11.*

**22243. Biomechanics of Organisms.** *PQ: Completion of the general education requirement in 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. Autumn. L. Not offered 2010–11; will be offered 2013–14.*

**22244. Introduction to Invertebrate Biology.** (=EVOL 34100) *PQ: Completion of the general education requirement in 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. Autumn. L.*

**22260. Vertebrate Structure and Function.** *PQ: BIOS 20181-20183 or 20191-20193, or consent of instructor.* This course is devoted to vertebrate bones and muscles, with a focus on some remarkable functions they perform. The first part takes a 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 looks 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. Spring. 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. Spring. L.*

**23232. Ecology and Evolution in the Southwest.** *PQ: Completion of the general education requirement in the biological sciences, BIOS 20185, or consent of instructor.* This lecture 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.* This lecture/lab course is the same course as BIOS 13111, but includes a lab section preparatory to a two-week field trip at end of Spring Quarter, specific dates to be announced. Our goal in the lab is to prepare proposals for research projects to conduct in the field portion of this course. *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.*

**23241. Primate Evolution.** (= ANTH 28100, EVOL 38700) *This course is the first of three in the Primate Biology and Human Evolution sequence (see also BIOS 23248 and 23253).* This course 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. Autumn, University of Chicago Paris Center.*

**23247. Bioarchaeology and the Human Skeleton.** (=ANTH 28400/38800) This course is intended to provide students in archaeology with a thorough understanding of bioanthropological and osteological methods used in the interpretation of prehistoric societies by introducing bioanthropological methods and theory. In particular, lab instruction stresses hands-on experience in analyzing the human skeleton, whereas seminar classes integrate bioanthropological theory and application to specific cases throughout the world. Lab and seminar-format class meet weekly. *M. C. Lozada. Winter.*

**23248. Primate Behavior and Ecology.** (=CHDV 21800/34300, EVOL 37300) *PQ: Completion of the general education requirement in 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 evolution. Specific topics include methods for the study of primate behavior, history of primate behavior research, socioecology, foraging, predation, affiliation, aggression, mating, parenting, development, communication, cognition, and evolution of human behavior. *D. Maestriperi. Autumn.*

**23249. Animal Behavior.** (=CHDV 23249, PSYC 23249) *PQ: Completion of the general education requirement in the biological sciences.* This course introduces the mechanism, ecology, and evolution of behavior, primarily in nonhuman species, at the individual and group level. Topics include the genetic basis of behavior, developmental pathways, communication, physiology and behavior, foraging behavior, kin selection, mating systems and sexual selection, and the ecological and social context of behavior. A major emphasis is placed on understanding and evaluating scientific studies and their field and lab techniques. *S. Pruett-Jones (even years), J. Mateo (odd years). Winter.*

**23252. Field Ecology.** *PQ: Consent of instructor. Open only to students who are 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. *This course is offered in alternate (odd) years. S. Pruett-Jones. Spring. L.*

**23253. Apes and Human Evolution.** (=ANTH 28600/38600, EVOL 38600, HIPS 23700) *BIOS 23241 recommended.* This course is a critical examination of



the ways in which data on the behavior, morphology, and genetics of apes have been used to elucidate human evolution. We emphasize bipedalism, hunting, meat eating, tool behavior, food sharing, cognitive ability, language, self-awareness, and sociability. Visits to local zoos and museums, film screenings, and demonstrations with casts of fossils and skeletons required. *R. Tuttle. Autumn, University of Chicago Paris Center.*

**23254. Mammalian Ecology.** *PQ: Completion of the general education requirement in 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. Principles of Paleontology.** (=EVOL 32300, GEOS 26400/36400) *PQ: GEOS 13100-13200, or PHSC 10900/11000, or completion of the general education requirement in the biological sciences, or consent of instructor.* Our focus is on the nature of the fossil record, the information it provides on patterns and processes of evolution through geologic time, and how it can be used to solve geological and biological problems. Lectures cover the principles of paleontology (e.g., fossilization, classification, morphologic analysis and interpretation, biostratigraphy, paleoecology, macroevolution); labs are systematic, introducing major groups of fossil invertebrates. *M. Foote. Spring. L.*

**23258. Molecular Evolution I: Fundamentals and Principles.** (=ECEV 44001, EVOL 44001) *PQ: Two quarters of biology and calculus, or consent of instructor.* The comparative analysis of DNA sequence variation has become an important tool in molecular biology, genetics, and evolutionary biology. This course covers major theories that form the foundation for understanding evolutionary forces that govern molecular variation, divergence, and genome organization. Particular attention is given to selectively neutral models of variation and evolution, and to alternative models of natural selection. The course provides practical information on accessing genome databases, searching for homologous sequences, aligning DNA and protein sequences, calculating sequence divergence, producing sequence phylogenies, and estimating evolutionary parameters. *M. Kreitman. Winter. L.*

**23259. Molecular Evolution II: Genes and Genomes.** (=ECEV 44021, EVOL 44002) *PQ: BIOS 23258 or consent of instructor.* This course covers the knowledge and well-established evolutionary analyses of genes and genomes, as well as related areas (e.g., origination and evolution of new genes, exon-intron structure, sex-related genes, sex-determination genetic systems, transposable elements, gene regulation systems, duplication of genes and genomes, evolution of genome sizes). These topics are discussed under the processes driven by various evolutionary forces and genetic mechanisms. The analysis of these problems is

conducted with the genomic context. Lectures, discussions, and experiments are combined. *This course is offered in alternate (odd) years. M. Long. Spring.*

**23261. Invertebrate Paleobiology and Evolution.** (=EVOL 32400, GEOS 26300/36300) *PQ: GEOS 13100 and 13200, or equivalent. Students majoring in biological sciences only: Completion of the general education requirement in the biological sciences, or consent of instructor.* This course provides a detailed overview of the morphology, paleobiology, evolutionary history, and practical uses of the invertebrate and microfossil groups commonly found in the fossil record. Emphasis is placed on understanding key anatomical and ecological innovations within each group and interactions among groups responsible for producing the observed changes in diversity, dominance, and ecological community structure through evolutionary time. Labs supplement lecture material with specimen-based and practical application sections. An optional field trip offers experience in the collection of specimens and raw paleontological data. Several "Hot Topics" lectures introduce important, exciting, and often controversial aspects of current paleontological research linked to particular invertebrate groups. *Labs required. M. Webster. Autumn. L.*

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

**23281. Evolutionary Aspects of Gene Regulation.** (=DVBI 32500, ECEV 32500, EVOL 32600, GENE 32500) *PQ: 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. Winter.*

**23286. An Introduction to Population Genetics.** *PQ: BIOS 20182 or BIOS 20192.* Population genetics connects genetics and evolution. It addresses such questions as: What determines the level of genetic variation in a population? How fast do populations evolve? This course emphasizes population genetics theory and modeling, but connects them to empirical observations in many organisms, including humans. Many concepts are examined with computer programs written in R, and homework problems require students to write R programs. Prior programming experience is not required, and instruction in R is provided. *R. Hudson. 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 in the biological sciences.* This course examines the growth, differentiation, and development of plants at the molecular, cellular, and whole plant levels. Emphasis is placed on the signal transduction mechanisms that regulate the developmental and adaptive processes in plants. Students are especially encouraged to develop critical thinking and collaborative skills. *J. Greenberg. Spring.*

**23351. Ecological Applications to Conservation Biology.** *PQ: Completion of the general education requirement in the biological sciences or consent of instructor.* This course focuses 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., risk of extinction, impact of harvesting, role of species interaction, analysis of global change). Course material is drawn mostly from current primary literature; lab and field components complement concepts taught through lecture. Overnight field trip required. *C. Pfister, E. Larsen. Autumn. L.*

**23404. Reconstructing the Tree of Life: An Introduction to Phylogenetics.** (=EVOL 35401) *PQ: Completion of the general education requirement in the biological sciences or consent of instructor.* This course is an introduction to the tree of life (phylogeny): its conceptual origins, methods for discovering its structure, and its importance in evolutionary biology and other areas of science. Topics include history and concepts, sources of data, methods of phylogenetic analysis, and the use of phylogenies to study the tempo and mode of lineage diversification, coevolution, biogeography, conservation, molecular biology, development, and epidemiology. One Saturday field trip and weekly computer labs required in addition to scheduled class time. *This course is offered in alternate (odd) years. C. Moreau, R. Ree. Autumn. L. Not offered 2010–11; will be offered 2011–12.*

**23406. Biogeography.** (=ENST 25500, EVOL 45500, GEOG 25500/35500) *PQ: Completion of the general education requirement in 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.*

**23409. The Ecology and Evolution of Infectious Diseases.** *PQ: Integral calculus and some background in biology.* Understanding the ecology and evolution of infectious diseases is crucial for both human health and for preservation of the natural environment. In this course, we combine mathematical modeling with ecological and evolutionary analyses to understand how fundamental

mechanisms of host-pathogen interactions are translated into disease dynamics and host-pathogen co-evolution. *G. Dwyer. Autumn 2011.*

**23410. Complex Interactions: Coevolution, Parasites, Mutualists, and Cheaters.** *PQ: BIOS 20185.* This course emphasizes the enormous diversity of interactions between organisms. It is an introduction to the biology and ecology of parasitic and mutualistic symbiotic associations and their evolution. Topics include endosymbioses and their impact on the evolution of photosynthetic organisms, bacterial symbioses (e.g., nitrogen fixation), symbioses that fungi evolved with plants and animals (e.g., endophytes, mycorrhizae, lichens), pollination biology, insect-plant associations, and associations of algae with animals. Methods to elucidate the evolution of these associations are discussed with a focus on coevolutionary events and the origin of cheaters. *T. Lumbsch. 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. *X. Zhuang, M. Sherman, E. Grove. Autumn.*

**24204. Cellular Neurobiology.** *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, A. Fox. Winter.*

**24205. Systems Neuroscience.** (=PSYC 24000/31200) *PQ: BIOS 24204, 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. *M. Hale, D. Freedman. Spring.*

**24207. Developmental Neurobiology.** (=DVBI 35800, NURB 32500) *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. Spring.*

**24208. Survey of Systems Neuroscience.** (=CPNS 30116, NURB 31600, ORGB 32500) *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 2012.*

**24218. Molecular Neurobiology.** *PQ: BIOS 20200 and 24204, or consent of instructor.* This lecture/seminar course 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 endocytosis, 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 is 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: Information Processing in Neural Systems.** *PQ: BIOS 24221.* In this course, we survey mathematical approaches that have been fruitfully applied to the study of the nervous system. We describe the theoretical basis for each framework and examine how it has been used to address a variety of questions related to neural coding and motor control. The course begins with an overview of the visual system, with emphasis on aspects of visual processing that could only be addressed using mathematics. We then consider a variety of mathematical/computational approaches, including Hebbian learning, Bayesian inference, signal detection theory, information theory, and graph theory, applied to various neural systems. *S. Bensmaia. Winter. L.*

**24223. Computational Neuroscience III: Cognitive Neuroscience.** (=ORGB 34600, PSYC 34400) *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). Psychophysical, functional imaging,

and electrophysiological methods are introduced. Mathematical and statistical methods (e.g., neural networks, information theory, pattern recognition for studying neural encoding in individual neurons and populations of neurons) are discussed. *Weekly lab sections allow students to program cognitive neuroscientific experiments and simulations. N. Hatsopoulos. Spring. L.*

**24239. Cellular Mechanisms of Learning.** *PQ: BIOS 20183 or BIOS 20193; BIOS 24203 and BIOS 24204 recommended.* We explore the molecular and cellular mechanisms that have been proposed to underlie learning and memory. Although we briefly mention other animal systems, we focus primarily on cellular/molecular studies in *Aplysia* and the mammalian hippocampus and cerebellum, and on genetic and molecular studies in *Drosophila* and *C. elegans*. *P. Lloyd. Spring.*

**24246. Neurobiology of Disease I.** (=CPNS 34600, NURB 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, NURB 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 is it 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. Spring.*

**25205. Microbiology Laboratory.** *PQ: BIOS 25206.* This laboratory meets bi-weekly in two-hour sessions over four weeks (eight sessions total) from mid-October to mid-November. It is intended for students who require a microbiology lab experience for application to some schools (including veterinary, optometry, etc). Students take a final written and practical exam to fulfill the class requirements. *D. Missiakas. Autumn.*

**25206. Fundamentals of Bacterial Physiology.** (=MICR 30600) *This course meets one of the requirements of the microbiology specialization, BIOS 25256.* 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. *D. Missiakas. Autumn.*

**25216. Molecular Basis of Bacterial Diseases.** (=MICR 31600) *PQ: Completion of the general education requirement in the biological sciences. 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. Winter.*

**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, R. Cohen. 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 in 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 plague are among some of the diseases covered. *I. Pavlova. Spring.*

**25256. Immunobiology.** *PQ: BIOS 20180s or 20190s, 25206, and consent of instructor. Prior knowledge of microbiology (e.g., BIOS 25206) will be advantageous.* This comprehensive survey course presents an integrated and detailed 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 ongoing fights against the anti-immunology strategies of 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.*

**25260. Host Pathogen Interactions.** (=IMMU 31200, MICR 31200) *PQ: BIOS 25206 and BIOS 25256.* 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. *A. Chervonsky. Autumn.*

**25266. Molecular Immunology.** (=IMMU 30266) *PQ: BIOS 20200 or 25256, or consent of instructor.* This discussion-oriented course examines the molecular principles of immune recognition. We explore the roles of protein modification, protein-protein and protein-DNA interactions in the discrimination between self and non-self, and study the molecular fundamentals of cell stimulation and signaling. Primary literature focused on molecular research of the immune system is integrated with lectures on commonly used biochemical, structural and immunological techniques used in the research papers examined. *E. Adams. Spring.*

**25287. Introduction to Virology.** (=MICR 34600) *PQ: Completion of the general education requirement in the biological sciences and third- or fourth-year standing.* 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. *T. Golovkina, B. Roizman. 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 who are 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. We use 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. *This course is offered in alternate years. A. Chong. Winter.*

**25418. Systems Biology of Cancer.** (=CABI 40500) *PQ: Introductory statistics course and third or fourth-year standing, or consent of instructor.* Cancer is a genetic disease characterized by the complex actions and interactions of environmental factors, multiple inherited and acquired genetic factors, networks, and cells.

Together, they predispose some individuals to develop cancer, protect others against it despite lifelong exposures to carcinogens, and determine the likelihood of response to therapy. This inherent complexity presents constant challenges for diagnosing and treating patients with cancer. The goal of this course is to teach students to manipulate and analyze the enormous datasets generated by genome-wide platforms. Although the focus of the course is “systems biology of cancer,” the course has relevance to students interested in using systems biology strategies to investigate a variety of complex diseases. *R. Jones, K. Onel, A. Skol. Winter.*

**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 any area of biology. It provides a broad exposure to applied mathematics methods for modeling and simulation of diverse biological systems.

**26210. Mathematical Methods for Biological Sciences I.** (=CPNS 31000, ISTP 26210, PSYC 36210) *PQ: MATH 15300 or equivalent.* This course focuses on ordinary differential equations as models for biological processes changing with time. The emphasis is on dynamical systems theory, stability analysis, and different phase portraits, including limit cycles and chaos. Linear algebra concepts are introduced and developed. Numerous biological models are analyzed, and labs introduce numerical methods in MATLAB. *D. Kondrashov. Autumn. L.*

**26211. Mathematical Methods for Biological Sciences II.** (=CPNS 31100, ISTP 26211, PSYC 36211) *PQ: BIOS 26210.* This course continues the study of time-dependent biological processes and introduces discrete-time systems, studying period-doubling, and onset of chaos. Fourier transform methods are used to analyze temporal and spatial variation, leading to the study of partial differential equations. The diffusion, convection, and reaction-diffusion equations are all used to model biological systems. Finally, common optimization methods are introduced. In labs, computational techniques are used to analyze sample data and study models. *D. Kondrashov. Winter. L.*

**26212. Mathematical Methods for Biological Sciences III.** (=CPNS 31200, ISTP 26212, PSYC 36212) This course covers basic mathematical probability, probability distributions, correlation, principal and independent component analysis, and stochastic processes. Stochastic behavior is ubiquitous at all levels of biology, and examples range from electrophysiology to bioinformatics. In labs, students use stochastic models to model and analyze these systems. *D. Kondrashov. Spring. L.*

**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. Spring.*

**27100. Personal Genomics and Translational Bioinformatics.** (=CCTS 42100) *PQ: Completion of BIOS 20180s, 20190s, or AP 5 sequence in Biology. Third and fourth year only.* This course focuses on the emerging fields of personal genomics and translational bioinformatics that impact our understanding of molecular mechanisms involved in personal health, as well as diseases' diagnosis, prognosis, and treatment. Trainees learn to understand the different genomic measurements, the biotechnologies involved, and their interpretation. Since interpretation can be conducted at the single measure or genome-wide levels, we present straightforward genome-wide tools and computational bioinformatics or statistical methods that enhance the understanding of the molecular underpinnings of diseases. *Y. Lussier. Autumn.*

**28407. Genomics and Systems Biology.** (=CABI 47300, HGEN 47100) *PQ: STAT 23400 or Statistics in the Biomath Sequence.* This lecture course explores the technologies that enable high-throughput collection of genomic-scale data, including sequencing, genotyping, gene expression profiling, assays of copy number variation, protein expression and protein-protein interaction. We also cover study design and statistical analysis of large data sets, as well as how data from different sources can be used to understand regulatory networks (i.e., systems). Statistical tools introduced include linear models, likelihood-based inference, supervised and unsupervised learning techniques, methods for assessing quality of data, hidden Markov models, and controlling for false discovery rates in large data sets. Readings are drawn from the primary literature. *Y. Gilad, D. Nicolae. Spring.*

### *Big Problems Courses*

**02490. Biology and Sociology of AIDS.** (=BPRO 24900, SSAD 65100) *PQ: Third- or fourth-year standing. This course does not meet requirements for the biological sciences major.* This interdisciplinary course deals with current issues of the AIDS epidemic. Readings are based primarily on *AIDS Update 2006*. *J. Quintans, H. Pollack. Winter.*

### *Specialized Courses*

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

**29100. Biology of Toxoplasma.** *PQ: Consent of instructor. This course is suitable for undergraduates with a good background in biology and molecular genetics. This course does not meet requirements for the biological sciences major.* This course undertakes a study of *Toxoplasma gondii* and toxoplasmosis: a model system to study the cellular and molecular biology, biochemistry, and genetics of an obligate intracellular protozoan parasite; the immune responses it elicits; its interactions with host cells; and the pathogenesis of the diseases it causes. This information is also applied to consideration of public health measures for

prevention of infection, for vaccines, and for development of new antimicrobial treatments. General principles applicable to the study of other microorganisms are emphasized. *R. Mcleod. Autumn, Spring.*

**29280. Developmental Psychopathology.** (=PSYC 22750) *This course does not meet requirements for the biological sciences major.* This advanced course focuses on the development of mental disorders that have their onset in infancy, childhood, or adolescence from the perspective of developmental psychopathology. Developmental psychopathology is a field that lies at the interface of clinical and developmental psychology within which the aim is to identify the earliest deviations from normative developmental processes that likely lead to the development of psychopathology. By incorporating the study of basic biological and psychological processes into the study of psychopathology, the identification of earliest markers, and ultimately causal factors, may be achieved. *K. Keenan. Spring.*

**29285. Evolution and Medicine; Brain and Sex.** (=ECEV 30900, EVOL 30900, GNDR 26600) *PQ: Completion of the general education requirement in 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.* This course draws on readings in and case studies of language evolution, biological evolution, cognitive development and scaffolding, processes of socialization and formation of groups and institutions, and the history and philosophy of science and technology. We seek primarily to elaborate theory to understand and model processes of cultural evolution, while exploring analogies, differences, and relations to biological evolution. This has been a highly contentious area, and we examine why. We seek to evaluate what such a theory could reasonably cover and what it cannot. *W. Wimsatt, S. Muftwene. Not offered 2010–11; will be offered 2011–12. Winter.*

**29294. Introduction to Global Health.** (=CCTS 43000, HSTD 30030) *This course does not meet requirements for the biological sciences major.* This course provides an overview of global health from the historical perspective to the current state of global health. The course features weekly guest lecturers with a broad range of expertise in the field: topics include the social and economic determinants of health, the economics of global health, global burden of disease, and globalization of health risks, as well as the importance of ethics, human rights, and diplomacy in promoting a healthier world. The course is designed



for graduate-level students and senior undergraduates with an interest in global health work in resource-limited settings. *J. Schneider, C. S. Olopae. Winter.*

**29308. Pharmacogenomics.** (=CABI 47500, CCTS 40001) *PQ: Consent of instructor. This course does not meet requirements for the biological sciences major.* Pharmacogenomics is aimed at advancing our knowledge of the genetic basis for variable drug response. Advances in genetic knowledge gained through sequencing have been applied to drug response, and identifying heritable genetic variants that predict response and toxicity is an area of great interest to researchers. The ultimate goal is to identify clinically significant variations to predict the right choice and dose of medications for individuals—“personalizing medicine.” The study of pharmacogenomics is complicated by the fact that response and toxicity are multigenic traits and are often confounded by nongenetic factors (e.g., age, co-morbidities, drug-drug interactions, environment, diet). Using knowledge of an individual’s DNA sequence as an integral determinant of drug therapy has not yet become standard clinical practice; however, several genetics-guided recommendations for physicians have been developed and are highlighted. The ethics and economics of pharmacogenomics are also discussed. *M. E. Dolan, R. S. Huang. Spring.*

**29313. Medical Ethics: Who Decides and on What Basis?** (=BPRO 26210, HIPS 21911, HIST 25009/35009, PHIL 21610/31610) *PQ: Third- or fourth-year standing. This course does not meet requirements for the biological sciences major.* Decisions about medical treatment take place in the context of changing health care systems, changing ideas about rights and obligations, and among doctors and patients who have diverse religious and cultural backgrounds. By means of historical, philosophical, and medical readings, this course examines such issues as paternalism, autonomy, the commodification of the body, and the enhancement of mental and/or physical characteristics. *D. Brudney, J. Lantos, A. Winter. Spring.*

**29317. Issues in Women’s Health.** (=GNDR 30500, HSTD 30500) *This course does not meet requirements for the biological sciences major.* This course, which is comprised of scientific/medical lectures and student-led discussions of readings, focuses on important sources of morbidity and mortality in women. Topics include heart disease, breast cancer, depression, eating disorders, and HIV. In addition to learning about the etiology and epidemiology of these conditions, we explore related social, historical, political, and cultural issues. *L. Kurina. Spring.*

**29318. Principles of Epidemiology.** (=ENST 27400, HSTD 30900, PPHA 36400, STAT 35000) *This course does not meet requirements for the biological sciences major.* Epidemiology is the study of the distribution and determinants of health and disease in human populations. This course introduces the basic principles of epidemiologic study design, analysis, and interpretation through lectures, assignments, and critical appraisal of both classic and contemporary research articles. *L. Kurina. Autumn.*

**29319. What Genomes Teach about Evolution.** (=BPRO 29100) *This course does not meet requirements for the biological sciences major.* The twenty-first century

opened with publication of the draft human genome sequence, and there are currently over 3,000 species whose genomes have been sequenced. This rapidly growing database constitutes a test of nineteenth- and twentieth-century theories about evolution and a source of insights for new theories. We discuss what genome sequences have to teach us about the relatedness of living organisms, the diversity of cellular life, mechanisms of genome change over evolutionary time, and the nature of key events in the history of life on earth. The scientific issues are related to the history of evolutionary thought and current public controversies about evolution. *J. A. Shapiro, M. Long. Spring.*

**29320. Introduction to History and Philosophy of Biology.** (=PHIL 28900/38900, CHSS 38901, HIPS 28903) *This course does not meet requirements for the biological sciences major.* In this course we (1) use the history of biological science to help us identify and solve philosophical problems in biology, and (2) use the tools of philosophical analysis to help us understand the importance of particular episodes in the history of biology. Among other things, we examine historical and philosophical issues associated with the theory of natural selection, macroevolution, and developmental biology. *C. Haufe. Spring.*

**29321. The Problem of Evil: Disease?** (=RETH 30300) *PQ: Third- and fourth-year students only. This course does not meet requirements for the biological sciences major.* The problem of evil remains a central problem for monotheistic religions: How can an omnipotent and benevolent God allow evil in the world? Disease represents an important “test case” for this question. Some argue that disease should not be called evil and would reserve this word for moral ills. Others argue that disease is a dysfunction of nature and therefore represents evil *par excellence*. In this course, we examine a variety of texts treating the question of disease as a philosophical issue and exemplar of the problem of evil. The texts include Scripture (Job) and selections from the writings of Aristotle, Thomas Aquinas, Feodor Dostoevsky, Albert Camus, and Thomas Mann. *S. Meredith. Spring.*

**29326. Introduction to Medical Physics and Medical Imaging.** (=MPHY 29326) *PQ: PHYS 23500. This course does not meet requirements for the biological sciences major. Students majoring in physics may use this course either as an elective or as one of the topics courses to meet the general education requirement in the biological sciences.* 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.*

**29408. Signal Analysis and Modeling for Neuroscientists.** (=CPNS 32110) *PQ: BIOS 26210 and 26211, or consent of instructor. This course meets requirements for the biological sciences major only for students specializing in neuroscience.* The course provides an introduction into signal analysis and modeling for neuroscientists. We cover linear and nonlinear techniques and model both single neurons and

neuronal networks. The goal is to provide students with the mathematical background to understand the literature in this field, the principles of analysis and simulation software, and allow them to construct their own tools. Several of the 90-minute lectures include demonstrations and/or exercises in Matlab. *W. van Drongelen. 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.*

**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.*