Biological Sciences

Department Website: https://college.uchicago.edu/academics/biological-sciences-collegiate-division

Program of Study

Biology is the study of life, past and present. The faculty of the College believe that a sound knowledge of biology is essential for understanding ourselves and the world in which we live, as well as engaging many pressing problems facing humanity and becoming a part of their eventual solution. Our curriculum offers courses in many fields, from theoretical to experimental biology, and from molecular and genetic mechanisms underlying life to the complex interactions of organisms in ecosystems. At a major research institution, the focus of all courses in the Biological Sciences Collegiate Division is on scientific reasoning, research, and discovery. 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.

The BA is designed for students who wish to gain extensive training in modern biology but also retain the flexibility to take elective courses outside the major. The BS is best suited for students who wish to take more courses within the major and to write a senior thesis.

General Education Requirements

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

1. A two-quarter general education sequence for non-majors.
2. The Pre-Med Sequence for non-science majors (BIOS 20170 Microbial and Human Cell Biology - BIOS 20175 Biochemistry and Metabolism), of which two courses will be credited towards general education.
3. BIOS 20153 Fundamentals of Ecology and Evolutionary Biology and BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic) or BIOS 20152 Introduction to Quantitative Modeling in Biology (Advanced).
4. Completion of three quarters of the Advanced Biology Fundamentals Sequence (see below).

Advanced Placement Credit

Students with a score of 4 or 5 on the AP Biology test who complete the first three quarters of the Advanced Biology Fundamentals Sequence will be awarded a total of two quarters of credit to be counted toward the general education requirement in 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.

Program Requirements for the BA in Biological Sciences

Students can earn a bachelor of arts (BA) in the Biological Sciences by completing the following course work:

Biological Sciences Fundamentals Sequences

Required foundational courses in the Biological Sciences program of study are referred to as Fundamentals Sequences. There are three sequences to choose from:

1. Molecules to Organisms (Sections 1 and 2) sequence—begins in the Winter Quarter of the first year and is structured to provide students with a broad-based understanding of contemporary biology:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 20151</td>
<td>Introduction to Quantitative Modeling in Biology (Basic) #</td>
<td>100</td>
</tr>
<tr>
<td>or BIOS 20152</td>
<td>Introduction to Quantitative Modeling in Biology (Advanced) #</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20153</td>
<td>Fundamentals of Ecology and Evolutionary Biology #</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20186</td>
<td>Fundamentals of Cell and Molecular Biology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20187</td>
<td>Fundamentals of Genetics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20188</td>
<td>Fundamentals of Physiology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20189</td>
<td>Fundamentals of Developmental Biology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20200</td>
<td>Introduction to Biochemistry</td>
<td>100</td>
</tr>
</tbody>
</table>

2. Life, Ecosystems, and Evolution sequence (formerly Track C)—designed for students interested in focusing their studies on ecology and evolution or environmental science:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 20151</td>
<td>Introduction to Quantitative Modeling in Biology (Basic) #</td>
<td>100</td>
</tr>
<tr>
<td>or BIOS 20152</td>
<td>Introduction to Quantitative Modeling in Biology (Advanced) #</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20153</td>
<td>Fundamentals of Ecology and Evolutionary Biology #</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20186</td>
<td>Fundamentals of Cell and Molecular Biology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20187</td>
<td>Fundamentals of Genetics</td>
<td>100</td>
</tr>
</tbody>
</table>
3. **Advanced Biology sequence**—open to students who have achieved a score of 4 or 5 on the AP Biology test:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 20234</td>
<td>Molecular Biology of the Cell</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20235</td>
<td>Biological Systems</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20236</td>
<td>Biological Dynamics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20242</td>
<td>Principles of Physiology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 20200</td>
<td>Introduction to Biochemistry</td>
<td>100</td>
</tr>
</tbody>
</table>

* BIOS 20151/BIOS 20152 and BIOS 20153 fulfill the general education requirement in the biological sciences and are prerequisites for the rest of the courses in the fundamentals sequence. BIOS 20151 may be taken simultaneously with BIOS 20186.

# Non–Biological Sciences majors can take a Fundamentals Sequence without the fundamentals prerequisites (BIOS 20151/BIOS 20152) unless they pursue a double major in Biological Sciences. Students opting not to take the prerequisites should be aware that subsequent courses in the sequence expect competency in mathematical modeling of biological phenomena and basic coding in R.

After completion of three quarters of a Fundamentals Sequence, students begin taking upper-level elective courses in the biosciences and may start a specialization.

**Mathematical and Physical Sciences Requirements**

In addition to taking a Fundamentals Sequence, students completing a bachelor of arts degree in Biological Sciences are required to satisfy general education requirements in the mathematical and physical sciences as follows:

**PHYSICAL SCIENCES.** One of the following sequences:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 10100</td>
<td>Introductory General Chemistry I</td>
<td>200</td>
</tr>
<tr>
<td>&amp; CHEM 10200</td>
<td>and Introductory General Chemistry II (or equivalent)</td>
<td></td>
</tr>
<tr>
<td>CHEM 11100-11200</td>
<td>Comprehensive General Chemistry I-II</td>
<td>200</td>
</tr>
</tbody>
</table>

**MATHEMATICAL SCIENCES.** One of the following sequences:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 13100-13200</td>
<td>Elementary Functions and Calculus I-II (or higher)</td>
<td>200</td>
</tr>
<tr>
<td>MATH 15100-15200</td>
<td>Calculus I-II</td>
<td>200</td>
</tr>
<tr>
<td>MATH 16100-16200</td>
<td>Honors Calculus I-II</td>
<td>200</td>
</tr>
</tbody>
</table>

**Total Units** 400

In addition, all students completing a bachelor of arts degree in Biological Sciences must complete further courses in physical and mathematical sciences as described in the Summary of Requirements tables below.

**Biological Sciences Upper-Level Elective Requirements**

In addition to completing a Fundamentals Sequence and the above mathematical and physical sciences requirements, students must take five upper-level courses (course numbers 21000 to 28999) in Biological Sciences to complete the bachelor of arts degree. These courses may be selected by the student or in consultation with the BSCD Senior Advisers (Megan McNulty, mmcnulty@uchicago.edu, and Christine Andrews, candrews@uchicago.edu).

If the student chooses to complete a specialization (see sections that follow), courses should be chosen in consultation with the specialization adviser (listed below).

**NOTE:** BIOS 00199 Undergraduate Research, BIOS 00206 Readings: Biology, and BIOS 00299 Advanced Research: Biological Sciences may not be used to meet requirements for the Biological Sciences degree. Courses listed under the heading Specialized Courses (course numbers in the 29000 range) may not be used to meet requirements for the Biological Sciences degree.

**Summary of Requirements: Molecules to Organisms/Advanced Biology**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 11300</td>
<td>Comprehensive General Chemistry III (or equivalent)</td>
<td>100</td>
</tr>
<tr>
<td>CHEM 22000</td>
<td>Organic Chemistry I</td>
<td>200</td>
</tr>
<tr>
<td>&amp; CHEM 22100</td>
<td>and Organic Chemistry II</td>
<td>200</td>
</tr>
<tr>
<td>PHYS 12100-12200</td>
<td>General Physics I-II (or higher)</td>
<td>200</td>
</tr>
</tbody>
</table>

One of the following general quantitative courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 26210</td>
<td>Mathematical Methods for Biological Sciences I</td>
<td>100</td>
</tr>
<tr>
<td>PHYS 12300</td>
<td>General Physics III (or higher)</td>
<td>100</td>
</tr>
<tr>
<td>STAT 22000</td>
<td>Statistical Methods and Applications</td>
<td>100</td>
</tr>
</tbody>
</table>

**Molecules to Organisms Fundamentals Sequence or Advanced Biology Sequence** 500
Five courses, BIOS 21000 and above in Biological Sciences 500

Total Units 1600

Summary of Requirements: Life, Ecosystems, and Evolution

CHEM 11300 Comprehensive General Chemistry III (or equivalent) 100

One of the following two-quarter sequences: 200

CHEM 22000 & CHEM 22100 Organic Chemistry I and Organic Chemistry II

or

PHYS 12100-12200 General Physics I-II (or higher)

One of the following general quantitative courses: 100

BIOS 26210 Mathematical Methods for Biological Sciences I

PHYS 12300 General Physics III (or higher)

STAT 22000 Statistical Methods and Applications (or higher)

Life, Ecosystems, and Evolution Fundamentals Sequence 400

Five courses, BIOS 21000 and above in Biological Sciences 500

Three additional quantitative course* 300

Total Units 1600

* Students can satisfy this requirement with quantitative upper-level BIOS courses or courses from other departments (e.g., MATH, PHYS, STAT, or CMSC). Biological Sciences majors pursuing this track should confirm their quantitative course selections with Senior Biology Advisor Chris Andrews (candrews@uchicago.edu).

NOTE 1: The Biological Sciences major does NOT require the third quarter of calculus in any of the sequences. Students entering the Molecules to Organisms or the Life, Ecosystems, and Evolution sequence MUST take BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic) or BIOS 20152 Introduction to Quantitative Modeling in Biology (Advanced), and students in the Advanced Biology sequence MUST take BIOS 20236 Biological Dynamics. NO Mathematics courses may be substituted for these requirements.

NOTE 2: Students planning to apply to medical school should be aware of individual medical school admissions requirements and should tailor their program accordingly with the help of UChicago Careers in Health Professions (https://careeradvancement.uchicago.edu/uchicago-careers-in/health-professions) (UCIHP).

Program Requirements for the BS in Biological Sciences

Students can earn a bachelor of science (BS) in the Biological Sciences by (1) completing three upper level elective courses in Biological Sciences beyond those required for the BA degree, and (2) writing a BS thesis (research paper or literature review) under the supervision of an adviser who is a member of the Biological Science Division research faculty. The BA is designed for students who wish to gain extensive training in modern biology but also retain the flexibility to take elective courses outside the major. The BS is best suited for students who wish to take more courses within the major and to write a senior thesis. Students completing the honors program or a specialization that requires a senior thesis can submit the same thesis for the BS degree. If you have any questions, please contact BSCD Senior Adviser Christine Andrews (candrews@uchicago.edu) or Megan McNulty (mmcnulty@uchicago.edu). Details of the BS degree and a timeline for completion of requirements are provided on the BSCD website (https://college.uchicago.edu/academics/biological-sciences-collegiate-division). (https://bscd.uchicago.edu/page/bs-biological-sciences)

Grading and Academic Honesty

Students must receive quality grades in all courses that fulfill requirements for the BA or BS degree in Biological Sciences.

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.

Honors

Honors in Biological Sciences can be earned via one of two tracks.

Scholar Honors: This track recognizes exceptional academic performance (minimum cumulative GPA of 3.75 or above), including submission and acceptance of a scholarly thesis.

Research Honors: This track emphasizes exceptional achievement in a program of original research (minimum cumulative GPA of 3.30 or above) plus submission and acceptance of an in-depth research thesis. Both programs require formal declarations of intent to seek honors by the candidates. The details of each program are provided on the BSCD website (https://college.uchicago.edu/academics/biological-sciences-collegiate-division). Candidates must apply for either program no later than the beginning of Spring Quarter of their third year in the College.
Research Opportunities

Students are encouraged to carry out individual guided research in an area of their interest. A student may propose an arrangement with any faculty member in the Biological Sciences Division to sponsor and supervise research on an individual tutorial basis. Students may register for BIOS 00199 Undergraduate Research or BIOS 00299 Advanced Research: Biological Sciences if they want to receive course credit for their research work, but this is not required. For more information, see bscd.uchicago.edu/content/undergrad-research or contact John Kennedy (jmkennedy@uchicago.edu).

NOTE: Course credit cannot be given for work that is compensated by a salary. BIOS 00199 and BIOS 00299 may not be used to meet the requirements of the Biological Sciences degree.

Limited financial support is available to students for summer research through their research supervisors or through fellowships awarded competitively by the Biological Sciences Collegiate Division. Application deadlines for fellowships range from mid-February to early April. Please see bscd.uchicago.edu/content/undergrad-research for more information about fellowship opportunities in Biological Sciences at the University of Chicago, or the College Center for Research and Fellowships (http://ccrf.uchicago.edu) for a searchable database of internal and external research and fellowship opportunities.

Specialization Programs in the Biological Sciences

Specializations represent recommended programs of study for students interested in one particular field within the Biological Sciences. Students who wish to complete a specialization should discuss their plans with the specialization director by Spring Quarter of their second year. Students may complete only one specialization. All courses must be taken for a quality grade in order to count towards a specialization.

Specialization in Cancer Biology
Specialization in Cellular and Molecular Biology
Specialization in Ecology and Evolution
Specialization in Endocrinology
Specialization in Genetics
Specialization in Global Health Sciences
Specialization in Immunology
Specialization in Microbiology
Specialization in Quantitative Biology

Specialization in Cancer Biology

Students who complete the requirements detailed below will be recognized as having completed a specialization in cancer biology.

To be eligible to carry out a specialization in cancer biology, students must average a B grade in the first three quarters of a Biological Sciences Fundamentals Sequence.

Students who plan to specialize in cancer biology are advised to begin the required specialization courses below in their third year. Students who elect to specialize should consult Dr. Kay F. Macleod, Ben May Department for Cancer Research and the Committee on Cancer Biology (kmacleod@uchicago.edu), who is available to advise on the objectives of the specialization and the importance of each of the classes, and to identify labs in which individual research projects can be carried out.

The following two courses are required for a specialization in cancer biology. To continue in the specialization, students must achieve an A or B grade in both courses.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 25108</td>
<td>Cancer Biology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25308</td>
<td>Heterogeneity in Human Cancer: Etiology and Treatment</td>
<td>100</td>
</tr>
</tbody>
</table>

To complete the specialization in cancer biology, students should also take one of the following two courses in either their third or fourth year, having successfully completed BIOS 25108 and BIOS 25308 above, and started work in their chosen research laboratory.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 25326</td>
<td>Tumor Microenvironment and Metastasis</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25327</td>
<td>Health Disparities in Breast Cancer</td>
<td>100</td>
</tr>
</tbody>
</table>

Laboratory Research

To complete the specialization in cancer biology, students will also carry out an individual guided cancer research project that is written up as an honors thesis and evaluated by an honors thesis committee, and attend cancer biology–related seminars. Participation in the research component of the specialization in cancer biology is by invitation only and is based on: (1) performance in the above-mentioned courses, (2) identification of a research project and mentor, (3) submission of a
research abstract for consideration by the end of the Winter Quarter of their junior year to the Director of the Specialization in Cancer Biology (Dr. Kay Macleod).

Independent research projects performed by students in the specialization in cancer biology must be approved by the Director of the Specialization (Dr. Macleod) and be of sufficiently high standard to qualify as a senior honors project and ideally to produce data that contributes to peer-reviewed publication.

Students are encouraged to begin their research project no later than the Spring/Summer Quarter of their junior year.

Specialization in Cellular and Molecular Biology

Biological Sciences majors can complete the specialization in cellular and molecular biology by either:

1. Successful completion of CHEM 22200 Organic Chemistry III or CHEM 23200 Honors Organic Chemistry III plus four upper-level BIOS courses selected from the list below.

OR

2. Successful completion of CHEM 22200 (Organic Chemistry III) or CHEM 23200 (Honors Organic Chemistry III) plus three upper-level BIOS courses selected from the list below and completion of a senior thesis on an independent research project. This project must either (1) satisfy the requirements for the BSCD honors program, (2) satisfy the requirements for a BS in Biological Sciences, or (3) be approved by the directors of the specialization no later than Spring Quarter of the third year.

Please consult Christine Andrews (candrews@uchicago.edu) or Megan McNulty (mmcnulty@uchicago.edu) for approval of research projects or to request approval for any non-listed course with significant content in cellular and molecular biology.

Courses

| BIOS 21208 | Fundamentals of Molecular Biology | 100 |
| BIOS 21236 | Genetics of Model Organisms | 100 |
| BIOS 21237 | Developmental Mechanisms | 100 |
| BIOS 21238 | Cell Biology II | 100 |
| BIOS 21360 | Advanced Molecular Biology | 100 |
| BIOS 23299 | Plant Development and Molecular Genetics | 100 |

*If students choose a developmental course, they must choose from BIOS 21237 Developmental Mechanisms or BIOS 23299 Plant Development and Molecular Genetics.

Specialization in Ecology and Evolution

Students majoring in Biological Sciences who complete the requirements detailed below 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 Advisers may also help the student find an appropriate research lab in which to conduct an individual research project.

The following requirements must be met:

Courses

1. Students intending to pursue the ecology and evolution specialization are strongly encouraged to follow Life, Ecosystems, and Evolution (formerly Track C) for the BIOS Fundamentals sequence. Students who take the Advanced Biology sequence are also eligible for the specialization and should consult with Christine Andrews (candrews@uchicago.edu) to plan their course work.

2. Students in the ecology and evolution specialization must take three courses in statistics (STAT 22000 Statistical Methods and Applications or higher) or other quantitative approaches relevant to their research plans (BIOS 26210 Mathematical Methods for Biological Sciences I and BIOS 26211 Mathematical Methods for Biological Sciences II recommended). These courses can count toward the quantitative requirements for the Life, Ecosystems, and Environment sequence.

3. Three of the upper-level courses required for completion of the BIOS major must be chosen from the areas of behavior, ecology, evolution, and genetics.

Students must select the courses required for the ecology and evolution specialization in consultation with the Faculty Research Adviser, the director of the specialization (Cathy Pfister, 773.834.0071, cpfister@uchicago.edu) or the BSCD Ecology and Evolution Adviser (Christine Andrews, 773.702.1214, candrews@uchicago.edu).

Laboratory or Field Research
Students specializing in ecology and evolution must perform original research under the guidance of a member of the ecology and evolution faculty and write a senior thesis based on this research. The research paper draft should be submitted before the end of fifth week in Spring Quarter, with the final thesis due in eighth week. NOTE: Students must complete field research by the end of the growing season (summer) of their third year.

The specialization in ecology and evolution is administered by the Department of Ecology and Evolution. For more information, please consult the director of the specialization, Cathy Pfister (773.834.0071, cpfister@uchicago.edu).

Specialization in Endocrinology

Students majoring in Biological Sciences who complete the requirements detailed below 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 must take three introductory courses listed below plus two additional courses from the elective list. 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 introductory courses can be completed as Endocrinology I–II–III or Endocrinology II–III–I. Students will also have the option of participating in a hands-on research component in an endocrinology lab.

Introductory Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 25226</td>
<td>Endocrinology I: Cell Signaling (Autumn)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25227</td>
<td>Endocrinology II: Systems and Physiology (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25228</td>
<td>Endocrinology III: Human Disease (Spring)</td>
<td>100</td>
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</table>

Elective Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 22236</td>
<td>Reproductive Biology of Primates</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 22249</td>
<td>Principles of Toxicology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 24248</td>
<td>Biological Clocks and Behavior</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25109</td>
<td>Topics in Reproduction and Cancer</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25126</td>
<td>Animal Models of Human Disease</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 29271</td>
<td>The Psychology and Neurobiology of Stress</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 29300</td>
<td>Biological Psychology</td>
<td>100</td>
</tr>
</tbody>
</table>

* Courses beginning with 29XXX count as general electives, but do not count in the Biological Sciences major.

The specialization in endocrinology is administered by the Section of Endocrinology, Diabetes, and Metabolism, the Committee on Molecular Metabolism and Nutrition, and the NIH-funded Diabetes Research and Training Center. For more information, consult Matthew Brady (mbrady@medicine.bsd.uchicago.edu).

Specialization in Genetics

Students majoring in Biological Sciences who complete the requirements below will be recognized as having completed a specialization in genetics. Students must either:

1. Complete five courses from the categories listed below, including at least one from each category.

OR

2. Complete three courses chosen from the categories listed below, including one course in each category, and complete a senior thesis or an independent research project. This project must either (1) satisfy the requirements for the BSCD honors program, (2) satisfy the requirements for a BS in Biological Sciences, or (3) be approved by the directors of the specialization no later than Spring Quarter of the third year.

Please consult Christine Andrews (candrews@uchicago.edu) or Megan McNulty (mmcnulty@uchicago.edu) for approval of research projects or to request approval for any non-listed course with significant genetics content.

One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>STAT 22000</td>
<td>Statistical Methods and Applications (or higher)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21306</td>
<td>Human Genetics and Evolution</td>
<td>100</td>
</tr>
</tbody>
</table>

One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 21236</td>
<td>Genetics of Model Organisms (Autumn)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 23258</td>
<td>Molecular Evolution I: Fundamentals and Principles (Winter)</td>
<td>100</td>
</tr>
</tbody>
</table>

One of the following with research or three of the following without research:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 21216</td>
<td>Intro Statistical Genetics (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21229</td>
<td>Genome Informatics: How Cells Reorganize Genomes (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21237</td>
<td>Developmental Mechanisms (Winter)</td>
<td>100</td>
</tr>
</tbody>
</table>
BIOS 23299  Plant Development and Molecular Genetics (Spring)  100
BIOS 25216  Molecular Basis of Bacterial Disease (Winter)  100
BIOS 25287  Introduction to Virology (Spring)  100
BIOS 28407  Genomics and Systems Biology (Spring)  100

Please consult Megan McNulty (mmcnulty@uchicago.edu) or Chris Andrews (candrews@uchicago.edu) for more information.

Specialization in Global Health Sciences

Students majoring in Biological Sciences who complete the following requirements will be recognized as having completed a specialization in global health sciences.

Required Courses

Students wishing to specialize in global health sciences are required to take the foundational series of courses either in Chicago (offered as a year-long sequence every year) OR at the University of Chicago Center in Paris (offered every year during Winter Quarter. See study-abroad.uchicago.edu/programs/paris-global-health).

The Chicago series of foundational courses:

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 27810</td>
<td>Epidemiology and Population Health: Global Health Sciences I (Autumn)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 27811</td>
<td>Global Health Sciences II: Microbiology (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 29814</td>
<td>Global Health Sciences III: Biological and Social Determinants of Health (Spring) *</td>
<td>100</td>
</tr>
</tbody>
</table>

* Courses beginning with 29XXX count as general electives, but do not count in the Biological Sciences major.

OR

The Paris series of foundational courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 27813</td>
<td>Global Health Sciences I: Cancer Concepts: Causes and Consequences (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 27811</td>
<td>Global Health Sciences II: Microbiology (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 29814</td>
<td>Global Health Sciences III: Biological and Social Determinants of Health (Winter)</td>
<td>100</td>
</tr>
</tbody>
</table>

To complete the specialization, students must take two additional upper level courses relevant to global health from the lists below (one from the BIOS list and one from the non-BIOS list) OR complete a research thesis relevant to global health policy:

Non-BIOS upper-level electives:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTH 21420</td>
<td>Ethnographic Methods</td>
<td>100</td>
</tr>
<tr>
<td>ANTH 24302</td>
<td>Disability in Local and Global Contexts</td>
<td>100</td>
</tr>
<tr>
<td>ANTH 24315</td>
<td>Culture, Mental Health, and Psychiatry</td>
<td>100</td>
</tr>
<tr>
<td>ANTH 24330</td>
<td>Medical Anthropology</td>
<td>100</td>
</tr>
<tr>
<td>CHDV 21000</td>
<td>Cultural Psychology</td>
<td>100</td>
</tr>
<tr>
<td>ENST 25460</td>
<td>Environmental Effects on Human Health</td>
<td>100</td>
</tr>
<tr>
<td>GLST 23101</td>
<td>Global Studies I</td>
<td>100</td>
</tr>
<tr>
<td>GLST 29610</td>
<td>Cultures and Politics of Water</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 21501</td>
<td>Environmental Justice</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 25370</td>
<td>Social Justice and Social Policy</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 25832</td>
<td>Early Human Capital Development</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 26530</td>
<td>Environment, Agriculture, and Food: Economic and Policy Analysis</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 26690</td>
<td>The Politics of Health Care</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 27000</td>
<td>International Economics</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 27905</td>
<td>Global Health Metrics</td>
<td>100</td>
</tr>
<tr>
<td>PBPL 28150</td>
<td>U.S. Foreign Policy: Inst &amp; Decision making 21st Century</td>
<td>100</td>
</tr>
<tr>
<td>PSYC 28791</td>
<td>Behavioral Science and Public Policy</td>
<td>100</td>
</tr>
</tbody>
</table>

BIOS upper-level electives:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 02280</td>
<td>Drinking Alcohol: Social Problem or Normal Cultural Practice?</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 02490</td>
<td>Biology and Sociology of AIDS</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21306</td>
<td>Human Genetics and Evolution</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 22249</td>
<td>Principles of Toxicology</td>
<td>100</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>BIOS 23365</td>
<td>Evolutionary and Genomic Medicine I</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 23409</td>
<td>The Ecology and Evolution of Infectious Diseases</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25216</td>
<td>Molecular Basis of Bacterial Disease</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25260</td>
<td>Host Pathogen Interactions</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25287</td>
<td>Introduction to Virology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25308</td>
<td>Heterogeneity in Human Cancer: Etiology and Treatment</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25327</td>
<td>Health Disparities in Breast Cancer (given at MBL)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 27720</td>
<td>Microbiomes Across Environments</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 29271</td>
<td>The Psychology and Neurobiology of Stress</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 29314</td>
<td>Medical Ethics: Central Topics</td>
<td>100</td>
</tr>
</tbody>
</table>

Other courses may be substituted with the consent of the director of the specialization, Professor Sola Olopade (solopade@bsd.uchicago.edu).

Research projects must be approved by the director of the specialization in third year. Thesis requirements are fulfilled either by completing a BS thesis or an honors research thesis, or by special arrangement with the director of the specialization.

Summer research fellowships are awarded competitively by the Center for Global Health or the Biological Sciences Collegiate Division. The deadline for applications for fellowships is early February preceding the summer of the fellowship application. For more information on the Center for Global Health fellowships, students should consult with Ms. Absera Melaku (amelaku@medicine.bsd.uchicago.edu) and for the Biological Sciences Collegiate Division fellowships John Kennedy (jmkennedy@uchicago.edu).

Specialization in Immunology

Students majoring in Biological Sciences will be recognized as having completed a specialization in immunology if they complete the following: (1) three of the four courses listed below, and (2) either two additional courses, selected in consultation with the director of the specialization, or a research project, approved by the director of the specialization.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 25256</td>
<td>Immunobiology (Autumn)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25258</td>
<td>Immunopathology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25266</td>
<td>Molecular Immunology (Spring, offered every other year in odd years)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26403</td>
<td>Quantitative Immunobiology (Winter)</td>
<td>100</td>
</tr>
</tbody>
</table>

For more information, students should consult with Bana Jabri, Department of Pathology and Committee on Immunobiology (773.834.8670, 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 (773.834.8670, bjabri@bsd.uchicago.edu).

Specialization in Microbiology

Students majoring in Biological Sciences who complete the requirements detailed below will be recognized as having completed a specialization in microbiology. Students must take the three courses listed below and either two additional courses or a research project. With prior approval from the director of the specialization, Dominique Missiakas (dmissiak@bsd.uchicago.edu), students may substitute BIOS 25206 Fundamentals of Bacterial Physiology and BIOS 25216 Molecular Basis of Bacterial Disease with GEOS 26650 Environmental Microbiology and BIOS 27811 Global Health Sciences II: Microbiology.

Students are encouraged to begin this sequence in Autumn Quarter of their third year, carry out individual guided research, participate in the honors research program, and attend the Microbiology Seminar series (micro.uchicago.edu/events). Students who elect to specialize should consult Dominique Missiakas (dmissiak@bsd.uchicago.edu).
(dmissiak@bsd.uchicago.edu) for advice on the choice of courses and identification of a laboratory to carry out research projects in microbiology.

Required Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 25206</td>
<td>Fundamentals of Bacterial Physiology (Autumn)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25216</td>
<td>Molecular Basis of Bacterial Disease (Winter)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25287</td>
<td>Introduction to Virology (Spring)</td>
<td>100</td>
</tr>
</tbody>
</table>

Total Units: 300

Elective Courses:

Two of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 23409</td>
<td>The Ecology and Evolution of Infectious Diseases</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25420</td>
<td>Microbial Omics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 25256</td>
<td>Immunobiology</td>
<td>100</td>
</tr>
<tr>
<td>CHEM 22200</td>
<td>Organic Chemistry III</td>
<td>100</td>
</tr>
<tr>
<td>GEOS 26650</td>
<td>Environmental Microbiology (Autumn)</td>
<td>100</td>
</tr>
</tbody>
</table>

Specialization in Quantitative Biology

Students majoring in Biological Sciences who complete the following requirements will be recognized as having completed a specialization in quantitative biology. Quantitative biology is a burgeoning interdisciplinary field that encompasses questions ranging across all scales of biology, from populations to molecules, and uses quantitative methods drawn from computer science, statistics, and mathematics. Students will acquire skills necessary for cutting-edge biological research: to program in a high-level language, to extract information from data sets, and to analyze mathematical models of dynamic and stochastic systems.

Students are required to take two foundational courses and three additional courses from the lists below, including at least one from the list of BIOS courses and one from the list of courses in other departments. Students must also complete a research-based senior thesis.

For additional information, please contact the director of the specialization, Dmitry Kondrashov, at dkon@uchicago.edu.

FOUNDATIONAL COURSES

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 26210</td>
<td>Mathematical Methods for Biological Sciences I (fulfills one of the major course requirements)</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26211</td>
<td>Mathematical Methods for Biological Sciences II</td>
<td>100</td>
</tr>
</tbody>
</table>

BIOS LIST

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOS 21216</td>
<td>Intro Statistical Genetics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21249</td>
<td>Organization, Expression, and Transmission of Genome Information</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21328</td>
<td>Biophysics of Biomolecules</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21349</td>
<td>Protein Structure and Functions in Medicine</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21358</td>
<td>Simulation, Modeling, and Computation in Biophysics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21407</td>
<td>Image Processing in Biology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21417</td>
<td>Systems Biology: Molecular Regulatory Logic of Networks</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 21507</td>
<td>The Engineering and Biology of Tissue Repair</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 23258</td>
<td>Molecular Evolution I: Fundamentals and Principles</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 23365</td>
<td>Evolutionary and Genomic Medicine I</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 23404</td>
<td>Reconstructing the Tree of Life: An Introduction to Phylogenetics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 23409</td>
<td>The Ecology and Evolution of Infectious Diseases</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26120</td>
<td>An Introduction to Bioinformatics and Proteomics</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26318</td>
<td>Fundamentals of Biological Data Analysis</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 26403</td>
<td>Quantitative Immunobiology</td>
<td>100</td>
</tr>
<tr>
<td>BIOS 28407</td>
<td>Genomics and Systems Biology</td>
<td>100</td>
</tr>
</tbody>
</table>

NON-BIOS LIST, OTHER DEPARTMENTS

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 19620</td>
<td>Linear Algebra</td>
<td>100</td>
</tr>
<tr>
<td>MATH 21100</td>
<td>Basic Numerical Analysis</td>
<td>100</td>
</tr>
<tr>
<td>MATH 21200</td>
<td>Advanced Numerical Analysis</td>
<td>100</td>
</tr>
<tr>
<td>MATH 23500</td>
<td>Markov Chains, Martingales, and Brownian Motion</td>
<td>100</td>
</tr>
</tbody>
</table>
MATH 27300  Basic Theory of Ordinary Differential Equations  100
MATH 27500  Basic Theory of Partial Differential Equations  100
STAT 22000  Statistical Methods and Applications  100
or STAT 23400  Statistical Models and Methods  100
STAT 22200  Linear Models and Experimental Design  100
STAT 22400  Applied Regression Analysis  100
STAT 22700  Biostatistical Methods  100
STAT 22810  Epidemiology and Population Health  100
STAT 24300  Numerical Linear Algebra  100
STAT 24400-24500  Statistical Theory and Methods I-II  200
STAT 25100  Introduction to Mathematical Probability  100
STAT 25300  Introduction to Probability Models  100
STAT 27725  Machine Learning  100
CMSC 12100-12200-12300  Computer Science with Applications I-II-III  300
CMSC 23900  Data Visualization  100
CMSC 25025  Machine Learning and Large-Scale Data Analysis  100
CMSC 27200  Theory of Algorithms  100
CMSC 27610  Digital Biology  100
MENG 21400  Introduction to Applications of Quantum Mechanical Methods to Materials Design  100
MENG 21600  Bioengineering Kinetics  100
MENG 24100-24200  Selected Topics in Molecular Engineering: Molecular/Materials Modeling I-II  200
MENG 24300  The Engineering and Biology of Tissue Repair  100
MENG 24310  Cellular Engineering  100

Other courses from quantitative programs may be counted by consent of the director of the specialization.

Research Component

Students will develop the skills necessary for quantitative biology research, which is expected to be primarily, though not exclusively, computational in nature. They will work on mini-research projects starting in the foundational BIOS 26210-26211 sequence and in the third year develop a research proposal under the direction of a faculty advisor, which must be approved by the director of the specialization by the Spring Quarter. In their last year students will complete either (1) a senior honors project based on original research or (2) a senior thesis project approved by the director of the specialization. Students are expected to communicate and share their research with their peers through participation in the Quantitative Biology discussion club and by presenting their research in the annual Quantitative Biology undergraduate research conference. Opportunities to further their quantitative biology training and to work on their research project over the summer exist through summer quantitative biology fellowships.

Minor in Biological Sciences

Students who wish to complete a minor in Biological Sciences should meet with one of the BSCD Senior Advisers (Christine Andrews (candrews@uchicago.edu) or Megan McNulty (mmcnulty@uchicago.edu)) by the Spring Quarter of their second year in order to obtain formal consent (https://humanities-web.s3.us-east-2.amazonaws.com/college-prod/s3fs-public/documents/Consent_Minor_Program.pdf) and to plan out the appropriate program of study.

Students must meet general education requirements in the biological sciences and the physical sciences before entering the minor program. Biological Sciences courses at the 10000 level or above and MATH 13100 Elem Functions and Calculus I Elementary Functions and Calculus I and MATH 13200 Elem Functions and Calculus II Elementary Functions and Calculus II are the minimal general education requirements for the minor. After completing general education requirements, students complete the minor in Biological Sciences by taking three courses from a Biological Sciences Fundamentals sequence and four upper-level BIOS courses.

Typical minor plan:

General education in the biological sciences: BIOS 20153 Fundamentals of Ecology and Evolutionary Biology and BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic) or BIOS 20152 Introduction to Quantitative Modeling in Biology (Advanced) (recommended), or a two-quarter general education sequence for non-majors (Biological Sciences/ The Curriculum)

Three courses from a Biological Sciences Fundamentals sequence or from the Pre-Med Sequence

Four upper-level BIOS courses numbered BIOS 21000-28999

Minor plan for students in the Pre-Med Sequence for Non-Majors:
General education in the biological sciences: BIOS 20170 Microbial and Human Cell Biology and BIOS 20171 Human Genetics and Developmental Biology

Fundamentals-level courses: BIOS 20172 Mathematical Modeling for Pre-Med Students, BIOS 20173 Perspectives of Human Physiology, and BIOS 20175 Biochemistry and Metabolism

Four upper-level courses numbered BIOS 21000-28999

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. All courses for the minor must be taken for quality grades.

Minor in Computational Neuroscience

The minor in computational neuroscience is offered by the Biological Sciences Collegiate Division. Information regarding the program and its requirements can be found on the Computational Neuroscience page of this catalog.

BIOS Courses

Students must confirm their registration with their instructors by the second class meeting or their registration may be canceled.

In the following course descriptions, L indicates courses with a laboratory.

BIOS 20170. Microbial and Human Cell Biology. 100 Units.
This course is the entry point into an integrated biology sequence designed to prepare non-biology majors for application to medical school. We explore topics in human cell biology within the context of evolutionary biology, chemistry, microbiology, and medicine. We pay special attention to the influence of prokaryotes on the history of life and to the ecological interactions between humans and their microbiota, which have major implications for human health and disease. Students read and discuss papers from the scientific literature, attend discussions led by physicians, researchers, and other medical professionals, and gain experience with microbiological basic microscopy techniques in lab.
Instructor(s): C. Andrews, R. Zaragoza, E. Kovar Terms Offered: Winter. L.
Prerequisite(s): First or second-year standing, or consent of instructors.

BIOS 20171. Human Genetics and Developmental Biology. 100 Units.
This course covers the fundamentals of genetics, with an emphasis on human traits and diseases. Topics include Mendelian genetics, simple and complex traits, genetic diseases, the human genome, and testing for human traits and diseases. After establishing a foundation in genetics, we will discuss mechanisms underlying differentiation and development in humans. We will focus on events that lead to gastrulation and the establishment of the body plan (how humans develop from an unpatterned egg into a recognizable human form). Other topics may include limb development and stem cell biology.
Instructor(s): O. Pineda-Catalan, R. Zaragoza Terms Offered: Spring. L.
Prerequisite(s): BIOS 20170

BIOS 20172. Mathematical Modeling for Pre-Med Students. 100 Units.
This course covers mathematical approaches in biology and medicine, including basic statistics and hypothesis testing, mathematical modeling of biological systems, and an introduction to bioinformatics. Students will apply what they learn as they analyze data and interpret primary papers in the biological and clinical literature. BIOS 20172 lays the foundation for biomathematical approaches explored during subsequent courses in the BIOS 20170s sequence.
Instructor(s): E. Haddadian Terms Offered: Spring. L.
Prerequisite(s): BIOS 20170

BIOS 20173. Perspectives of Human Physiology. 100 Units.
This course will explore the structure and function of the human body as a set of integrated, interdependent systems. We will continue the cellular, genetic, and developmental themes of the previous courses to explore the emergent functions of the human body, from cells to systems. The laboratory exercises will allow the students to experience the concepts discussed in lecture in a way that introduces them to the methods of academic research, including the application of mathematical models to physiological questions. Students will be asked to serve as test subjects in several of the laboratory exercises. In required weekly discussions, students will present on papers from the scientific literature and attend talks by physicians, researchers, and other medical professionals.
Instructor(s): C. Andrews, E. Kovar Terms Offered: Autumn. L.
Prerequisite(s): BIOS 20170, BIOS 20171, BIOS 20172

BIOS 20175. Biochemistry and Metabolism. 100 Units.
The course introduces cellular biochemical metabolism. The chemical characteristics, biochemical properties, and function of carbohydrates, proteins, and lipids are introduced. Basic protein structure and enzyme kinetics including basic allosteric interactions are considered. The integration of carbohydrates, proteins, and lipids in cellular intermediary metabolism is examined including pathway regulation and bioenergetics. Adaptation of the pathways to changes in nutritional or disease state is used to highlight interrelationships in cellular metabolism.
Instructor(s): P. Striegleman Terms Offered: Winter
Prerequisite(s): BIOS 20170, BIOS 20171, BIOS 20172, BIOS 20173
Prerequisite Courses for Biological Sciences Majors

**BIOS 20151. Introduction to Quantitative Modeling in Biology (Basic) 100 Units.**
The goal for this course is to give future biologists the quantitative tools to fully participate in modern biological research. These include descriptive statistics, linear regression, stochastic independence and hypothesis testing, Markov models and stationary probability distributions, solutions of linear differential equations, equilibria and stability analysis of nonlinear differential equations. The ideas are applied to different areas of biology, e.g. molecular evolution, allometry, epidemiology, and biochemistry, and implemented by students in computer assignments using the R computational platform.
Instructor(s): D. Kondrashov Terms Offered: Spring. L.
Prerequisite(s): Two quarters of calculus of any sequence (MATH 13200 or 15200 or 16200). First-year Biology Major standing only.

**BIOS 20152. Introduction to Quantitative Modeling in Biology (Advanced) 100 Units.**
This is a more advanced version of 20151, intended for students with greater mathematical maturity. In addition to the topics covered in the regular version, students will learn about nonlinear least-squares fitting, eigenvalues and eigenvectors, bifurcations and bistability in differential equations. Additional applications will include phylogenetic distance and systems biology.
Instructor(s): D. Kondrashov Terms Offered: Winter. L.
Prerequisite(s): MATH placement of 15200 or higher OR either MATH 15200 or MATH 16200 and second-year standing or higher.

**BIOS 20153. Fundamentals of Ecology and Evolutionary Biology. 100 Units.**
This course surveys the basic principles of ecology and evolutionary biology to lay the foundation for further study in all fields of biology. Broad ecological concepts, such as population growth, disease dynamics, and species interactions, will be explored through a combination of published data, simulations, and mathematical models. The emphasis is on “ecological thinking” rather than specific notions. Essential topics in the modern study of evolutionary biology will be covered with a focus on both theory and empirical examples. Examples of topics include history of evolutionary thought, evidence for evolution, mechanisms of microevolution, phylogenetics, molecular evolution, and speciation.
Instructor(s): T. Price, M. Kronforst, C. Andrews, A. Hunter. Terms Offered: Winter. L.

**Fundamentals Sequence Courses for Biological Sciences majors**

**Notes:** These sequences require completion or concurrent enrollment in BIOS 20151/20152 and 20153. Neuroscience majors and other non-Biological Sciences majors may take BIOS 20186 without BIOS 20151/BIOS 20152 and 20153. However, all students in BIOS 20186 will be expected to possess the competencies in mathematical modeling of biological phenomena and basic coding in R covered in BIOS 20151/BIOS 20152 and BIOS 20153.

**BIOS 20186 through 20191 and 20200**

**Molecules to Organisms Fundamentals Sequence**

This sequence is designed for students who are preparing for a career in the Biological Sciences. Topics include cell and molecular biology, genetics, physiology, and developmental biology. 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.

**BIOS 20186. Fundamentals of Cell and Molecular Biology. 100 Units.**
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; temporal organization and regulation of metabolism; regulation of gene expression; and altered cell functions in disease states.
Prerequisite(s): BIOS 20150 or 20153 & at least concurrent registration in 20151 or 20152 or similar math prep. Avg. grade of C or higher in, and completion of, CHEM 10100-10200 or 11100-11200 or 12100-12200, a 5 on the AP Chem. exam, or consent. Reg. by lab sec.
Note(s): NSCI majors and other students may take BIO20186 without BIOS 20151/20152, 20153 unless they plan to pursue a double major in Biological Sciences. All students in BIOS20186 will be expected to possess the competency in mathematical modeling of biological phenomena covered in BIOS 20151 or BIOS 20152. Contact BSCD Advisers, Megan McNulty (mmcnulty@uchicago.edu) or Chris Andrews (candrews@uchicago.edu) to petition.

**BIOS 20187. Fundamentals of Genetics. 100 Units.**
The goal of this course is to integrate recent developments in molecular genetics into the structure of classical genetics with an emphasis on recent advances in genetics and genomics. Topics include Mendelian inheritance, genotype-phenotype relationships, linkage analysis, modern gene mapping techniques, gene expression, model systems genetics and analysis of genetic pathways.
Prerequisite(s): BIOS 20186
BIOS 20188. Fundamentals of Physiology. 100 Units.
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.
Prerequisite(s): BIOS 20187. Credit can NOT be earned for both BIOS 20188 and BIOS 20191.

BIOS 20189. Fundamentals of Developmental Biology. 100 Units.
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.
Prerequisite(s): BIOS 20187. Credit can NOT be earned for both BIOS 20189 and BIOS 20190.

BIOS 20200. Introduction to Biochemistry. 100 Units.
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.
Instructor(s): M. Makinen, E. Özkan, P. Strielemann, M. Zhao. Terms Offered: Autumn Spring Summer. L.
Prerequisite(s): Completion of a Biological Sciences fundamentals sequence with an average grade of C and CHEM 22000-22100/23100 with an average grade of C.

BIOS 20196 through 20198

Life, Ecosystems, and Evolution Fundamentals Sequence

This variation of the Molecules to Organisms sequence is designed for students majoring in Biological Sciences and interested in pursuing a course of study in ecology and evolution or environmental science. In this sequence, students omit BIOS 20188 Fundamentals of Physiology, BIOS 20189 Fundamentals of Developmental Biology, and BIOS 20200 Introduction to Biochemistry and take the following courses:

BIOS 20196. Ecology and Conservation. 100 Units.
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.
Prerequisite(s): BIOS 20150, BIOS 20151 or BIOS 20152 Note(s): BIOS 20196 is identical to the previously offered BIOS 23251. Students who have taken BIOS 23251 should not enroll in BIOS 20196. Equivalent Course(s): ENSC 24400
Instructor(s): C. Pfister, E. Larsen Terms Offered: Autumn. L.
Prerequisite(s): BIOS 20150, BIOS 20151 or BIOS 20152 Note(s): BIOS 20196 is identical to the previously offered BIOS 23251. Students who have taken BIOS 23251 should not enroll in BIOS 20196. Equivalent Course(s): ENSC 24400

BIOS 20198. Biodiversity. 100 Units.
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.
Instructor(s): M. LaBarbera, C. Andrews Terms Offered: Spring. L.
Prerequisite(s): BIOS 20150 except for Geophysical Sciences majors
Note(s): BIOS 20198 is identical to the previously offered BIOS 20184. Students who have taken BIOS 20184 should not enroll in BIOS 20198.

BIOS 20234 through 20242

Advanced Biology Fundamentals Sequence

This is an accelerated four-quarter Fundamentals sequence designed for motivated first-year students with exceptionally strong science and mathematics backgrounds and an intense interest in research in the biological sciences. A score of 4 or 5 on the Biology AP exam is required and successful students usually also have strong preparation in chemistry and calculus as well as some experience in computer programming. Students are expected to devote significant time to this sequence (minimum four to eight hours/week for reading primary literature and background information and for working problem sets, in addition to attendance at lectures and participation in laboratory exercises and discussion sections). Upon completion of the first three quarters of the Advanced Biology sequence, students will have three credits towards the Biological Sciences major and they will have met the general education requirement in the biological sciences.

Note: Biological Sciences majors who opt not to complete the sequence after the first quarter (BIOS 20234 Molecular Biology of the Cell) should take BIOS 20151/BIOS 20152, which will be applied to their general education requirement in the biological sciences along with their AP Biology credit. BIOS 20234 would be counted as a credit towards the
Biological Sciences major. Students would then complete the major by following the requirements for either the Molecules to Organisms sequence or the Life, Ecosystems, and Evolution sequence.

**BIOS 20234. Molecular Biology of the Cell. 100 Units.**
This course covers the fundamentals of molecular and cellular biology. Topics include protein structure and function; DNA replication, repair, and recombination; transcription, translation, control of gene expression; cytoskeletal dynamics; protein modification and stability; cellular signaling; cell cycle control; mitosis; and meiosis. Prerequisite(s): Score of 4 or 5 on the AP biology test
Instructor(s): M. Glotzer, A. Ruthenburg, N. Bhasin. L. Terms Offered: Autumn
Prerequisite(s): Score of 4 or 5 on the AP biology test
Note(s): To continue in the sequence, students must receive a minimum grade of B- in BIOS 20234

**BIOS 20235. Biological Systems. 100 Units.**
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.
Instructor(s): I. Rebay, M. Pascual, N. Bhasin. L. Terms Offered: Winter
Prerequisite(s): A grade of B- or above in BIOS 20234

**BIOS 20236. Biological Dynamics. 100 Units.**
This class introduces the use of quantitative approaches to study biological dynamics. Deeper exploration of cellular and developmental processes introduced in BIOS 20234 and BIOS 20235 will emphasize the use of quantitative analysis and mathematical modeling to infer biological mechanisms from molecular interactions. The lab portion of the class will introduce basic approaches for simulating biological dynamics using examples drawn from the lectures.
Instructor(s): E. Munro, M. Rust, E. Kovar. Terms Offered: Spring. L.
Prerequisite(s): BIOS 20234 and BIOS 20235 with a minimum grade of B- in each course.

**BIOS 20242. Principles of Physiology. 100 Units.**
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. We emphasize physiological reasoning, problem solving, and current research.
Instructor(s): M. Feder, E. Kovar. Terms Offered: Autumn. L.
Prerequisite(s): BIOS 20236 or BIOS 20189 or consent of instructor

**Upper-level Elective Courses**
Course numbers 21000 and above
These courses assume mastery of the material covered in the Fundamentals Sequences, and explore specific areas of biology at an advanced level. In most cases, students will be reading primary scientific literature. Students who have not yet completed the Fundamentals Sequence should consult with the course instructor and the BSCD Senior Advisers before registering for an upper-level elective course. Students must confirm their registration with their instructors by the second class meeting or their registration may be canceled.

**BIOS 21216. Intro Statistical Genetics. 100 Units.**
This course focuses on models for complex human disorders and quantitative traits. Topics covered also include linkage and linkage disequilibrium mapping and genetic models for complex traits, and the explicit and implicit assumptions of such models.
Instructor(s): Xin He, Hae Kyung Im Terms Offered: Winter
Prerequisite(s): For Biological Sciences majors: Three quarters of a Biological Sciences Fundamentals sequence Equivalent Course(s): HGEN 47100

**BIOS 21229. Genome Informatics: How Cells Reorganize Genomes. 100 Units.**
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.
Instructor(s): J. Shapiro Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235

**BIOS 21236. Genetics of Model Organisms. 100 Units.**
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.
Instructor(s): D. Bishop, H.-C Lee, E. Ferguson, I. Moskowitz Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235
BIOS 21237. Developmental Mechanisms. 100 Units.
This course provides an overview of the fundamental questions of developmental biology, with particular emphasis on the
 genetic, molecular and cell biological experiments that have been employed to reach mechanistic answers to these questions.
Topics covered will include formation of the primary body axes, the role of local signaling interactions in regulating cell fate
and proliferation, the cellular basis of morphogenesis, and stem cells.
Instructor(s): E. Ferguson, R. Fehon Terms Offered: Winter
Prerequisite(s): For undergraduates only: Three quarters of a Biological Sciences Fundamentals sequence including BIOS
20189, BIOS 20190, or BIOS 20235. AND CONSENT OF INSTRUCTOR
Equivalent Course(s): DVBI 36400, MGCB 36400

BIOS 21238. Cell Biology II. 100 Units.
This course covers the mechanisms with which cells execute fundamental behaviors. Topics include signal transduction,
cell cycle progression, cell growth, cell death, cancer biology, cytoskeletal polymers and motors, cell motility, cytoskeletal
diseases, and cell polarity. Each lecture will conclude with a dissection of primary literature with input from the students.
Students will write and present a short research proposal, providing excellent preparation for preliminary exams.
Instructor(s): M. Glotzer, D. Kovar Terms Offered: Winter
Prerequisite(s): For undergraduates: Three quarters of a Biological Sciences Fundamentals sequence.
Equivalent Course(s): MGCB 31700, DVBI 31700, BCMB 31700

BIOS 21249. Organization, Expression, and Transmission of Genome Information. 100 Units.
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.
Instructor(s): J. Shapiro Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Recommended for Advanced Biology
students

BIOS 21306. Human Genetics and Evolution. 100 Units.
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 will be introduced through lectures and will be complemented by discussion and student presentations of
original research papers.
Instructor(s): A Di Rienzo, Yang Li Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Fundamentals Sequence including BIOS 20187 or BIOS 20235.

BIOS 21317. Topics in Biological Chemistry. 100 Units.
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.
Instructor(s): P. Rice, R. Keenan Terms Offered: Spring
Prerequisite(s): BIOS 20200

BIOS 21328. Biophysics of Biomolecules. 100 Units.
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.
Equivalent Course(s): BCMB 32200, BPHS 31000

BIOS 21349. Protein Structure and Functions in Medicine. 100 Units.
This course explores how molecular machinery works in the context of medicine (vision, flight or flight, cancer, and action
of drugs). We first explore the physical and biochemical properties of proteins in the context of cellular signaling. We then
examine how proteins and other cellular components make up the signal transduction pathway of humans and conduct their
biological functions. The course engages students to strengthen their scientific communication and teaching skills via the in-
class podcast, oral examinations, computer-aided structural presentations, student lectures, and discussions.
Instructor(s): W-J. Tang Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Biochemistry strongly recommended.
Equivalent Course(s): CABI 31900, NURB 33500
BIOS 21356. Vertebrate Development. 100 Units.
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 including embryology, genetics, and molecular genetics.
Instructor(s): V. Prince, P. Kratsios. Terms Offered: Spring
Prerequisite(s): For Biological Sciences majors: Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20189 or BIOS 20190
Equivalent Course(s): ORGB 33600, MGCB 35600, DVBI 35600

BIOS 21358. Simulation, Modeling, and Computation in Biophysics. 100 Units.
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 distributors. A term project involves writing a small program that simulates a process. Familiarity with a programming language or Matlab would be valuable.
Instructor(s): B. Roux Terms Offered: Winter
Prerequisite(s): BIOS 20200 and BIOS 26210-26211, or consent from instructor
Equivalent Course(s): BCMB 31358, CPNS 31358

BIOS 21360. Advanced Molecular Biology. 100 Units.
This course covers genome structures, transcription of DNA to RNA, messenger RNA splicing, translation of RNA to protein, transcriptional and post-transcriptional gene regulations, non-coding RNA functions, epigenetics and epitranscriptomics. Basic methods in molecular biology will also be covered. The course also includes special, current topics on genomics, single molecule studies of gene expression, epitranscriptomics, and others.
Instructor(s): J. Fei, T. Pan. Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and one year of calculus
Equivalent Course(s): MGCB 34300

BIOS 21407. Image Processing in Biology. 100 Units.
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.
Instructor(s): R. Josephs Terms Offered: Spring. Offered every other year in even years.
Prerequisite(s): For College students: Three quarters of a Biological Sciences Fundamentals sequence and one year of calculus
Equivalent Course(s): BCMB 31358, CPNS 31358

BIOS 21415. Stem Cells in Development and Diseases. 100 Units.
This course will provide a survey of concepts and biology of stem cells based on experimental evidence for their involvement in developmental processes and human diseases. Topics will discuss classic models as well as recent advances made in the biomedical research community.
Instructor(s): A. Imamoto, X. Wu Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, including BIOS 20186 and BIOS 20187

BIOS 21416. Stem Cells and Regeneration. 100 Units.
The course will focus on the basic biology of stem cells and regeneration, highlighting biomedically relevant findings that have the potential to translate to the clinic. We will cover embryonic and induced pluripotent stem cells, as well as adult stem cells from a variety of systems, both invertebrate and vertebrates.
Instructor(s): E. Ferguson, V. Prince, J. Cunningham, J. De Jong, X. Wu Terms Offered: Autumn
Prerequisite(s): For undergraduates only: completion of a Biological Sciences fundamentals sequence
Equivalent Course(s): DVBI 36200

BIOS 21418. Historical and Conceptual Foundations of DevoEvo. 100 Units.
The goal of this course is to explore the historical and conceptual foundations of Developmental Evolution (DevoEvo) through readings and group discussions of historical and philosophical literature on evolutionary and developmental biology, in particular the role developmental biology played in the formulation of evolutionary theory and its subsequent banishment from the Modern Synthesis. The course begins with a review of nineteenth-century scientific and evolutionary thought, including an examination of competing theories of evolution (Theistic Evolutionism, Lamarckism, Orthogenesis, and Mutation Theory) and their contribution (or lack thereof) to modern evolutionary biology. We then explore how (and why) developmental biology was excluded from the formulation of the Synthesis and Neo-Darwinian thought, and examine the source of continued conflicts between Neo-Darwinism and DevoEvo. The course concludes with a discussion of what (if anything) DevoEvo can contribute to evolutionary theory that other research programs cannot (for example, what kinds of phenomena do developmental mechanisms contribute more to the explanation of evolutionary processes than population genetic mechanisms?).
Instructor(s): V. Lynch. Terms Offered: Winter
Prerequisite(s): For Biology Majors: Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235.
Equivalent Course(s): HGEN 39500, ORGB 39500
**BIOS 21506. Biological Physics. 100 Units.**

This course is an introduction to the physics of living matter. Its goal is to understand the design principles from physics that characterize the condensed and organized matter of living systems. Topics include: basic structures of proteins, nucleotides, and biological membranes; application of statistical mechanics to diffusion and transport; hydrodynamics of low Reynolds number fluids; thermodynamics and chemical equilibrium; physical chemistry of binding affinity and kinetics; solution electrostastics and depletion effect; biopolymer mechanics; cellular mechanics and motions; molecular motors.

Terms Offered: Spring
Prerequisite(s): PHYS 13300 or PHYS 14300
Note(s): Students majoring in Physics may use this course either as a Physics elective OR as a upper level elective in the Biological Sciences major.
Equivalent Course(s): PHYS 25500, MENG 21900

**BIOS 21507. The Engineering and Biology of Tissue Repair. 100 Units.**

In this course, students will gain an understanding of the science and application of tissue engineering, a field that seeks to develop technologies for restoring lost function in diseased or damaged tissues and organs. The course will first introduce the underlying cellular and molecular components and processes relevant to tissue engineering: extracellular matrices, cell/matrix interactions such as adhesion and migration, growth factor biology, stem cell biology, inflammation, and innate immunity. The course will then discuss current approaches for engineering a variety of tissues, including bone and musculoskeletal tissues, vascular tissues, skin, nerve, and pancreas. Students will be assessed through in-class discussions, take-home assignments and exams, and an end-of-term project on a topic of the student's choice.

Instructor(s): Jeffrey Hubbell Terms Offered: Spring
Prerequisite(s): BIOS 20186 or BIOS 20234
Equivalent Course(s): MPMM 34300, MENG 34300, MENG 24300

**BIOS 22233. Comparative Vertebrate Anatomy. 100 Units.**

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.

Instructor(s): M. Westneat. L. Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.
Note(s): Offered Winter 2019 and every other year thereafter.
Equivalent Course(s): ORGB 32233

**BIOS 22236. Reproductive Biology of Primates. 100 Units.**

The aim of this advanced-level course is to provide a comparative overview of adaptations for reproduction in primates as a background to human reproductive biology. Where appropriate, reference will be made to other mammals and some comparisons will be even wider. Ultimately, the aim of all comparisons is to arrive at concrete lessons for human reproduction, notably in the realm of obstetrics and gynecology. For this reason, the course will be of interest for medical students as well as for those studying anthropology, biology or psychology.

Instructor(s): R. Martin Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.

**BIOS 22245. Biomechanics: How Life Works. 100 Units.**

This course will explore form and function in a diversity of organisms, using the principles of physics and evolutionary theory to understand why living things are shaped as they are and behave in such a diversity of ways. Biomechanics is at the interface of biology, physics, art, and engineering. We will study the impact of size on biological systems, address the implications of solid and fluid mechanics for organismal design, learn fundamental principles of animal locomotion, and survey biomechanical approaches. Understanding the mechanics of biological organisms can help us gain insight into their behavior, ecology and evolution.

Instructor(s): M. Westneat Terms Offered: Spring. L. Spring.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Physics useful.
Note(s): This course will include a lab and will alternate years with BIOS 22233.
Equivalent Course(s): EVOL 32245, ORGB 32245

**BIOS 22249. Principles of Toxicology. 100 Units.**

This course covers basic concepts of toxicology including routes of exposure and uptake, metabolic conversion, and elimination of toxic agents, as well as fundamental laws governing the interaction of external chemicals with biological systems. In addition to toxins of biological origin, we also consider a set of physical and chemical toxicants in the environment, including air pollution, radiation, manufactured chemicals, metals, and pesticides. Methods of risk assessment will also be considered.

Instructor(s): Y-Y He Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and BIOS 20200
BIOS 22250. Chordates: Evolution and Comparative Anatomy. 100 Units.
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 body plans, 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.

Instructor(s): M. Coates Terms Offered: Winter. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, including BIOS 20187 or BIOS 20235

Note(s): Not offered Winter 2019 - Offered Winter 2020 and every other year thereafter.
Equivalent Course(s): EVOL 30250, EVOL 30200

BIOS 22260. Vertebrate Structure and Function. 100 Units.
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.

Instructor(s): P. Sereno. L. Terms Offered: Spring. Not offered 2019; Will be offered 2020
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and consent of instructor. See also http://paulsereno.uchicago.edu/fossil_lab/classes/vertebrate_structure_and_function for more information.

BIOS 22265. Human Origins: Milestones in Human Evolution and the Fossil Record. 100 Units.
This course aims at exploring the fundamentals of human origins by tracking the major events during the course of human evolution. Starting with a laboratory based general introduction to human osteology and muscle function, the latest on morphological and behavioral evidence for what makes Homo sapiens and their fossil ancestors unique among primates will be presented. Our knowledge of the last common ancestor will be explored using the late Miocene fossil record followed by a series of lectures on comparative and functional morphology, adaptation and biogeography of fossil human species. With focus on the human fossil record, the emergence of bipedalism, advent of stone tool use and making, abandonment of arboreality, advent of endurance walking and running, dawn of encephalization and associated novel life histories, language and symbolism will be explored. While taxonomic identities and phylogenetic relationships will be briefly presented, the focus will be on investigating major adaptive transitions and how that understanding helps us to unravel the ecological selective factors that ultimately led to the emergence of our species. The course will be supported by fresh data coming from active field research conducted by Prof. Alemseged and state of the art visualization methods that help explore internal structures. By tracing the path followed by our ancestors over time, this course is directly relevant to reconnoitering the human condition today and our place in nature.

Instructor(s): Z. Alemseged Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, or consent of Instructor.
Equivalent Course(s): ANTH 28110, ORGB 33265

BIOS 22270. Bones and Genes: The Story of Homo Sapiens. 100 Units.
The primary aim of this course is to explore the biological and behavioral makings of our species, anatomically modern Homo sapiens, by considering hypotheses, models, evidence, and the latest consensus from the complementary fields of paleoanthropology and genetics. The course is divided into two blocks, one focusing on our origins and the other on migrations across the globe. After a brief introduction to the human skeleton, students will learn about the pool of potential direct ancestors that lived before Homo sapiens emerged 300,000 year ago, as well as the environmental and cultural environments that may have led to the arrival of our species. This will be complemented by an evaluation of competing genetic models for the origin of our species and evidence for genetic intermixing with archaic humans such as Neanderthals and Denisovans. We will, then, follow modern humans out of Africa and study the fossil, archaeological, and genetic evidence for the peopling of the planet and adaptations to novel environments. Finally, the contributions of paleoanthropology and genetics to our understanding of behavior, cognition, physical traits/phenotypes, diet, and disease evolution will be explored. Complementary laboratory and discussion sessions will expose students to state-of-the-art methods and current research endeavors in these fields.

Instructor(s): M. Raghavan, Z. Alemseged Terms Offered: Spring
Prerequisite(s): BIOS Majors: Three quarters of a Biological Sciences Fundamentals sequence. Also open to students in Anthropology and Genetics with an interest in human evolution, or consent of instructors.

BIOS 22306. Evolution and Development. 100 Units.
The course will provide a developmental perspective on animal body plans in phylogenetic context. The course will start with a few lectures, accompanied by reading assignments. Students will be required to present a selected research topic that fits the broader goal of the course and will be asked to submit a referenced written version of it after their oral presentation. Grading will be based on their presentation (oral and written) as well as their contributions to class discussions.

Prerequisite(s): Advanced undergraduates may enroll with the consent of the instructor.
Instructor(s): U. Schmidt-Ott Terms Offered: Autumn
Prerequisite(s): Advanced undergraduates may enroll with the consent of the instructor.
Equivalent Course(s): EVOL 33850, DVBI 33850, ORGB 33850
BIOS 23100. Dinosaur Science. 100 Units.
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. Instructor(s): P. Sereno. L. Terms Offered: Spring
Prerequisite(s): Consent of instructor, three quarters of a Biological Sciences Fundamentals sequence and a prior course in general science, preferably geology. See also http://paulsereno.uchicago.edu/fossil_lab/classes/dinosaur_science for more information.
Note(s): Need based financial assistance for field trip may be available. Apply to the Master of BSCD (jmalamy@bsd.uchicago.edu)

BIOS 23232. Ecology and Evolution in the Southwest. 100 Units.
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.
Instructor(s): E. Larsen Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, or consent of instructor

BIOS 23233. Ecology and Evolution in the Southwest: Field School. 100 Units.
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.
Instructor(s): E. Larsen Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and consent of instructor

BIOS 23242. Primate Evolution and the Roots of Human Biology. 100 Units.
The course is designed to achieve a state-of-the-art synthesis of primate evolution and human origins. An overview of the biology and evolution of the mammalian order Primates provides a broad foundation for considering the special case human evolution. Across primates as a group, the course explores and integrates comparative evidence from anatomy, physiology, behavior, chromosomal studies, and molecular genetics. Both living primates and their fossil relatives are covered, with due reference to theoretical aspects. Particular emphasis is given to evaluation of characters for inference of evolutionary relationships and to explicit examination of scaling effects of body size in between-species comparisons. Within the general framework of origins and adaptations of primates, human evolution is examined with respect to all features covered. Special features of humans are identified and related to an overview of the hominid fossil record. A specific goal of this course is to guide students to read, interpret, and synthesize scientific literature, and exercise critical thinking with respect to selected topics. As shown by examples, the course is directly relevant to the field of Darwinian medicine, which considers health and disease in relation to the evolutionary background of human biology.
Instructor(s): R. Martin Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235, or consent of instructor

BIOS 23247. Bioarchaeology and the Human Skeleton. 100 Units.
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.
Instructor(s): M. C. Lozada Terms Offered: Winter. Winter 2020
Note(s): This course qualifies as a Methodology selection for Anthropology majors.
Equivalent Course(s): ANTH 38800, ANTH 28400

BIOS 23249. Animal Behavior. 100 Units.
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.
Instructor(s): S. Pruett-Jones (even years), J. Mateo (odd years) Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.
Note(s): CHDV Distribution: A
Equivalent Course(s): PSYC 23249, CHDV 23249
BIOS 23252. Field Ecology. 100 Units.
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.
Instructor(s): S. Pruett-Jones Terms Offered: Spring. This course is offered in alternate (odd) years.
Prerequisite(s): Consent of instructor

BIOS 23254. Mammalian Ecology. 100 Units.
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.
Instructor(s): E. Larsen Terms Offered: Spring. L. Offered every other year in odd years.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and third-year standing or consent of instructor.

BIOS 23258. Molecular Evolution I: Fundamentals and Principles. 100 Units.
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.
Instructor(s): M. Kreitman Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235 and two quarters of calculus, or consent of instructor.
Equivalent Course(s): EVOL 44001, ECEV 44001

BIOS 23261. Invertebrate Paleobiology and Evolution. 100 Units.
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. (L)
Instructor(s): M. Webster Terms Offered: Autumn
Prerequisite(s): 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.
Equivalent Course(s): GEOS 26300, GEOS 36300, EVOL 32400

BIOS 23262. Mammalian Evolutionary Biology. 100 Units.
This course examines mammalian evolution—the rise of living mammals from ancient fossil ancestors stretching back over 300 million years. Lectures focus on the evolutionary diversification of mammals, including anatomical structure, evolutionary adaptations, life history, and developmental patterns. Labs involve detailed comparative study of mammalian skeletons, dissection of muscular and other systems, trips to the Field Museum to study fossil collections, and studies of human anatomy at the Pritzker School of Medicine. Students will learn mammalian evolution, functional morphology, and development, and will gain hands-on experience in dissection. Taught by instructors who are active in scientific research on mammalian evolution, the course is aimed to convey new insights and the latest progress in mammalian paleontology, functional morphology, and evolution. Prerequisite(s): Second-year standing and completion of a Biological Sciences Fundamentals sequence; or GEOS 13100-13200 or GEOS 22300, or consent of instructors.
Instructor(s): Z. Luo, K. Angielczyk Terms Offered: Autumn. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235; or GEOS 13100-13200 or GEOS 22300, or consent of instructors.
Equivalent Course(s): EVOL 31201, ORGB 31201

BIOS 23266. Evolutionary Adaptation. 100 Units.
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, the comparative method in evolutionary biology, and the genetic architecture of adaptive traits. Students will draw on the logical frameworks covered in lecture as they evaluate primary papers and prepare two writing assignments on an adaptive question of their choice.
Instructor(s): C. Andrews Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235 or consent of instructor.
BIOS 23289. Marine Ecology. 100 Units.
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.
Instructor(s): T. Wootton Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and prior introductory course in ecology or consent of instructor.
Equivalent Course(s): ENST 23289

BIOS 23299. Plant Development and Molecular Genetics. 100 Units.
Genetic approaches to central problems in plant development will be discussed. Emphasis will be placed on embryonic pattern formation, meristem structure and function, reproduction, and the role of hormones and environmental signals in development. Lectures will be drawn from the current literature; experimental approaches (genetic, cell biological, biochemical) used to discern developmental mechanisms will be emphasized. Graduate students will present a research proposal in oral and written form; undergraduate students will present and analyze data from the primary literature, and will be responsible for a final paper.
Instructor(s): J. Greenberg Terms Offered: Spring
Prerequisite(s): For undergraduates only: Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235.
Equivalent Course(s): MGCB 36100, ECEV 32900, DVBI 36100

BIOS 23365. Evolutionary and Genomic Medicine I. 100 Units.
Evolution is regularly investigated in free-living organisms, but some of its most fascinating and important examples occur in the interface between free-living and non-free-living states. In this course, we will use evolutionary and ecological principles to study the dynamics of viruses, unicellular organisms and cells in multi-cellular organisms relevant to human medicine. In EGM I, the emphasis will be on the evolution of pathogens, the evolution of cells of the immune system in response to pathogen invasion, the basis of autoimmune disorders, and the population genetics of cancerous cells in light of recent cancer genomic studies. EGM II will cover more general topics including Darwinian medicine, aging, and systems biology/medicine.
Instructor(s): S. Cobey, C-I. Wu Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235.
Background in evolution and population genetics.
Equivalent Course(s): ECEV 33365

BIOS 23404. Reconstructing the Tree of Life: An Introduction to Phylogenetics. 100 Units.
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.
Instructor(s): R. Ree. Terms Offered: Autumn. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence or consent of instructor
Note(s): This course is offered in alternate (odd) years.
Equivalent Course(s): EVOL 35401

BIOS 23405. Darwinian Health. 100 Units.
This course will use an evolutionary, rather than clinical, approach to understanding why we get sick. In particular, we will consider how health issues such as menstruation, senescence, pregnancy sickness, menopause, and diseases can be considered adaptations rather than pathologies. We will also discuss how our rapidly changing environments can reduce the benefits of these adaptations.
Instructor(s): J. Mateo Terms Offered: Winter
Prerequisite(s): Prerequisite(s): For BIOS Majors: Three quarters of a Biological Sciences Fundamentals sequence or consent of instructor.
Note(s): CHDV Distribution: A
Equivalent Course(s): GNSE 21500, HLTH 21500, HIPS 22401, CHDV 21500

BIOS 23406. Biogeography. 100 Units.
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).
Instructor(s): B. Patterson (odd years, lab), L. Heaney (even years, discussion) Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and a course in either ecology, evolution, or earth history; or consent of instructor.
Equivalent Course(s): GEOG 35500, EVOL 45500, GEOG 25500, ENST 25500
BIOS 23409. The Ecology and Evolution of Infectious Diseases. 100 Units.
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.
Instructor(s): G. Dwyer Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and Integral calculus.

BIOS 23410. Complex Interactions: Coevolution, Parasites, Mutualists, and Cheaters. 100 Units.
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.
Instructor(s): T. Lumbsch Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.

BIOS 24110. Fundamental Neuroscience. 100 Units.
This course is a rigorous introduction to the study of neurons, nervous systems and brains. The systems anatomy and physiology of the vertebrate brain will be covered in depth. Common features of neural circuits, such as those subserving the stretch reflex, will be examined. The biology of brain evolution and development will be introduced. A highlight of this course will be student dissections of sheep brains and the laboratory presentation of human brain dissections by the instructors.
Instructor(s): C. Ragsdale, P. Mason Terms Offered: Autumn
Prerequisite(s): At least two quarters of Biological Sciences instruction (including courses taken concurrently) or consent of instructor
Equivalent Course(s): NSCI 20110

BIOS 24120. Cellular Neuroscience. 100 Units.
This course describes the cellular and subcellular properties of neurons, including passive and active electrophysiological properties, and their synaptic interactions. Readings are assigned from a general neuroscience textbook.
Instructor(s): M. Sheffield, W. Wei Terms Offered: Winter
Prerequisite(s): NSCI 20110, along with completion of MATH 13100, or MATH 15100, or MATH 16100, or consent of instructor
Equivalent Course(s): NSCI 20120

BIOS 24130. Systems Neuroscience. 100 Units.
This course covers 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.
Instructor(s): D. Freedman Terms Offered: Spring
Prerequisite(s): NSCI 20111, NSCI 20121 or consent of instructors
Equivalent Course(s): NSCI 20130

BIOS 24131. Molecular Neuroscience. 100 Units.
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 endo-cytosis, and development and mechanisms of neurological diseases.
Instructor(s): S. Sisodia Terms Offered: Spring
Prerequisite(s): NSCI 20111, NSCI 20121 and BIOS 20200, or consent of instructor
Equivalent Course(s): NSCI 22100

BIOS 24208. Survey of Systems Neuroscience. 100 Units.
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. Somatic, visual, auditory, vestibular and olfactory sensory systems are presented in particular depth. A highlight of this course is that students become practiced at recognizing the nuclear organization and cellular architecture of many regions of brain in rodents, cats and primates.
Instructor(s): S. Bensmaia Terms Offered: Autumn
Prerequisite(s): NSCI 20130. For Biological Sciences majors: Three quarters of a Biological Sciences fundamentals sequence
Equivalent Course(s): ORGB 32500, CPNS 30116, NURB 31600, NSCI 23500
BIOS 24217. Conquest of Pain. 100 Units.
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. Instructor(s): K. Ruskin Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, CHEM 2200-22100-22200 or BIOS 20200 and prior course in neurobiology or physiology is recommended.

BIOS 24231. Methods in Computational Neuroscience. 100 Units.
Topics include (but are not limited to): Hodgkin-Huxley equations, Cable theory, Single neuron models, Information theory, Signal Detection theory, Reverse correlation, Relating neural responses to behavior, and Rate vs. temporal codes. Instructor(s): S. Bensmaia Terms Offered: Winter.
Prerequisite(s): For Neuroscience Majors: NSCI 20130, BIOS 26210 and BIOS 26211 which must be taken concurrently, or consent of instructor.
Equivalent Course(s): NSCI 23700, PSYC 24231, CPNS 34231

BIOS 24232. Computational Approaches to Cognitive Neuroscience. 100 Units.
This course is concerned with the relationship of the nervous system to higher order behaviors (e.g., perception, object recognition, action, attention, learning, memory, and decision making). Psychophysical, functional imaging, and electrophysiological methods are introduced. Mathematical and statistical methods (e.g. neural networks and algorithms for studying neural encoding in individual neurons and decoding in populations of neurons) are discussed. Weekly lab sections allow students to program cognitive neuroscientific experiments and simulations. Instructor(s): N. Hatsopoulos Terms Offered: Winter.
Prerequisite(s): For Neuroscience Majors: NSCI 20110, NSCI 20130, BIOS 26210, and knowledge using Matlab, or consent of instructor.
Equivalent Course(s): NSCI 23600, PSYC 34410, ORGB 34650, CPNS 33200

BIOS 24248. Biological Clocks and Behavior. 100 Units.
This course will address physiological and molecular biological aspects of circadian and seasonal rhythms in biology and behavior. The course will primarily emphasize biological and molecular mechanisms of CNS function, and will be taught at a molecular level of analysis from the beginning of the quarter. Those students without a strong biology background are unlikely to resonate with the course material. Instructor(s): B. Prendergast Terms Offered: Autumn.
Prerequisite(s): A quality grade in PSYC 20300 Introduction to Biological Psychology. Additional biology courses are desirable. Completion of Core biology will not suffice as a prerequisite.
Equivalent Course(s): PSYC 21750, HLTH 21750, NSCI 21400

BIOS 24408. Modeling and Signal Analysis for Neuroscientists. 100 Units.
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. Instructor(s): W. van Drongelen Terms Offered: Spring.
Prerequisite(s): Undergraduates: Biology Major - BIOS 26210 and 26211, or consent of instructor. Neuroscience Major - NSCI 20130, BIOS 26210 and 26211, or consent of instructor.
Equivalent Course(s): NSCI 24000, CPNS 32111

BIOS 25108. Cancer Biology. 100 Units.
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). Instructor(s): M. Rosner, W. Du Terms Offered: Winter.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.

BIOS 25109. Topics in Reproduction and Cancer. 100 Units.
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. Instructor(s): G. Greene, L. Becker Terms Offered: Spring.
Prerequisite(s): For Biology majors: Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235 and Biochemistry, or consent of Instructor.
BIOS 25126. Animal Models of Human Disease. 100 Units.
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.
Instructor(s): K. Luchins Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 of BIOS 20235, or consent of instructor

BIOS 25206. Fundamentals of Bacterial Physiology. 100 Units.
This course meets one of the requirements of the microbiology specialization. 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.
Instructor(s): D. Missiakas Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, or consent of instructor
Equivalent Course(s): MICR 30600

BIOS 25216. Molecular Basis of Bacterial Disease. 100 Units.
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.
Instructor(s): H. Shuman Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.
Equivalent Course(s): MICR 31600

BIOS 25226. Endocrinology I: Cell Signaling. 100 Units.
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.
Instructor(s): M. Brady, R. Cohen Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and BIOS 25200.
Equivalent Course(s): NPHP 33600

BIOS 25227. Endocrinology II: Systems and Physiology. 100 Units.
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.
Instructor(s): M. Brady, R. Cohen Terms Offered: Winter
Prerequisite(s): Completion of the first three quarters of a Biological Fundamentals Sequence.

BIOS 25228. Endocrinology III: Human Disease. 100 Units.
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).
Instructor(s): Y. C. Li Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence is required and BIOS 25227 is strongly recommended.

BIOS 25256. Immunobiology. 100 Units.
This comprehensive survey course presents an integrated coverage of the tactics and logistics of innate and adaptive immunity in mammalian organisms. It conveys the elegance and complexity of immune responses against infectious agents. It introduces their implications in autoimmune diseases, cancer and organ transplantation and presents some of the emerging immunotherapeutics that are transforming health care. Prior knowledge of microbiology (e.g., BIOS 25206) will be advantageous. Prerequisite(s): Completion of a Biological Sciences Fundamentals Sequence which includes, Cell, Genetics, Developmental Biology, and Physiology
Instructor(s): A. Bendelac Terms Offered: Autumn
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235, and BIOS 20188 and BIOS 20189
BIOS 25258. Immunopathology. 100 Units.
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.
Instructor(s): B. Jabri Terms Offered: Winter
Equivalent Course(s): PATH 30010, IMMU 30010

BIOS 25260. Host Pathogen Interactions. 100 Units.
This course explores the basic principles of host defense against pathogens, including evolutionary aspects of innate and adaptive immunity and immune evasion strategies. Specific examples of viral and bacterial interactions with their hosts are studied in depth. A review of immunological mechanisms involved in specific cases is incorporated in the course.
Instructor(s): A. Chervonsky Terms Offered: Autumn
Prerequisite(s): BIOS 25206 and BIOS 25256
Equivalent Course(s): MICR 31200, IMMU 31200

BIOS 25266. Molecular Immunology. 100 Units.
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.
Instructor(s): E. Adams Terms Offered: Spring. Offered in odd years
Prerequisite(s): BIOS 20200 or 25256, or consent of instructor
Equivalent Course(s): IMMU 30266

BIOS 25268. Barrier Immunity. 100 Units.
Nowhere is the body's immune system so critical in saving an organism from death as at barrier sites, areas where we are directly exposed to the external environment: These are the first entry sites of a plethora of potentially lethal pathogens. However, inflammatory responses for the exclusion of pathogens need to be carefully balanced with tolerance to benign or even beneficial agents such as our microbiome or food, and with a homeostatic role of the immune system in tissue repair. Failure to make the right call on defensive versus immunosuppressive reactions to the exterior can lead to severe pathologies such as chronic inflammation, allergies, autoimmunity and cancer. These challenges are met by a plethora of innate and adaptive immune cells that adapt to the barrier environment or are even exclusively found in these niches. Further complexity is imposed by the fact that all barriers have their particular environmental challenges based on location and tissue function. The fascinating uniqueness of Barrier Immunity is the subject of this course. Examining the historical but also cutting edge literature on the topic, we will explore together how the immune systems of the intestine, the lung, the skin and the vaginal tract, the four major barrier sites, deal with maintaining defense while not jeopardizing tissue function. We will first study each site on its own, with a particular focus on the interaction with the local homeostatic microbiome and what's known in men and mice.
Instructor(s): D. Esterhazy Terms Offered: Spring
Prerequisite(s): BIOS 25256 with a grade of B+ or better, or consent if grade lower than B+.

BIOS 25287. Introduction to Virology. 100 Units.
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.
Instructor(s): M. Gack Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence and third- or fourth-year standing
Equivalent Course(s): MICR 34600

BIOS 25308. Heterogeneity in Human Cancer: Etiology and Treatment. 100 Units.
This course addresses the importance of understanding human tumor heterogeneity (organ site by organ site) in terms of predicting whether tumors will progress to malignancy and how tumors will respond to standard treatments or require tailored molecular therapeutics. Alternating lecture and discussion lectures will explore and tease apart the controversies in the field that limit progress in cancer prevention, diagnosis and treatment. At the end of the course, students should have an in-depth understanding of the complexities, challenges and opportunities facing modern cancer researchers and clinical oncologists and be able to discuss novel scientific approaches to solving these issues.
Instructor(s): K. MacLeod Terms Offered: Autumn 2018
Prerequisite(s): A grade of B or better in BIOS 25108
Equivalent Course(s): CABI 30500
BIOS 25326. Tumor Microenvironment and Metastasis. 100 Units.
The tumor microenvironment regulates disease progression and chemoresistance in most cancers. This course addresses the functional contribution of the different cellular and non-cellular constituents of the tumor that surround the malignant cancer cells in cancer progression and metastasis. We will thoroughly discuss the function of stroma, inflammation, tumor senescence, immunity and the interaction in cancer progression and metastasis. Moreover, we will evaluate the translational impact of targeting the tumor microenvironment. Laboratory studies will introduce key techniques and organotypic model systems to elucidate these functions. At the end of the course, students should be able to understand the biology behind cancer metastasis and to evaluate manuscripts reporting novel findings in cancer biology. Prerequisite(s): BIOS 25108 and BIOS 25308.
Instructor(s): H. Kenny, E. Lengyel Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.
Note(s): Three optional weekend, one-day workshops will be offered during the quarter. This course qualifies in the Cancer Specialization.

BIOS 25327. Health Disparities in Breast Cancer. 100 Units.
Across the globe, breast cancer is the most common women's cancer. In the last two decades, there have been significant advances in breast cancer detection and treatment that have resulted in improved survival rates. Yet, not all populations have benefited equally from these improvements, and there continues to be a disproportionate burden of breast cancer felt by different populations. In the U.S., for example, white women have the highest incidence of breast cancer but African-American women have the highest breast cancer mortality overall. The socioeconomic, environmental, biological, and cultural factors that collectively contribute to these disparities are being identified with a growing emphasis on health disparities research efforts. In this 10-week discussion-based course students will meet twice weekly and cover major aspects of breast cancer disparities.
Instructor(s): E. Dolan, S. Conzen Terms Offered: Winter
Prerequisite(s): BIOS 25108
Equivalent Course(s): GNSE 20408, HLTH 20400, CCTS 20400, CCTS 40400

BIOS 25407. Organ Transplantation. 100 Units.
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.
Instructor(s): A. Chong Terms Offered: Winter. Offered Winter 2020
Prerequisite(s): BIOS 25256

BIOS 25420-26120-26121. An Introduction to Bioinformatics and Proteomics; Introduction to Transcriptonomics; Microbial ‘Omics.
These courses may be taken as a sequence.

BIOS 25420. Microbial ‘Omics. 100 Units.
Every ecological niche our planet has to offer, including the human body itself, is home to an astonishing number of microbial cells that form complex communities. The last several years witnessed tremendous advances in molecular and computational approaches which now offer unprecedented access to these communities through new ‘omics strategies. Developing an overall understanding of these strategies -including the ability to identify their appropriate applications and shortcomings- has quietly become a de facto necessity in the journey of an independent life scientist. The primary aim of this course is to offer an evaluation of current concepts and methods to study the ecology, evolution, and functioning of naturally occurring microbial communities. Participants will have a chance to acquire hands-on experience with state-of-the-art computational methods and work with real-world microbial data. Through equal proportions of theory and practice, the course will cover concepts and strategies that help us wrap our collective mind around the most diverse form of life on our planet.
Instructor(s): A. Murat Eren Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals Sequence

BIOS 25420. An Introduction to Bioinformatics and Proteomics. 100 Units.
Modern biology generates massive amounts of data; this course is devoted to biological information and the models and techniques used to make sense of it. Students learn about biological databases, algorithms for sequence alignment, phylogenetic tree building, and systems biology. They will also learn about the basics of large-scale study of proteins, particularly their structures and functions. Students will be introduced to basics of high performance computation (HPC) and its application to the field of bioinformatics. They will learn how to use our in-house Super Computer to process and analyze next generation sequencing data. Using state of the art tools, students will align and genotype a group of genes in order to identify disease-relevant variants. The course will be taught as a hands on computer approach (a computation background would be helpful, but not needed).
Instructor(s): E. Haddadian Terms Offered: Autumn. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence or BIOS 20172 or consent of Instructor.
No computation background required.
BIOS 26121. Introduction to Transcriptonomics. 100 Units.
The objective of this course is to educate our students about modern genomics technologies and their applications in biological and biomedical sciences, with emphasis on transcriptomics and how it connects to (epi)-genomics and proteomics. The course will be divided into three parts: 1) Introduction of technologies that generate transcriptomics data, 2) Statistical challenges emerging from transcriptomics studies, and 3) Case studies and applications. Topics will include introduction of microarray, sequencing technology, bulk and single cell RNA processing, data preprocessing, batch effect correction, differential expression analysis, false discovery rate control, clustering analysis, etc. Students will obtain hands-on experience in downloading public data and performing basic analysis using the Bioconductor and R packages. We expect students to develop basic computational skills that will allow them to process and analyze transcriptomic data. We will also organize visits to research laboratories and sequencing facility for the students to observe standard RNA-seq workflows.

Instructor(s): Anindita Basu, Mengjie Chen, Esmael Haddadian
Terms Offered: Winter
Prerequisite(s): BIOS 26120 or consent of instructor.

BIOS 26120. An Introduction to Bioinformatics and Proteomics. 100 Units.
Modern biology generates massive amounts of data; this course is devoted to biological information and the models and techniques used to make sense of it. Students learn about biological databases, algorithms for sequence alignment, phylogenetic tree building, and systems biology. They will also learn about the basics of large-scale study of proteins, particularly their structures and functions. Students will be introduced to basics of high performance computation (HPC) and its application to the field of bioinformatics. They will learn how to use our in-house Super Computer to process and analyze next generation sequencing data. Using state of the art tools, students will align and genotype a group of genes in order to identify disease-relevant variants. The course will be taught as a hands on computer approach (a computation background would be helpful, but not needed).

Instructor(s): E. Haddadian
Terms Offered: Autumn.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence or BIOS 20172 or consent of Instructor. No computation background required.

BIOS 26211. Mathematical Methods for Biological Sciences I-II.
The following two courses are intended to be taken as a sequence.

BIOS 26210. Mathematical Methods for Biological Sciences I. 100 Units.
This course builds on the introduction to modeling course biology students take in the first year (BIOS 20151 or 152). It begins with a review of one-variable ordinary differential equations as models for biological processes changing with time, and proceeds to develop basic dynamical systems theory. Analytic skills include stability analysis, phase portraits, limit cycles, and bifurcations. Linear algebra concepts are introduced and developed, and Fourier methods are applied to data analysis. The methods are applied to diverse areas of biology, such as ecology, neuroscience, regulatory networks, and molecular structure. The students learn computations methods to implement the models in MATLAB.

Instructor(s): D. Kondrashov
Terms Offered: Autumn.
Prerequisite(s): BIOS 20151 or BIOS 20152 or equivalent quantitative experience by consent of instructor, and three quarters of a Biological Sciences Fundamentals sequence or consent of the instructor.
Equivalent Course(s): PSYC 36210, CPNS 31000

BIOS 26211. Mathematical Methods for Biological Sciences II. 100 Units.
This course is a continuation of BIOS 26210. The topics start with optimization problems, such as nonlinear least squares fitting, principal component analysis and sequence alignment. Stochastic models are introduced, such as Markov chains, birth-death processes, and diffusion processes, with applications including hidden Markov models, tumor population modeling, and networks of chemical reactions. In computer labs, students learn optimization methods and stochastic algorithms, e.g., Markov Chain Monte Carlo, and Gillespie algorithm. Students complete an independent project on a topic of their interest.

Instructor(s): D. Kondrashov
Terms Offered: Winter.
Prerequisite(s): BIOS 26210 or equivalent.
Equivalent Course(s): CPNS 31100, PSYC 36211
BIOS 26211. Mathematical Methods for Biological Sciences II. 100 Units.
This course is a continuation of BIOS 26210. The topics start with optimization problems, such as nonlinear least squares fitting, principal component analysis and sequence alignment. Stochastic models are introduced, such as Markov chains, birth-death processes, and diffusion processes, with applications including hidden Markov models, tumor population modeling, and networks of chemical reactions. In computer labs, students learn optimization methods and stochastic algorithms, e.g., Markov Chain, Monte Carlo, and Gillespie algorithm. Students complete an independent project on a topic of their interest.
Instructor(s): D. Kondrashov Terms Offered: Winter. L.
Prerequisite(s): BIOS 26210 or equivalent.
Equivalent Course(s): CPNS 31100, PSYC 36211

BIOS 26318. Fundamentals of Biological Data Analysis. 100 Units.
This course is intended for students who have original data from a research project and are looking to produce a thesis or publication. Students will learn to organize, process, visualize, and make inferences from biological data sets using the data processing tools of R. We will review statistics concepts, such as probability distributions, linear and nonlinear fitting, estimation and hypothesis testing, and introduce new concepts relevant for the specific research questions identified by the students. The end result will be a written report that can function as a methods and results section of a research publication and contains high-quality graphics.
Instructor(s): D. Kondrashov, S. Allesina Terms Offered: Autumn. L.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals Sequence, STAT 22000 or higher, and fourth-year standing, or consent of Instructor. Primarily intended for students that have a data set from original research.

BIOS 26403. Quantitative Immunobiology. 100 Units.
The science of immunology was born at the end of the 19th century as a discipline focused on the body's defenses against infection. The following 120+ years has led to the discovery of a myriad of cellular and molecular players in immunity, placing the immune system alongside the most complex systems such as Earth's global climate and the human brain. The functions and malfunctions of the immune system have been implicated in virtually all human diseases. It is thought that cracking the complexity of the immune system will help manipulate and engineer it against some of the most vexing diseases of our times such as AIDS and cancer. To tackle this complexity, immunology in the 21st century - similar to much of the biological sciences - is growing closer to mathematics and data sciences, physics, chemistry and engineering. A central challenge is to use the wealth of large datasets generated by modern day measurement tools in biology to create knowledge, and ultimately predictive models of how the immune system works and can be manipulated. The goal of this course is to introduce motivated students to the quantitative approaches and reasoning applied to fundamental questions in immunology.
Instructor(s): Nicolas Chevrier Terms Offered: Winter
Prerequisite(s): Completion of the first two quarters of a Biological Sciences Fundamentals Sequence. Knowledge of R is recommended but not required. Courses in immunology and microbiology are an advantage but not required (e.g., BIOS 25256 Immunobiology; BIOS 25206 Fundamentals of Bacterial Physiology).
Equivalent Course(s): IMMU 34800, MENG 24800, MENG 34800

BIOS 27710-27711-27712-27713-27714-27715. Ecology – Marine Biological Laboratory; Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems – Marine Biological Laboratory.; Independent Undergraduate Research in Environmental Sciences – Marine Biological Laboratory; Quantitative Environmental Analyses – Marine Biological Laboratory; Methods in Microbial Ecology – Marine Biological Laboratory.; Roles of Animals in Ecosystems – Marine Biological Laboratory.
Marine Biological Laboratory Semester in Environmental Science Sequence (SES). Courses BIOS 27710-27715 are the College designations for the Semester in Environmental Science that is taught at the Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts. Registration in BIOS 27710, 27711, and 27712, plus one of BIOS 27713, 27714, or 27715 is required. Admission to the Semester in Environmental Science program is by application, which must be received by the MBL in March of the year preceding the start of the semester. Admissions decisions will be mailed in April. Note that these courses start at the beginning of September, typically four weeks prior to the start of the College’s Autumn Quarter and are completed by the end of Autumn Quarter. More information on the course content and the application process can be found at https://college.uchicago.edu/academics/semester-environmental-science.

BIOS 27710. Ecology - Marine Biological Laboratory. 100 Units.
This course examines the structure and functioning of terrestrial and aquatic ecosystems including the application of basic principles of community and ecosystem ecology. The course also examines contemporary environmental problems such as the impacts of global and local environmental change on community composition and food webs within forest, grassland, marsh and nearshore coastal ecosystems on Cape Cod. This course examines the structure and functioning of terrestrial and aquatic ecosystems including the application of basic principles of community and ecosystem ecology. The course also examines contemporary environmental problems such as the impacts of global and local environmental change on community composition and food webs within forest, grassland, marsh and nearshore coastal ecosystems on Cape Cod.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27711 and BIOS 27712 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Equivalent Course(s): ENSC 24100
BIOS 27711. Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems # Marine Biological Laboratory. 100 Units.
This course examines the interface of biological processes with chemical processes in ecological systems. Course content emphasizes aquatic chemistry and the role of microbes in the cycling of nitrogen, carbon, and other elements. Effects of global changes on chemical cycling are emphasized.
Instructor(s): Marine Biological Laboratory Staff. Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710 and BIOS 27712 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Equivalent Course(s): ENSC 23820

BIOS 27712. Independent Undergraduate Research in Environmental Sciences # Marine Biological Laboratory. 100 Units.
This course is the culmination of the Semester in Environmental Science at the Marine Biological Laboratory. An independent research project, on a topic in aquatic or terrestrial ecosystem ecology, is required. Students will participate in a seminar for scientific communication as well as submit a final paper on their project.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710 and BIOS 27711 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Equivalent Course(s): ENSC 29800

BIOS 27713. Quantitative Environmental Analyses # Marine Biological Laboratory. 100 Units.
This course emphasizes the application of quantitative methods to answering ecological questions. Students apply mathematical modeling approaches to simulating biological and chemical phenomena in terrestrial and marine ecosystems.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent Only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711 and BIOS 27712.
Equivalent Course(s): ENSC 28100

BIOS 27714. Methods in Microbial Ecology - Marine Biological Laboratory. 100 Units.
This course explores the biology of microbes found in the environment, including relationships with the physical, chemical, and biotic elements of their environment. Emphasis is placed on understanding the science underlying the various methodologies used in the study of these organisms and systems. In the laboratory, students will work with the latest techniques to measure microbial biomass, activity, extracellular enzymes, and biogeochemical processes. Students are also introduced to molecular methods for assessing microbial genomic diversity.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711 and BIOS 27712.
Equivalent Course(s): ENSC 24200

BIOS 27715. Roles of Animals in Ecosystems # Marine Biological Laboratory. 100 Units.
This course addresses the question, How do animals, including man, affect the structure and function of ecosystems. The course takes an interdisciplinary approach focused on the interactions of animal diversity, migration patterns, population dynamics, and behavior with biogeochemical cycles, productivity, and transport of materials across ecosystems. This course is an elective option within the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711, and BIOS 27712.
Equivalent Course(s): ENSC 24300

BIOS 27711. Biogeochemical Analysis in Terrestrial and Aquatic Ecosystems # Marine Biological Laboratory. 100 Units.
This course examines the interface of biological processes with chemical processes in ecological systems. Course content emphasizes aquatic chemistry and the role of microbes in the cycling of nitrogen, carbon, and other elements. Effects of global changes on chemical cycling are emphasized.
Instructor(s): Marine Biological Laboratory Staff. Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710 and BIOS 27712 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Equivalent Course(s): ENSC 23820
BIOS 27712. Independent Undergraduate Research in Environmental Sciences # Marine Biological Laboratory. 100 Units.
This course is the culmination of the Semester in Environmental Science at the Marine Biological Laboratory. An independent research project, on a topic in aquatic or terrestrial ecosystem ecology, is required. Students will participate in a seminar for scientific communication as well as submit a final paper on their project.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710 and BIOS 27711 along with one of BIOS 27713, BIOS 27714 or BIOS 27715.
Equivalent Course(s): ENSC 29800
BIOS 27713. Quantitative Environmental Analyses # Marine Biological Laboratory. 100 Units.
This course emphasizes the application of quantitative methods to answering ecological questions. Students apply mathematical modeling approaches to simulating biological and chemical phenomena in terrestrial and marine ecosystems.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711 and BIOS 27712.
Equivalent Course(s): ENSC 28100
BIOS 27714. Methods in Microbial Ecology - Marine Biological Laboratory. 100 Units.
This course explores the biology of microbes found in the environment, including relationships with the physical, chemical, and biotic elements of their environment. Emphasis is placed on understanding the science underlying the various methodologies used in the study of these organisms and systems. In the laboratory, students will work with the latest techniques to measure microbial biomass, activity, extracellular enzymes, and biogeochemical processes. Students are also introduced to molecular methods for assessing microbial genomic diversity.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn. L.
Prerequisite(s): Consent only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711 and BIOS 27712.
Equivalent Course(s): ENSC 24200
BIOS 27715. Roles of Animals in Ecosystems # Marine Biological Laboratory. 100 Units.
This course addresses the question, How do animals, including man, affect the structure and function of ecosystems. The course takes an interdisciplinary approach focused on the interactions of animal diversity, migration patterns, population dynamics, and behavior with biogeochemical cycles, productivity, and transport of materials across ecosystems. This course is an elective option within the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA.
Instructor(s): Marine Biological Laboratory Staff Terms Offered: Autumn
Prerequisite(s): Consent Only. Admission by application to the Semester in Environmental Science program at the Marine Biological Laboratory in Woods Hole, MA; concurrent registration in BIOS 27710, BIOS 27711, BIOS 27712, and BIOS 27713.
Equivalent Course(s): ENSC 24300
BIOS 27721-27723. SEPTEMBER COURSES AT MARINE BIOLOGICAL LABORATORY, WOODS HOLE.
The September courses are taken as part of the Autumn Quarter, but end before classes commence in Chicago. The September courses combine lecture with hands-on learning and development of independent research ideas and projects. All are taught by University of Chicago or MBL faculty, and take advantage of the unique research strengths and the natural environmental resources found at MBL. These are intensive, three-week-long courses that meet for up to eight hours per day for 5–6 days per week, combining morning lectures with afternoon labs and fieldwork. Each student can only enroll in one course at a time. The September courses at MBL have no prerequisites, and can count either to fulfill the general education requirement in Biology OR as an upper-level elective. Also offered in this program is HIPS 15100 - Visualization and the environment.
BIOS 27721. Observing Proteins in Action: How to Design and Build Your Own Instruments. 100 Units.
New insights into cell function are now possible using technologies that resolve single molecules. However, as devices become more complicated, we are often faced with three questions: What is it that our instruments actually measure; how can we change the instrument to see a new behavior; and, how do we analyze the data to get the greatest insight? We will learn how to answer these questions by designing, building, and using our own electrical and optical instruments, making measurements, and then analyzing the results. Membrane proteins play an essential role in the behavior of all cells. We will study membrane protein channels in synthetic membranes, host cells, and giant axons from squid collected in the waters surrounding the MBL. The movement of electrical charge produced by conformational changes will be correlated with both the current passing thru single channels and structural information obtained from light and electron microscopy. The course will proceed from simple measurements to student-designed projects.
Note(s): This course will be given at Marine Biological Laboratory, Woods Hole, Massachusetts
BIOS 27723. Biodiversity and Genomics: Exploring the Marine Animal Diversity of Woods Hole Using Molecular Tools. 100 Units.
In this course, student will have the opportunity to explore the large diversity of marine animal species in Woods Hole, Massachusetts and its surroundings. We will combine fieldwork with genomic and bioinformatic approaches to study different aspects of the evolution, ecology, taxonomy, physiology, and biogeography of marine animals in this unique location. Student will integrate knowledge and analytical tools from different biological disciplines to develop short research projects. During the three weeks of the course, student will have access to the Marine Biological Laboratory's collection of living marine animals, participate in ongoing research projects at MBL, and contribute data that will advance our understanding of marine biodiversity.
Instructor(s): O. Pineda-Catalan Terms Offered: Autumn. L. September 2018
Note(s): This course will be given at Marine Biological Laboratories, Woods Hole, Massachusetts.

BIOS 27723. Biodiversity and Genomics: Exploring the Marine Animal Diversity of Woods Hole Using Molecular Tools. 100 Units.
In this course, student will have the opportunity to explore the large diversity of marine animal species in Woods Hole, Massachusetts and its surroundings. We will combine fieldwork with genomic and bioinformatic approaches to study different aspects of the evolution, ecology, taxonomy, physiology, and biogeography of marine animals in this unique location. Student will integrate knowledge and analytical tools from different biological disciplines to develop short research projects. During the three weeks of the course, student will have access to the Marine Biological Laboratory's collection of living marine animals, participate in ongoing research projects at MBL, and contribute data that will advance our understanding of marine biodiversity.
Instructor(s): O. Pineda-Catalan Terms Offered: Autumn. L. September 2018
Note(s): This course will be given at Marine Biological Laboratories, Woods Hole, Massachusetts.

BIOS 27750. Stem Cells and Regeneration: from aquatic research organisms to mammals. 100 Units.

BIOS 27751. Biological Oceanography. 100 Units.
This intensive four-week course addresses fundamental oceanographic processes that maintain and structure marine biodiversity and productivity, including physical oceanographic processes of dispersal and upwelling, environmental selection, biogeography, nutrient dynamics, primary production, and food web dynamics. Students will design an original research project during an initial week-long shore component at Marine Biological Laboratory (MBL) in Woods Hole, MA, and then address their own questions by collecting samples and data aboard Sea Education Association (SEA)'s oceanographic research sailing vessel, the SSV Corwith Cramer, on a 10-day offshore voyage. At sea students will deploy oceanographic instruments, interpret various data streams, and work as research teams and watch members as they navigate and sail the vessel. During a final week-long shore component at MBL, students will analyze and interpret the data they collected and present their results in written and oral reports. For students unable to participate in the ocean-going component of the course, an alternative onshore research component will explore diverse local marine ecosystems including estuaries, salt marshes, and coastal embayments.
Instructor(s): Schell, J. Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals Sequence.

BIOS 27810. Epidemiology and Population Health: Global Health Sciences I. 100 Units.
Epidemiology is the basic science of public health. It is the study of how diseases are distributed across populations and how one designs population-based studies to learn about disease causes, with the object of identifying preventive strategies. Epidemiology is a quantitative field and draws on biostatistical methods. Historically, epidemiology's roots were in the investigation of infectious disease outbreaks and epidemics. Since the mid-twentieth century, the scope of epidemiologic investigations has expanded to a fuller range non-infectious diseases and health problems. This course will introduce classic studies, study designs and analytic methods, with a focus on global health problems. Prerequisite(s): Completion of the first three quarters of a Biological Sciences Fundamentals Sequence or consent of the Master of BSCD, Laurens Mets (mets@uchicago.edu). STAT 220 or other introductory statistics highly desirable.
Instructor(s): D. Lauderdale. Terms Offered: Autumn
Prerequisite(s): Completion of the three quarters of a Biological Sciences Fundamentals Sequence and completion of the quantitative requirements for the biological sciences major. STAT 22000 or other introductory statistics highly desirable.

BIOS 27811. Global Health Sciences II: Microbiology. 100 Units.
This course will examine infectious diseases with global health impact, analyzing their historic and projected impact, their biological foundations, treatment, and preventative control. Course topics include gastrointestinal infections (e.g., cholera, bacillary dysentery, typhoid fever, rotavirus infections), sexually transmitted diseases (HIV), infections transmitted via aerosol droplets (tuberculosis, meningitis), and vector borne diseases (e.g., malaria, typhus, dengue fever, plague). Special emphasis will be placed on emerging infectious diseases (Ebola, Lassa, Rift Valley fever) and either completed or ongoing studies for infectious disease elimination (smallpox, polio, diphtheria, river blindness). The course encompasses lectures, student presentations, and the preparation of a capstone essay.
Instructor(s): D. Missiakas, O. Schneewind Terms Offered: Winter. This course is offered on campus in alternate years beginning Winter Quarter 2017 and in Paris in alternate years beginning Winter Quarter 2018
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, or consent of Instructor.
BIOS 27813. Global Health Sciences I: Cancer Concepts: Causes and Consequences. 100 Units.
The goal of this course is to build concepts and develop understanding of how cancers arise by addressing the genetic basis of cancer, in addition to the role of environmental stresses in tumorigenesis. Specifically, we will examine how genetic changes, infection, diet and stress all affect tumor stemness, tumor evolution & heterogeneity, tumor metabolism and drug resistance. We will focus in on the role of the human papillomavirus (HPV) in humans cancers as a means to dissect basic molecular mechanisms of cancer but also to explore how our understanding of HPV as an etiological factor in cancer has changed in recent years, how efforts to vaccinate against HPV serves as a paradigm (or not) for other cancers and the controversies surrounding all of the above. Finally, we will examine in more detail how obesity, altered metabolism and stress affect tumor metabolism, co-evolution of the tumor with its microenvironment, the gut microbiome and anti-tumor immunity, and how diet may be exploited to prevent cancers (or not). We will conclude with a discussion of possible future directions to better prevent and treat human cancers.
Instructor(s): K. Macleod Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235, or consent of Instructor.
Note(s): This course is offered in Paris.

BIOS 28407. Genomics and Systems Biology. 100 Units.
This lecture course explores technologies for high-throughput collection of genomic-scale data, including sequencing, genotyping, gene expression profiling, and assays of copy number variation, protein expression and protein-protein interaction. In addition, the course will cover study design and statistic 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 that will be 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 will be drawn from the primary literature. Evaluation will be based primarily on problem sets.
Instructor(s): Y. Gilad Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235 and STAT 23400 or BIOS 26210 and BIOS 26211
Equivalent Course(s): BPHS 47300, CABI 47300, IMMU 47300, HGEN 47300

BIOS 28900. Undergraduate Bachelor of Science Research. 100 Units.
This course is required in the autumn of the fourth year for students who are completing the Biological Sciences major with a BS degree (see guidelines at link to page with guidelines) but are not enrolled in the research course for the BSCD Honors program (BIOS 00296. Undergraduate Honors Research.) BIOS 00296 can be counted toward the Biological Sciences major and may be counted among the three upper-level courses required for the BS. Participants will give short presentations on their thesis research during mandatory evening sessions. Students will receive a quality grade in this course based on their thesis proposal, their research presentation, and a progress report from their thesis advisers.
Instructor(s): C. Andrews Terms Offered: Autumn
Prerequisite(s): Students must be Biological Sciences majors pursuing the BS degree. This course is not open to students in the BSCD Honors program who are enrolled in BIOS 00296. (Undergraduate Honors Research).

Big Problems Courses

The following two courses are part of the Big Problems Curriculum franke.uchicago.edu/bigproblems/bp-index.html.

BIOS 02280. Drinking Alcohol: Social Problem or Normal Cultural Practice? 100 Units.
Alcohol is the most widely used psychoactive agent in the world, and, as archaeologists have recently demonstrated, it has a very long history dating back at least 9,000 years. This course will explore the issue of alcohol and drinking from a trans-disciplinary perspective. It will be co-taught by an anthropologist/archaeologist with experience in alcohol research and a neurobiologist who has experience with addiction research. Students will be confronted with literature on alcohol research from anthropology, sociology, history, biology, medicine, psychology, and public health and asked to think through the conflicts and contradictions. Selected case studies will be used to focus the discussion of broader theoretical concepts and competing perspectives introduced in the first part of the course. Topics for lectures and discussion include: What is alcohol? The early history of alcohol; Histories of drinking in ancient, medieval, and modern times; Alcohol and the political economy; Alcohol as a cultural artifact; Styles of drinking and intoxication; Alcohol, addiction, and social problems; Alcohol and religion; Alcohol and health benefits; Comparative case studies of drinking.
Instructor(s): M. Dietler, W. Green Terms Offered: Spring
Prerequisite(s): Third or fourth-year standing.
Note(s): This course does not meet requirements for the biological sciences major.
Equivalent Course(s): ANTH 25310, BPRO 22800

BIOS 02490. Biology and Sociology of AIDS. 100 Units.
This interdisciplinary course deals with current issues of the AIDS epidemic.
Instructor(s): H. Pollack, J. Schneider Terms Offered: Not offered in 2019-2020
Prerequisite(s): Third- or fourth-year standing
Note(s): This course does not meet requirements for the biological sciences major.
Equivalent Course(s): BPRO 24900, SSAD 65100

Specialized Courses

These courses include biological sciences content and may be of particular interest to student of biology. They may not be used as an upper-level elective in the major, nor can they be used to satisfy the general education requirement in
the biological sciences unless otherwise noted in the course description or approved through petition to the BSCD Senior Advisers.

**BIOS 29100. Biology of Toxoplasma. 100 Units.**

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.

Instructor(s): R. McLeod
Terms Offered: Autumn, Spring
Prerequisite(s): Consent of instructor. This course does not meet the requirements for the Biological Sciences Major.

**BIOS 29142. From Fossils to Fermi's Paradox: Origin and Evolution of Intelligent Life. 100 Units.**

The course approaches Fermi's question, "Are we alone in the universe?", in the light of recent evidence primarily from three fields: the history and evolution of life on Earth (paleontology), the meaning and evolution of complex signaling and intelligence (cognitive science), and the distribution, composition and conditions on planets and exoplanets (astronomy). We also review the history and parameters governing extraterrestrial detection and signaling. The aim of the course is to assess the interplay between convergence and contingency in evolution, the selective advantage of intelligence, and the existence and nature of life elsewhere in the universe - in order to better understand the meaning of human existence.

Instructor(s): P. Sereno; L. Rogers; S. London
Terms Offered: May be offered in Winter 2021
Prerequisite(s): Third or fourth-year standing
Equivalent Course(s): ASTR 18700, PSYC 28810, BPRO 28800

**BIOS 29209. XCAP: The Experimental Capstone - The Art of Healing: Medical Aesthetics in Russia and the U.S. 100 Units.**

What makes a medical treatment look like it will work? What makes us feel that we are receiving good care, or that we can be cured? Why does the color of a pill influence its effectiveness, and how do placebos sometimes achieve what less inert medication cannot? In this course we will consider these problems from the vantage points of a physician and a cultural historian. Our methodology will combine techniques of aesthetic analysis with those of medical anthropology, history and practice. We will consider the narratology of medicine as we examine the way that patients tell their stories and the way that doctors, nurses, buildings, wards, and machines enter those narratives. The latter agents derive their meaning from medical outcomes, but are also embedded in a field of aesthetic values that shape their apprehension. We will look closely at a realm of medical experience that continues to evade the grasp of instruments: how the aesthetic experience shapes the phenomenon of medical treatment.

Instructor(s): William Nickell; Brian Callender; Elizabeth Murphy
Terms Offered: Autumn
Prerequisite(s): for BIOS 29209: This course does not meet the requirements for the Biological Sciences major.
Note(s): This course is one of three offered in The Experimental Capstone (XCAP) in the 2019-20 academic year.
Equivalent Course(s): KNOW 29901, HIPS 28350, ARTV 20014, ANTH 24360, HLTH 29901

**BIOS 29271. The Psychology and Neurobiology of Stress. 100 Units.**

This course explores the topic of stress and its influence on behavior and neurobiology. Specifically, the course will discuss how factors such as age, gender, and social context interact to influence how we respond to stressors both physiologically and behaviorally. The course will also explore how stress influences mental and physical health.

Instructor(s): G. Norman
Terms Offered: Autumn
Note(s): This course does not meet the requirements for the Biological Sciences Major.
Equivalent Course(s): PSYC 25750

**BIOS 29294. Introduction to Global Health. 100 Units.**

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.

Instructor(s): C. Babcock, N. Fenny
Terms Offered: Winter
Prerequisite(s): This course does not meet requirements for the Biological Sciences major
Equivalent Course(s): PBPL 29294, CCTS 43000
BIOS 29300. Biological Psychology. 100 Units.
What are the relations between mind and brain? How do brains regulate mental, behavioral, and hormonal processes; and how do these influence brain organization and activity? This course introduces the anatomy, physiology, and chemistry of the brain; their changes in response to the experiential and sociocultural environment; and their relation to perception, attention, behavioral action, motivation, and emotion.
Instructor(s): S. London, G. Norman Terms Offered: Winter
Prerequisite(s): Some background in biology and psychology.
Note(s): This course does not meet requirements for the Biological Sciences Major.
Equivalent Course(s): PSYC 20300, CHDV 20300

BIOS 29314. Medical Ethics: Central Topics. 100 Units.
Decisions about medical treatment, medical research, and medical policy often have profound moral implications. Taught by a philosopher, two physicians, and a medical lawyer, this course will examine such issues as paternalism, autonomy, assisted suicide, kidney markets, abortion, and research ethics. (A)
Instructor(s): D. Brudney; Staff Terms Offered: Winter
Prerequisite(s): Third or fourth year standing. This course does not meet requirements for the Biological Sciences major.
Note(s): Philosophy majors: this course fulfills the practical philosophy (A) requirement.
Equivalent Course(s): PHIL 31609, HIPS 21609, HLTH 21609, BPRO 22612, PHIL 21609

BIOS 29323. Health Care and the Limits of State Action. 100 Units.
In a time of great human mobility and weakening state frontiers, epidemic disease is able to travel fast and far, mutate in response to treatment, and defy the institutions invented to keep it under control: quarantine, the cordon sanitaire, immunization, and the management of populations. Public health services in many countries find themselves at a loss in dealing with these outbreaks of disease, a deficiency to which NGOs emerge as a response (an imperfect one to be sure). Through a series of readings in anthropology, sociology, ethics, medicine, and political science, we will attempt to reach an understanding of this crisis of both epidemiological technique and state legitimacy, and to sketch out options.
Instructor(s): H. Saussy, M. Schwartz Terms Offered: Not offered in 2019-2020
Prerequisite(s): Third- or fourth-year standing. This course does not meet requirements for the biological sciences major.
Equivalent Course(s): HMRT 28602, CMLT 28900, BPRO 28600

BIOS 29326. Introduction to Medical Physics and Medical Imaging. 100 Units.
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.
Instructor(s): S. Armato, P. La Riviere Terms Offered: Spring
Prerequisite(s): 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.
Equivalent Course(s): MPHY 29326

BIOS 29327. Topics in Clinical Research. 100 Units.
This course provides an overview of clinical research subject matter from the history and ethics of clinical research to the types and practice of contemporary clinical research. How does clinical research differ from other research traditions? What is special about clinical research? What types of questions can be answered by clinical research (what questions not)? What types of ethical oversight over the responsible conduct of research have arisen over the years? We will learn how to read and critique clinical research, survey the major types of clinical research designs, and the differences between hypothesis generation and hypothesis testing. Finally, we provide an overview of the mechanics of developing and implementing clinical research, including grant writing, regulatory issues, and quality assurance. Along the way, we will be teaching core statistical concepts including prevalence, risk ratios, and sensitivity and validation techniques. The objectives are for students to obtain an understanding of how and why to perform clinical research and to do so in an ethical and responsible manner.
Instructor(s): Valerie Press Terms Offered: Spring. Offered 2020
Prerequisite(s): Completed general education requirement in the social sciences. This course does not meet requirements for the Biological Sciences major.
Equivalent Course(s): CCTS 21003
BIOS 29329. Clinical and Health Services Research: Methods and Applications. 100 Units.
This course will introduce the interdisciplinary field of clinically-oriented health services research with a focus on policy-related implications. Through exposure to theoretical foundations, methodologies, and applications, students without significant investigative experience will learn about the design and conduct of research studies. We will cover the integration of research within the stages of translational medicine, and how science conducted across the translational medicine spectrum informs policy through purveyors of clinical services (e.g. physicians, hospitals), government, insurers, and professional societies. We will use the examples of postmenopausal hormone replacement therapy and autologous bone marrow transplantation to illustrate pitfalls in the progression from basic science research to clinical trials leading to diffusion in clinical medicine that can complicate the creation of logical, evidence-based practice guidelines, reimbursement, and clinical practice.
Instructor(s): Greg Ruhnke Terms Offered: Spring
Equivalent Course(s): CCTS 43007, CCTS 21007, HLTH 21007, PBPL 23007

BIOS 29814. Global Health Sciences III: Biological and Social Determinants of Health. 100 Units.
Global health is an interdisciplinary and empirically-driven field, requiring holistic and innovative approaches to navigate an ever-changing environment in the pursuit of health equity. This course will emphasize specific health challenges facing vulnerable populations in low resource settings including in the United States and the large scale social, political, and economic forces that contribute to them through topical events and case studies. Students will study the importance of science and technology, key institutions and stakeholders; environmental impacts on health; ethical considerations in research and interventions; maternal and child health; health and human rights; international legal frameworks and global health diplomacy. Students will gain skills in technical writing as they construct position statements and policy briefs on global health issues of interest. Career opportunities in global health will be explored throughout the course.
Instructor(s): C. Olopade, O. Olopade Terms Offered: Spring Winter
This course is offered every Spring quarter on campus and every Winter quarter in Paris.
Prerequisite(s): This course does not meet the requirements for the Biological Sciences major.
Equivalent Course(s): CCTS 22003, CCTS 42003

Independent Study and Research Courses
BIOS 00199-00299
Students pursuing independent research in the lab of a BSD faculty member may obtain credit by enrolling in the following courses. These courses cannot be counted towards the major in Biological Sciences.

BIOS 00199. Undergraduate Research. 100 Units.
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 two to three page summary on the completed work must be submitted to the research sponsor and the Master of BSCD before Friday of examination week.
Instructor(s): BSCD Master Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): Consent of research sponsor and the Master of BSCD.
Note(s): 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.

BIOS 00206. Readings: Biology. 100 Units.
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.
Terms Offered: Summer, Autumn, Winter, Spring
Prerequisite(s): Consent of faculty sponsor
Note(s): 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.

BIOS 00296. Undergraduate Honors Research. 100 Units.
This course is required for students accepted into the BSCD Research Honors program. Students must register for this course both Autumn and Winter Quarters of their fourth year. This course can be counted toward the Biological Sciences major and may be counted among the three upper-level courses required for the BS. See also bscd.uchicago.edu/page/honors-biology. Quality grade. Prerequisite(s): Consent Only. Acceptance in BSCD Honors Research Program.
Instructor(s): S. Kron Terms Offered: Autumn, Winter
Prerequisite(s): Consent Only. Acceptance in BSCD Honors Research Program.

BIOS 00299. Advanced Research: Biological Sciences. 100 Units.
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 two to three page summary on the completed work must be submitted to the research sponsor and the Master of BSCD before Friday of examination week. This course does may be counted as a general elective but does not meet requirements for the Biological Sciences major. In the first quarter of registration, students must submit College Reading and Research form to their research sponsor and the director of undergraduate research and honors.
Instructor(s): BSCD Master Terms Offered: Autumn, Spring, Summer, Winter
Prerequisite(s): Fourth-year standing and consent of research sponsor and Master of BSCD.
Note(s): Students are required to submit the College Reading and Research Course Form. This course is graded P/F.
### 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.

### Biological Sciences Courses: Organized by Quarter Offered

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; (MIV) Microbiology, Immunology, or Virology; (MBL) course given at Marine Biological Laboratory, Woods Hole, MA; (N) Neuroscience; (O) Organismal; (SB) Systems Biology; and (S) Specialized. L indicates courses with laboratory.

#### Autumn Quarter

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>20173</td>
<td>Human Physiology. L. (F)</td>
</tr>
<tr>
<td>20187</td>
<td>Fundamentals of Genetics. L. (F)</td>
</tr>
<tr>
<td>20196</td>
<td>Ecology and Conservation. L. (F)</td>
</tr>
<tr>
<td>20200</td>
<td>Introduction to Biochemistry. L. (F)</td>
</tr>
<tr>
<td>20234</td>
<td>Molecular Biology of the Cell. L. (F)</td>
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<tr>
<td>20242</td>
<td>Principles of Physiology. L. (F)</td>
</tr>
<tr>
<td>21236</td>
<td>Genetics of Model Organisms. (C)</td>
</tr>
<tr>
<td>21306</td>
<td>Human Genetics and Evolution. (C)</td>
</tr>
<tr>
<td>21416</td>
<td>Stem Cells and Regeneration. (C)</td>
</tr>
<tr>
<td>22249</td>
<td>Principles of Toxicology. (O)</td>
</tr>
<tr>
<td>22265</td>
<td>Human Origins: Milestones in Human Evolution and the Fossil Record. (E&amp;E)</td>
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<tr>
<td>22306</td>
<td>Evolution and Development. (O)</td>
</tr>
<tr>
<td>23261</td>
<td>Invertebrate Paleobiology and Evolution. (E&amp;E)</td>
</tr>
<tr>
<td>23262</td>
<td>Mammalian Evolutionary Biology. L. (E&amp;E)</td>
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<tr>
<td>23266</td>
<td>Evolutionary Adaptation. (E&amp;E)</td>
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<tr>
<td>23404</td>
<td>Reconstructing the Tree of Life: An Introduction to Phylogenetics. (E&amp;E)</td>
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<tr>
<td>24208</td>
<td>Survey of Systems Neuroscience. (N)</td>
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<tr>
<td>24248</td>
<td>Biological Clocks and Behavior. (N)</td>
</tr>
<tr>
<td>25206</td>
<td>Fundamentals of Bacterial Physiology. (MIV)</td>
</tr>
<tr>
<td>25226</td>
<td>Endocrinology I: Cell Signaling. (MIV)</td>
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<tr>
<td>25256</td>
<td>Immunobiology. (MIV)</td>
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<tr>
<td>25260</td>
<td>Host Pathogen Interactions. (MIV)</td>
</tr>
<tr>
<td>25308</td>
<td>Heterogeneity in Human Cancer: Etiology and Treatment. (MIV)</td>
</tr>
<tr>
<td>26120</td>
<td>An Introduction to Bioinformatics and Proteomics. L. (CI)</td>
</tr>
<tr>
<td>26210</td>
<td>Mathematical Models for Biological Sciences I. (CI)</td>
</tr>
<tr>
<td>26318</td>
<td>Fundamentals of Biological Data Analysis. (CI)</td>
</tr>
<tr>
<td>27721</td>
<td>Observing Proteins in Action: How to Design and Build Your Own Instruments. (MBL)</td>
</tr>
<tr>
<td>27723</td>
<td>Biodiversity and Genomics: Exploring the Marine Animal Diversity of Woods Hole Using Molecular Tools. (MBL)</td>
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</tbody>
</table>

#### Winter Quarter

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>27810</td>
<td>Epidemiology and Population Health: Global Health Sciences I</td>
</tr>
<tr>
<td>29271</td>
<td>The Psychology and Neurobiology of Stress. (S)</td>
</tr>
<tr>
<td>29313</td>
<td>Medical Ethics: Central Topics. (S)</td>
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<tr>
<td>Course Code</td>
<td>Course Title</td>
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<tr>
<td>20152</td>
<td>Introduction to Quantitative Modeling in Biology</td>
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<tr>
<td>20153</td>
<td>Fundamentals of Ecology and Evolution</td>
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<tr>
<td>20170</td>
<td>Microbial and Human Cell Biology</td>
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<tr>
<td>20175</td>
<td>Biochemistry and Nutrition</td>
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<tr>
<td>20188</td>
<td>Fundamentals of Physiology</td>
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<td>20189</td>
<td>Fundamentals of Development Biology</td>
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<tr>
<td>20235</td>
<td>Biological Systems</td>
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<tr>
<td>21216</td>
<td>Introductory Statistical Genetics</td>
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<tr>
<td>21229</td>
<td>Genome Informatics: How Cells Reorganize Genomes</td>
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<tr>
<td>21237</td>
<td>Developmental Mechanisms</td>
</tr>
<tr>
<td>21238</td>
<td>Cell Biology</td>
</tr>
<tr>
<td>21358</td>
<td>Simulation, Modeling, and Computation in Biophysics</td>
</tr>
<tr>
<td>21360</td>
<td>Advanced Molecular Biology</td>
</tr>
<tr>
<td>21415</td>
<td>Stem Cells in Development and Diseases</td>
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<tr>
<td>21418</td>
<td>Historical and Conceptual Foundations of Evolutionary Development</td>
</tr>
<tr>
<td>21508</td>
<td>Cellular Engineering</td>
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<tr>
<td>22233</td>
<td>Comparative Vertebrate Anatomy</td>
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<tr>
<td>22250</td>
<td>Chordates: Evolution and Comparative Anatomy</td>
</tr>
<tr>
<td>23247</td>
<td>Bioarchaeology and the Human Skeleton</td>
</tr>
<tr>
<td>23249</td>
<td>Animal Behavior</td>
</tr>
<tr>
<td>23258</td>
<td>Molecular Evolution I: Fundamentals and Principles</td>
</tr>
<tr>
<td>23365</td>
<td>Evolutionary and Genomic Medicine I</td>
</tr>
<tr>
<td>23406</td>
<td>Biogeography</td>
</tr>
<tr>
<td>24217</td>
<td>Conquest of Pain</td>
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<tr>
<td>24231</td>
<td>Methods in Computational Neuroscience</td>
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<tr>
<td>24232</td>
<td>Computational Approaches to Cognitive Neuroscience</td>
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<tr>
<td>24249</td>
<td>Neurobiology of Seeing</td>
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<tr>
<td>25108</td>
<td>Cancer Biology</td>
</tr>
<tr>
<td>25216</td>
<td>Molecular Basis of Bacterial Disease</td>
</tr>
<tr>
<td>25227</td>
<td>Endocrinology II: Systems and Physiology</td>
</tr>
<tr>
<td>25258</td>
<td>Immunopathology</td>
</tr>
<tr>
<td>25327</td>
<td>Health Disparities in Breast Cancer</td>
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<tr>
<td>25407</td>
<td>Organ Transplantation</td>
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<tr>
<td>26121</td>
<td>Introduction to Transcriptonomics</td>
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<tr>
<td>26211</td>
<td>Mathematical Models for Biological Sciences II</td>
</tr>
<tr>
<td>26403</td>
<td>Quantitative Immunobiology</td>
</tr>
<tr>
<td>27811</td>
<td>Microbiology: Global Health Sciences II</td>
</tr>
<tr>
<td>29142</td>
<td>From Fossils to Fermi's Paradox: Origin and Evolution of Intelligent Life</td>
</tr>
<tr>
<td>29294</td>
<td>Introduction to Global Health</td>
</tr>
<tr>
<td>29300</td>
<td>Biological Psychology</td>
</tr>
</tbody>
</table>
29314. Medical Ethics: Central Topics. (S)
29323. Health Care and the Limits of State Action. (S)

**Spring Quarter**

20151. Introduction to Quantitative Modeling in Biology. L. (Basic) (F)
20171. Human Genetics and Developmental Biology. L. (F)
20172. Mathematical Modeling for Pre-Med Students I. L. (F)
20186. Fundamentals of Cell and Molecular Biology. L. (F)
20188. Fundamentals of Physiology. L. (F)
20189. Fundamentals of Developmental Biology. L. (F)
20198. Biodiversity. L. (F)
20200. Introduction to Biochemistry. L. (F)
20236. Biological Dynamics. L. (F)
21249. Organization, Expression, and Transmission of Genome Information. (C)
21317. Topics in Biological Chemistry. (C)
21328. Biophysics of Biomolecules. (C)
21349. Protein Structure and Functions in Medicine. (C)
21356. Vertebrate Development. (O)
21407. Image Processing in Biology. (O)
21417. Systems Biology: Molecular Regulatory Logic of Networks. (C)
21506. Biological Physics. (C)
21507. Selected Topics in Molecular Engineering. (C)
22236. Reproductive Biology of Primates. (O)
22245. Biomechanics: How Life Works. (O)
22260. Vertebrate Structure and Function. (O)
23100. Dinosaur Science. (O)
23232. Ecology and Evolution in the Southwest. (E&E)
23233. Ecology and Evolution in the Southwest: Field School. (E&E)
23242. Primate Evolution and the Roots of Human Biology. (E&E)
23252. Field Ecology. L. (E&E)
23254. Mammalian Ecology. L. (E&E)
23299. Plant Development and Molecular Genetics. (E&E)
23409. The Ecology and Evolution of Infectious Diseases. (E&E)
23410. Complex Interactions: Coevolution, Parasites, Mutualists, and Cheaters. (E&E)
24408. Signal Analysis and Modeling for Neuroscientists. L. (N)
25109. Topics in Reproductive Biology and Cancer. (MIV)
25126. Animal Models of Human Disease. (MIV)
25228. Endocrinology III: Human Disease. (MIV)
25266. Molecular Immunology. (MIV)
25287. Introduction to Virology. (MIV)
25326. Tumor Microenvironment and Metastasis. (MIV)
25420. Microbial Omics. (MIV)
28407. Genomics and Systems Biology. (SB)
29326. Introduction to Medical Physics and Medical Imaging. (S)
29327. Topics in Clinical Research. (S)
29814. Biological and Social Determinants of Health: Global Health Sciences III. (S)
Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

- Times was used instead of Trajan.
- Times was used instead of Palatino.

The editor may contact Leepfrog for a draft with the correct fonts in place.