Biology

Biology is an exciting, diverse field ranging from the molecular biology of individual cells to interactions among entire populations of organisms. Members of the biology faculty are recognized internationally for their research and bring a variety of strengths and teaching styles into the classroom. The major program in biology provides a thorough education in the history of scientific discovery in biology, the logical and statistical procedures used to formulate and to test biological hypotheses, and technical skills needed for conducting contemporary biological research.

The biology major program emphasizes the hierarchical nature of biological complexity and the major structures and functions that emerge at the molecular, cellular, organismal, populational and ecosystem levels. Each student masters at least one dimension of contemporary research in sufficient detail to describe the major hypotheses currently being tested and to demonstrate techniques used to test those hypotheses. Mastery of this material is evident in a student's ability to critique published data, identifying ambiguities and uncertainties in conclusions drawn from those data, and to evaluate the societal importance of the research. Biology majors are prepared to make creative contributions to biology.

The biology major program provides a wide range of research opportunities. Because more than 400 faculty members conduct research in biology and biomedical sciences at Washington University, it is easy to find a project that suits a student's main interests. Many students complete their research projects at the Washington University School of Medicine, one of the top-ranked medical schools in the country. Summer research fellowship programs are available, funded by sources including the Howard Hughes Medical Institute, Children's Discovery Institute, National Science Foundation, and the Washington University Office of Undergraduate Research. Detailed information on finding a research mentor is available online (http://www.nslc.wustl.edu/courses/Bio500/bio500.html).

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Email: webmaster@biology.wustl.edu
Website: http://wubio.wustl.edu

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PhD, University of California, Berkeley

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Viktor Hamburger Professor in Arts & Sciences
PhD, California Institute of Technology

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Hani Zaher (http://wubio.wustl.edu/zaher)
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(Chemistry)

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Nobuo Suga (http://wubio.wustl.edu/suga)
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Alan R. Templeton (http://wubio.wustl.edu/templeton)
PhD, University of Michigan

Robert E. Thach (http://wubio.wustl.edu/thach)
PhD, Harvard University

**Majors**

Please refer to the following sections for more information about:

- The Major in Biology (p. 2)
  - Ecology and Evolution Track (p. 4)
  - Genomics and Computational Biology Track (p. 4)
  - Microbiology Track (p. 4)
  - Molecular Biology and Biochemistry Track (p. 4)
  - Neuroscience Track (p. 4)
- The Major in Environmental Biology (p. 4)

**The Major in Biology**

Total units required: 58-67

Required courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 2960</td>
<td>Principles of Biology I</td>
<td>4</td>
</tr>
<tr>
<td>Biol 2970</td>
<td>Principles of Biology II</td>
<td>4</td>
</tr>
<tr>
<td>Chem 111A</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>Chem 112A</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>Chem 151</td>
<td>General Chemistry Laboratory I</td>
<td>3</td>
</tr>
<tr>
<td>Chem 152</td>
<td>General Chemistry Laboratory II</td>
<td>2</td>
</tr>
<tr>
<td>Chem 261</td>
<td>Organic Chemistry I with Lab</td>
<td>4</td>
</tr>
<tr>
<td>Chem 262</td>
<td>Organic Chemistry II with Lab</td>
<td>4</td>
</tr>
</tbody>
</table>
Math 132 Calculus II 3
Math 2200 Elementary Probability and Statistics 3
  or Math 233 Calculus III
  or Math 3200 Elementary to Intermediate Statistics and Data Analysis
Physics 117A General Physics I 4
  or Physics 197 Physics I
Physics 118A General Physics II 4
  or Physics 198 Physics II

Total Units 40

Students may substitute Chem 401 Physical Chemistry I for Chem 262 Organic Chemistry II with Lab. Students who plan to take physical chemistry must take Math 233 Calculus III. Math 2200 Elementary Probability and Statistics, required for tracks in ecology and evolution and in genomics and computational biology, and Math 322 Biostatistics are valuable, particularly for students interested in research. Students who have taken Math 233 may take Math 3200 Elementary to Intermediate Statistics and Data Analysis rather than Math 2200 Elementary Probability and Statistics for a more advanced treatment of statistics.

At least 18 units in advanced biology courses (numbered 300 or above) are required. These 18 units may not include Biol 303A, Biol 307A, Biol 349, Biol 393, Biol 429, Biol 487, Biol 488; cross-listed courses originating in other departments (except Biol 360, Biol 4580, Biol 4810 and Biol 4820, which count as biology major credit despite external origins); courses in University College; or more than 3 units of history-of-science courses. Majors are required to take at least one course from each of these three areas:

**Area A: Cellular and Molecular Biology**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3041</td>
<td>Plant Biology and Genetic Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Biol 334</td>
<td>Cell Biology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 3371</td>
<td>Eukaryotic Genomes</td>
<td>4</td>
</tr>
<tr>
<td>Biol 349</td>
<td>Microbiology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 424</td>
<td>Immunology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4492</td>
<td>Infectious Diseases: History, Pathology, and Prevention</td>
<td>3</td>
</tr>
<tr>
<td>Biol 451</td>
<td>General Biochemistry</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4810</td>
<td>General Biochemistry I</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4820</td>
<td>General Biochemistry II</td>
<td>3</td>
</tr>
</tbody>
</table>

**Area B: Organismal Biology**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3151</td>
<td>Endocrinology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 328</td>
<td>Principles in Human Physiology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 3411</td>
<td>Principles of the Nervous System</td>
<td>3</td>
</tr>
<tr>
<td>Biol 3421</td>
<td>Introduction to Neuroethology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 3422</td>
<td>Genes, Brains and Behavior</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4023</td>
<td>How Plants Work: Physiology, Growth and Metabolism</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4030</td>
<td>Biological Clocks</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4071</td>
<td>Developmental Biology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4580</td>
<td>Principles of Human Anatomy and Development</td>
<td>3</td>
</tr>
</tbody>
</table>

**Area C: Evolution, Ecology and Population Biology**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3501</td>
<td>Evolution</td>
<td>4</td>
</tr>
<tr>
<td>Biol 381</td>
<td>Introduction to Ecology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4181</td>
<td>Population Genetics (and Microevolution)</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4182</td>
<td>Macroevolution</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4183</td>
<td>Molecular Evolution</td>
<td>3</td>
</tr>
<tr>
<td>Biol 419</td>
<td>Community Ecology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4202</td>
<td>Evolutionary Genetics</td>
<td>3</td>
</tr>
<tr>
<td>Biol 472</td>
<td>Behavioral Ecology</td>
<td>4</td>
</tr>
</tbody>
</table>

Majors also must take an advanced laboratory course from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3110</td>
<td>Vertebrate Structure Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>Biol 3491</td>
<td>Microbiology Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Biol 3492</td>
<td>Laboratory Experiments with Eukaryotic Microbes</td>
<td>3</td>
</tr>
<tr>
<td>Biol 3493</td>
<td>Bacterial Bioprospecting and Biotechnology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 360</td>
<td>Biophysics Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Biol 373</td>
<td>Laboratory on the Evolution of Animal Behavior</td>
<td>3</td>
</tr>
<tr>
<td>Biol 404</td>
<td>Laboratory of Neurophysiology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4193</td>
<td>Experimental Ecology Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4241</td>
<td>Immunology Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4342</td>
<td>Research Explorations in Genomics</td>
<td>4</td>
</tr>
<tr>
<td>Biol 434W</td>
<td>Research Explorations in Genomics (Writing-Intensive)</td>
<td>4</td>
</tr>
<tr>
<td>Biol 437</td>
<td>Laboratory on DNA Manipulation</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4520</td>
<td>Protein Function in Model Cellular Systems</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4522</td>
<td>Laboratory in Protein Analysis, Proteomics and Protein Structure</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4523</td>
<td>Mutagenesis and Enzyme Analysis</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4524</td>
<td>Structural Bioinformatics of Proteins</td>
<td>4</td>
</tr>
</tbody>
</table>
All courses to be counted toward a major in biology must be taken for a letter grade if a letter grade is offered. A grade of C- or better must be earned in all of these courses.

In special cases, students may earn credit for graduate courses offered by the Division of Biology and Biomedical Sciences.

**Optional Biology Major Tracks**

A student majoring in biology may choose one of four optional tracks within the major if the student's interests lie primarily within one of these subfields of biology. A track provides strong training for graduate study in its subfield. All tracks require completion of the biology major requirements as stated above but provide concentrated study in one of the four subfields.

**The Major in Biology: Ecology and Evolution Track**

Additional requirements include Math 2200 or Math 3200. Students whose main interest is ecology must take at least two ecology electives and one evolution elective; students whose main interest is evolution must take at least two evolution electives and one ecology elective (evolution electives: Biol 3501, Biol 4181, Biol 4182, Biol 4183, Biol 4202; ecology electives: Biol 381, Biol 419, Biol 472). Also required are one elective in analytical methodology (CSE 131, CSE 424 or Math 322) and one elective in earth and planetary sciences (EPSc 201, EPSc 323 or EPSc 418). The course used to fulfill the advanced laboratory requirement for the major must be Biol 373, Biol 4193, Biol 437, Biol 4342 or Biol 434W.

**The Major in Biology: Genomics and Computational Biology Track**

Additional requirements include Biol 3371 (or Biol 4183 or Biol 548), Math 2200 or Math 3200, and three outside electives (CSE 131, CSE 240, CSE 247). The course used to fulfill the advanced laboratory requirement for the major must be Biol 3492, Biol 4342, Biol 434W, Biol 437, or Biol 4524. Biology courses recommended for students in this track include Biol 334, Biol 3422, Biol 349, Biol 4030, Biol 4181, Biol 4183 and Biol 4810. Recommended electives outside biology include CSE 447T, Math 217 and Math 309.

**The Major in Biology: Microbiology Track**

Additional requirements include Biol 349, which should be taken spring of sophomore year, and either Biol 451 or the pair of courses Biol 4810 and Biol 4820. The advanced laboratory course used to fulfill major requirements must be one of the following: Biol 3491, Biol 3492, Biol 3493, Biol 437 and Biol 4520. At least one of the following must be taken as an advanced microbiology elective: the pair of courses Biol 4331 and Biol 4830, Biol 4492, Biol 4832, and Biol 5426. At least one of the following must be taken as an allied elective: the pair of courses Biol 191 and Biol 192, Biol 424, Chem 453 and EPSc 323. Biol 3501 is highly recommended as the course used to fulfill biology major area C. The total upper-level credits earned in major-track biology courses and allied electives must be at least 24.

**The Major in Biology: Molecular Biology and Biochemistry Track**

Additional requirements include both Biol 4810 and Biol 4820; and either Biol 334, Biol 3371 or Biol 349. The advanced laboratory course used to fulfill major requirements must be one of the following: Biol 3491, Biol 3492, Biol 3493, Biol 4241, Biol 4342/Biol 434W, Biol 437, Biol 4520, Biol 4522, Biol 4523, and Biol 4524. Additional biology courses recommended for students in this track include Biol 3041, Biol 4023, Biol 4071, Biol 4183, Biol 4832 and Biol 5312.

**The Major in Biology: Neuroscience Track**

Biology major requirements must be met with the following courses: Biol 3058, area A (Biol 334, Biol 451, Biol 4810 or Biol 4820), area B (Biol 3411), any course in area C, and advanced laboratory (Biol 360 or Biol 404). Students must select at least one biology elective (Biol 3110, Biol 3151, Biol 328, Biol 3371, Biol 3421, Biol 3422, Biol 4030, Biol 437, or Biol 4580) and one outside elective either in physics (Physics 350, Physics 352, Physics 355 or Physics 360) or in psychology (Psych 330, Psych 360, Psych 3604 or Psych 4604). Math 2200 (or Math 3200) is recommended.

Related majors can be found in the biomedical engineering (http://bulletin.wustl.edu/undergrad/engineering/biomedical/#majors), philosophy-neuroscience-psychology (PNP) (http://bulletin.wustl.edu/undergrad/arts/ci/philosophyneuropsciencespsychology/#majors) and philosophy of science (http://bulletin.wustl.edu/undergrad/arts/ci/philosophy/#majors) pages of this Bulletin.

**The Major in Environmental Biology**

Students interested in environmental biology typically take Biol 2950 Introduction to Environmental Biology during fall of the freshman year, although it may be taken later. A 400-level class to be required for Latin honors in environmental biology will be introduced. All other courses required for the environmental biology major are currently listed.

**Required courses:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 2950</td>
<td>Introduction to Environmental Biology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 2960</td>
<td>Principles of Biology I (lecture and lab)</td>
<td>4</td>
</tr>
<tr>
<td>Biol 2970</td>
<td>Principles of Biology II (lecture and lab)</td>
<td>4</td>
</tr>
<tr>
<td>Biol 381</td>
<td>Introduction to Ecology</td>
<td>3</td>
</tr>
</tbody>
</table>
One of the following Bio 300+ courses (Area C in Biology):

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3501</td>
<td>Evolution</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4181</td>
<td>Population Genetics</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4182</td>
<td>Macroevolution</td>
<td>3</td>
</tr>
<tr>
<td>Biol 419</td>
<td>Community Ecology</td>
<td>4</td>
</tr>
<tr>
<td>Biol 472</td>
<td>Behavioral Ecology</td>
<td>4</td>
</tr>
</tbody>
</table>

One additional Bio 300+ major-track course (may include Biol 500):

- Please refer to the Biology Course Listings (p. 6) in this Bulletin.

One of the following EPSC 300+ courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPSc 323</td>
<td>Biogeochemistry (only if not already taken for chemistry requirement)</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 352</td>
<td>Earth Materials</td>
<td>5</td>
</tr>
<tr>
<td>EPSc 353</td>
<td>Earth Forces</td>
<td>4</td>
</tr>
<tr>
<td>EPSc 385</td>
<td>Earth History</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 408</td>
<td>Earth's Atmosphere and Global Climate</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 409</td>
<td>Surface Processes</td>
<td>4</td>
</tr>
<tr>
<td>EPSc 413</td>
<td>Introduction to Soil Science</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 422</td>
<td>Sedimentary Geology</td>
<td>4</td>
</tr>
<tr>
<td>EPSc 428</td>
<td>Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 443</td>
<td>Methods in Biogeochemistry</td>
<td>3</td>
</tr>
<tr>
<td>EPSc 444</td>
<td>Environmental Geochemistry</td>
<td>3</td>
</tr>
</tbody>
</table>

Additional Information

Research: Research opportunities are available in the student's first or second year through Biol 200; such opportunities are available in the third and fourth years through Biol 500. A research emphasis in the major requires at least 6 credits (two semesters) of Biol 500 research and an approved senior thesis on this research. The research emphasis is acknowledged on the degree either by Latin honors or by a research milestone (for students who do not meet the GPA requirements for Latin honors as described below).

Senior Honors: Biology majors are encouraged to work for senior honors, which requires a 3.30 grade point average in biology, a 3.30 average in nonbiological sciences (mathematics, chemistry and physics courses) and a 3.65 overall grade point average at the time of graduation. Also required are 6 units of Biol 500 research and an approved thesis from this work. Students interested in senior honors should begin Biol 500 no later than spring of the junior year.

The biology department awards the Marian Smith Spector Prize to an undergraduate who has an excellent academic record and submits an outstanding honors thesis. It also awards the...
Harrison D. Stalker Prize to a graduating senior whose college career is distinguished by scholarship, service and breadth of interest.

**Minors**

**The Minor in Biology**

**Units required:** 18 units of biology and 14 units of chemistry

**Required courses:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 2960</td>
<td>Principles of Biology I (prerequisite Chem 111A)</td>
<td>4</td>
</tr>
<tr>
<td>Biol 2970</td>
<td>Principles of Biology II (prerequisite Chem 112A)</td>
<td>4</td>
</tr>
<tr>
<td>Chem 111A &amp; Chem 151</td>
<td>General Chemistry I and General Chemistry Laboratory I</td>
<td>5</td>
</tr>
<tr>
<td>Chem 112A &amp; Chem 152</td>
<td>General Chemistry II and General Chemistry Laboratory II</td>
<td>5</td>
</tr>
<tr>
<td>Chem 261</td>
<td>Organic Chemistry I with Lab</td>
<td>4</td>
</tr>
<tr>
<td>Total Units</td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>

**Elective courses:**

The minor requires 10 advanced units in biology selected from the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>Biol 3041</td>
<td>Plant Biology and Genetic Engineering</td>
<td>4</td>
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<tr>
<td>Biol 3058</td>
<td>Physiological Control Systems</td>
<td>2</td>
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<tr>
<td>Biol 3100</td>
<td>R Workshop in Biology</td>
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<tr>
<td>Biol 3110</td>
<td>Vertebrate Structure Laboratory</td>
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<tr>
<td>Biol 3151</td>
<td>Endocrinology</td>
<td>3</td>
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<tr>
<td>Biol 328</td>
<td>Principles in Human Physiology</td>
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<tr>
<td>Biol 334</td>
<td>Cell Biology</td>
<td>3</td>
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<tr>
<td>Biol 3371</td>
<td>Eukaryotic Genomes</td>
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<tr>
<td>Biol 3411</td>
<td>Principles of the Nervous System</td>
<td>3</td>
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<tr>
<td>Biol 3421</td>
<td>Introduction to Neuroethology</td>
<td>3</td>
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<tr>
<td>Biol 3422</td>
<td>Genes, Brains and Behavior</td>
<td>3</td>
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<tr>
<td>Biol 349</td>
<td>Microbiology</td>
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<tr>
<td>Biol 3491</td>
<td>Microbiology Laboratory</td>
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<tr>
<td>Biol 3492</td>
<td>Laboratory Experiments with Eukaryotic Microbes</td>
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<tr>
<td>Biol 3493</td>
<td>Bacterial Bioprospecting and Biotechnology</td>
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<tr>
<td>Biol 3501</td>
<td>Evolution</td>
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<td>Biol 360</td>
<td>Biophysics Laboratory</td>
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<tr>
<td>Biol 373</td>
<td>Laboratory on the Evolution of Animal Behavior</td>
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<tr>
<td>Biol 381</td>
<td>Introduction to Ecology</td>
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<tr>
<td>Biol 4023</td>
<td>How Plants Work: Physiology, Growth and Metabolism</td>
<td>3</td>
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<tr>
<td>Biol 4030</td>
<td>Biological Clocks</td>
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<tr>
<td>Biol 404</td>
<td>Laboratory of Neurophysiology</td>
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<tr>
<td>Biol 4071</td>
<td>Developmental Biology</td>
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<tr>
<td>Biol 4181</td>
<td>Population Genetics</td>
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<tr>
<td>Biol 4182</td>
<td>Macroevolution</td>
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<tr>
<td>Biol 4183</td>
<td>Molecular Genetics</td>
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<td>Biol 419</td>
<td>Community Ecology</td>
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<tr>
<td>Biol 4193</td>
<td>Experimental Ecology Laboratory</td>
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<tr>
<td>Biol 424</td>
<td>Immunology</td>
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<tr>
<td>Biol 4241</td>
<td>Immunochemistry Laboratory</td>
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<tr>
<td>Biol 427</td>
<td>Problem-Based Learning in Biomedical Sciences</td>
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<tr>
<td>Biol 4331</td>
<td>Algae: Cell Biology and Molecular Evolution</td>
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<tr>
<td>Biol 4342</td>
<td>Research Explorations in Genomics</td>
<td>4</td>
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<tr>
<td>Biol 434W</td>
<td>Research Explorations in Genomics (Writing-Intensive)</td>
<td>4</td>
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<tr>
<td>Biol 437</td>
<td>Laboratory on DNA Manipulation</td>
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<tr>
<td>Biol 4492</td>
<td>Infectious Diseases: History, Pathology, and Prevention</td>
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<tr>
<td>Biol 451</td>
<td>General Biochemistry</td>
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<tr>
<td>Biol 4520</td>
<td>Protein Function in Model Cellular Systems</td>
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<tr>
<td>Biol 4522</td>
<td>Laboratory in Protein Analysis, Proteomics and Protein Structure</td>
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<tr>
<td>Biol 4523</td>
<td>Mutagenesis and Enzyme Analysis</td>
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<tr>
<td>Biol 4524</td>
<td>Structural Bioinformatics of Proteins</td>
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<tr>
<td>Biol 4580</td>
<td>Principles of Human Anatomy and Development</td>
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<tr>
<td>Biol 472</td>
<td>Behavioral Ecology</td>
<td>4</td>
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<tr>
<td>Biol 4810</td>
<td>General Biochemistry I</td>
<td>3</td>
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<tr>
<td>Biol 4820</td>
<td>General Biochemistry II</td>
<td>3</td>
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<tr>
<td>Biol 4830</td>
<td>Bioenergy</td>
<td>2</td>
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<tr>
<td>Biol 4832</td>
<td>Molecular Mechanisms of Photosynthesis and Respiration</td>
<td>3</td>
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</table>

**Additional Information**

All courses utilized for the biology minor must be taken for a letter grade. A grade of C- or better must be earned in all of these courses.

**Courses**

L41 Biol 112 Introduction to Problem-Based Learning in Biology
Small groups of students take responsibility for their own active learning in their team with guidance from an instructor. Each group in rotation considers four problems of biological importance such as rainforest destruction, coral reefs, laboratory diagnoses, sleep, high altitude, deafness, infertility, modern epidermics, clinical cases, genetic engineering and cloned animals. Students find the background information by library searches and integrate this knowledge in group discussions. Enrollment limited. Intended for but not limited to prospective biology majors. Prerequisite: high school biology, preferably an AP class. For freshmen only. Credit 3 units. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 1260 The Secret Lives of Plants
This course is designed to familiarize undergraduate students with the fascinating lives of plants, their evolution, their remarkable structural and morphological diversity, how they grow, and how they have been modified to feed the planet. Topics include: how plants can survive with just water, minerals and light, how they transport water astonishing distances, their unusual sex lives, why they make seeds, how they can grow nearly forever, how plants survive extreme environments without running to hide, why they synthesize caffeine, nicotine, THC and opiates, how they defend themselves from pathogens without an immune system, how they sense their environment without dedicated sensory organs, how plants have been modified by humans to provide food, fiber and fuel, and how genetically modified (GMO) crops are made and their implications to the environment and society. Overall goals are to enhance an understanding and appreciation of the plant kingdom, to help young scientists understand the primary scientific literature, and as a starting point for possible careers in plant biology. Where appropriate, the class will also emphasize key differences between plants and animals. This course is primarily for freshmen interested in majoring in biology, with a possible emphasis on plants. This course is also for those that want to know more about where their food comes from, these amazing creatures survive and flourish, and how GMO crops are engineered. Upper-level students with an interest in food and sustainable agriculture but not necessarily focusing on plants will also be welcome. Course will be lecture/discussion/hands-on format for two of the three hours per week. Students will present 30-minute papers discussing topics relevant to their interests for the remaining one hour (two students per week). Prerequisites: Students must have taken both biology and chemistry in high school and at least one at the AP or IP levels; or have taken Biol 2960 or Chem 111/112. This course can be taken by both freshmen and upper-level undergraduates with a preference given to freshmen. Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 171 Neurosciences Futures 1: How do we learn about the brain?
In this seminar course for first-year students, students learn about how neurobiologists conduct and communicate research. We focus our discussion on primary research papers written by Washington University neurobiologists, who visit the class to present their work. Discussion then focuses on the formulation of scientific questions, evaluation of evidence and interpreting data within the context of a broader field. Students meet neuroscience colleagues in two joint class periods with participants in a neurobiology seminar for second-, third- and fourth-year students. May be repeated for credit; preference given to students who have not previously taken the course. Credit 1 unit. Arch: NSM Art: NSM

L41 Biol 1770 Genetics and Behavior of Dog Breeds
This freshman seminar uses the topic of dog behavior and genetics to teach fundamental scientific tools and to engage students in contributing to the building of an online public resource that summarizes the scientific literature on breeds. Our first task is learning to read and dissect primary scientific literature. We parse out the difference between scientific questions, hypotheses and predictions through a guided case-study exercise. We then apply the experience to outlining primary research articles, identifying the key components of the author’s arguments, and summarizing the results and implications. The second half of the semester is spent searching the scientific literature, sorting information into the new dog breed resource, and presenting results to peers around the seminar table. Credit 2 units.

L41 Biol 181 Freshman Seminar in Biology
A lecture course intended for first-year students that focuses on the practice and culture of biomedical research. Active researchers describe the biological context of their research, the specific questions formulated, the means by which they pursue the answers, and their data and conclusions. The focus is on process: how biologists pursue their profession in a research setting. Additional topics of clinical and contemporary interest are often included. Students are expected to attend all lectures. Must be taken credit/no credit. Credit 1 unit. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 191 Phage Hunters
A research-based laboratory class for freshmen. Students join a national experiment organized by HHMI, with the goal of isolating and characterizing bacteriophage viruses found in the soil in the St. Louis area. Laboratory work includes isolation and purification of the student’s own phage, DNA isolation and restriction mapping, and EM characterization of student’s phage. Several WUSTL phage are selected for genome sequencing over winter break, and are annotated in the spring in Biol 192, Phage Bioinformatics. Students who successfully isolate and annotate a phage may become co-authors on a scientific paper. Prerequisites: high school courses in biology and chemistry, at least one at the AP or International Baccalaureate level; permission of the instructor. Limited to 40 students. One hour lecture, one hour discussion, and three hours lab per week. Same as L61 Focus 1910 Credit 3 units. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 192 Focus: Phage Bioinformatics
A research-based laboratory class for freshmen. Students join a national experiment organized by HHMI, with the goal of genomic characterization of a local phage. Laboratory work focuses on learning computer-based tools for genome analysis followed by annotation and comparative analysis of the genome of a phage (bacterial virus) that was isolated fall semester at Washington University and sequenced over winter break. Prerequisites: high school courses in biology, chemistry and physics, at least one at the AP or International Baccalaureate level; permission of the instructor. Limited to 40 students;
L41 Biol 200 Introduction to Research
An introduction to laboratory and field research in biology for first- and second-year students. Students work under the supervision of a sponsor in a setting of established, ongoing research. Prerequisite: permission of sponsor and the department. For online enrollment instructions visit: http://nslc.wustl.edu/courses/Bio500/bio500.html. Students are registered by the department after approval is granted. Registration may not appear in WebSTAC until midsemester. Credit variable, maximum 3 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 2010 The Science of Biotechnology
Biotechnology is truly interdisciplinary with a myriad of pieces from biology, chemistry, engineering, physics, computer sciences, management, public policy and law that apply the scientific process to societal challenges. This course introduces topics for science and engineering majors with an interest in biotech and teaches scientific concepts to business students considering careers in biotech management and entrepreneurship. Students completing Biol 2010 understand key science concepts, how discoveries lead to applications addressing global challenges, effectively use a variety of resources to explore connections between science and biotech business, synthesize information from different fields, exhibit strong teamwork skills, and communicate information in written and oral forms. This course also provides a gateway for students interested in the two-year Biotech Explorers Program (BEP). The first two weeks of the course introduce students to the history of biotechnology, the BEP, and the use of case studies. The remainder of the course uses a series of four 3-week units that combine lecture material, in-class group assignments, and readings to introduce the science and scope of biotechnology. For each unit, student teams also develop short case studies of St. Louis biotech companies and present their findings to the class. A series of site-visits introduces students to the vibrant St. Louis biotech community. Limited to 20 students. Credit 3 units. A&S: NS A&S IQ: NSM

L41 Biol 2020 Biotechnology Entrepreneurs Seminar
Although the biotech industry is science-based, the risks of product and technology development, legal issues, and market pressures make the landscape full of uncertainty. Lectures and textbooks fall short of delivering true insight about the process and challenges of bringing ideas to real-world products. This second semester freshman seminar course is designed to develop an appreciation of how biotech companies achieve their goals by engaging students through interactions with experienced executives and entrepreneurs, whose shared knowledge and stories add depth and context to the learning process. This 1-credit seminar course introduces students to the basics of innovation and entrepreneurship as a framework for marketable discoveries, builds an appreciation of how biotech companies start, obtain funding, and navigate intellectual property, provides an overview of career options in biotech, and insight on the hiring process. Prerequisites: Students need to have completed Biol 2010: The Science of Biotechnology for enrollment in this course and be currently enrolled in Biol 2960: Principles of Biology I. Limited to 20 students. Credit 1 unit.

L41 Biol 2342 Wilderness First Aid
The National Outdoor Leadership School (NOLS) has developed a comprehensive curriculum to instruct individuals in backcountry first aid. This curriculum is the main content taught in the course. After successfully completing this detailed 18 hour NOLS Wilderness First Aid course, students are required to write-up a full assessment and treatment plan (5-7 page minimum) for one of the wilderness casualties described in Peter Stark’s Last Breath. Students meet for a half-day seminar during which each presents their case, assessment, underlying physiology, and treatment plan to the group. They receive feedback from one another, and from the instructor, about their assessment, explanation of the relevant physiology, and action of their proposed intervention. Credit 1 unit. A&S: NS A&S IQ: NSM

L41 Biol 2431 Focus: Missouri’s Natural Heritage, part 1
Missouri’s Natural Heritage is a multidisciplinary two-semester Freshman Focus course. The first semester of the sequence focuses on Missouri geology, climate, archaeology, and native megafauna. This provides a foundation on which to examine the ecology, restoration and management of our diverse habitats (prairie, forest, glade and stream) and the biology of our diverse plant and animal wildlife (arthropods, mollusks, fish, salamanders, lizards, birds and mammals) in the second semester. We also introduce basic concepts in biodiversity and resource management with attention to resolution of conflicts of interest. In addition to weekly lecture and discussion, students in this class visit sites across the state during three weekend camping trips and a longer camping trip during winter break. Attendance on field trips is an essential component of the course and grade. Lab fee covers transportation and meals for all field trips. Same as L61 Focus 2431 Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 265 Experience in the Life Sciences
Earn credit for nonclassroom learning in the life sciences in a variety of activities: accompany a physician on rounds and prepare a paper on an organ system or disease; participate in a clinical or applied ecological study and report on it; participate in science outreach teaching, etc. Participants must meet regularly with a supervisor and commit at least 140 hours over two semesters. A work plan is approved prior to registration. A progress report is due after one semester and a final paper after two semesters. Does not count toward the major. Credit: 1.5 units per semester, contingent upon completion of two semesters. Visit http://nslc.wustl.edu/research.html. Credit/no credit only. Credit 1.5 units. Art: NSM

L41 Biol 2651 MedPrep I-The Lecture Series
MedPrep I is a unique lecture series taught by a physician, medical school Course Master and member of the Committee on Admissions for the School of Medicine. Through a weekly two-hour lecture, this course gives students accurate, honest and detailed information regarding every step of the application and admissions process to medical school and the educational process and life of a physician. MedPrep I is particularly useful for freshmen and sophomores in that it reviews the
common pitfalls encountered by unsuccessful applicants to medical school. There is no outside course work and no exam. Attendance at all classes is required. Registration for Biol 2651 is done through the MedPrep website at http://medprep.wustl.edu. Registration is not done through WebSTAC. Credit 1 unit.

L41 Biol 2652 Pediatric Emergency Medicine Research Associates Program: Experiences in Life Sciences
The Pediatric Emergency Medicine Research Associates Program (PEMRAP) offers undergraduate pre-medical students an opportunity to participate in clinical, patient-oriented research projects in a hospital setting. Students have the opportunity to work in the St. Louis Children's Hospital Emergency Department, a nationally recognized pediatric emergency medicine and trauma care facility. A number of research projects are currently underway in various areas of pediatric emergency medicine. Credit/No Credit. Research Associates are expected to work two four-hour shifts per week in the St. Louis Children's Hospital Emergency Department and to attend a weekly two-hour lecture on Tuesdays in conference room 10A of the Northwest Tower Building (across from Children's Hospital) from 1:30-3:30 p.m. Weekly meetings include lectures given by Emergency Department faculty members. This program offers students the unique opportunity to be a vital part of the ED research team. In addition, the RA's experience in the ED may help them determine if medicine is truly the career path they wish to choose. May not be taken concurrently with Biol 2654: MedPrep II. Credit 3 units.

L41 Biol 2654 MedPrep II-The Shadowing Experience
MedPrep II offers students a real world, behind-the-scenes experience of a life in medicine. For three hours every other week, students shadow physicians in the Charles F. Knight Emergency and Trauma Center of Barnes-Jewish Hospital, the main teaching hospital of the Washington University School of Medicine. A weekly one-hour class is also held on the Danforth Campus for group discussion regarding the clinical experiences of the students. There is no outside course work and no exam. Attendance at all classes is required. Because of the orientation material covered, students must be present at the first class to take this course. Registration for Biol 2651 is done through the new MedPrep website at http://medprep.wustl.edu, not through WebSTAC. Prerequisite: Successful completion of Biol 2651 is required to take Biol 2654. Credit 1 unit.

L41 Biol 2656 Introduction to Health Professions: Occupational Therapy, Physical Therapy and Audiology
This course provides students interested in health professions with an overview of occupational therapy, physical therapy and audiology. Students gain a better understanding of the scope of practice, markets and skills required to succeed in these professions. Students learn about graduate and professional education options and how to build a competitive application for these programs. Finally, students are introduced to field experiences in each area and culminate their study with an interprofessional education session illustrating the role of each of the professions in a single case. Students finish the course with a better understanding of whether a career in health professions is right for them. Credit 1 unit.

L41 Biol 2658 Pediatric Emergency Medicine Research Associates Program - Experiences in Life Sciences (PEMRAP II)
PEMRAP II is a continuation of Bio 2652, Pediatric Emergency Medicine Research Associates Program - Experiences in Life Sciences. Returning PEMRAP Participants actively participate in new and ongoing research projects in various areas of pediatric emergency medicine. RAs assist during the active period of patient enrollment through screening of ED patients for study eligibility, reading information about the studies to the patients, collecting data regarding patient history and certain physical examination findings, and generally facilitating the study enrollment process. PEMRAP Returning RAs are vital members of the Emergency Department research team in the St. Louis Children's Hospital Emergency Department. Returning RAs assist in training and mentoring incoming PEMRAP students (Bio 2652) in ED protocol, work approximately one four-hour shift per week in the ED, record shift activities and hours worked on a daily Shift Log form, and participate in the physician shadowing program (as offered). Returning RAs are responsible to meet hospital non-appointee requirements and stay current with new study protocols by attending or viewing new study presentations for PEMRAP students. These lectures are given by pediatric department faculty members introducing the basics of the clinical research process, specific studies, as well as pediatric illness. The RA position carries with it important responsibility requiring maturity, initiative, diligence and excellent interpersonal skills. There is no outside course work and no exams. Full participation is required. 45 shift hours = 1 credit. Students may repeat this course for a maximum of 6 credits. Course may not be taken concurrently with Biol 2652, 2651, or 2654. Prerequisite: Biol 2652 (PEMRAP I), Pass/Fail. Credit 1 unit. Arch: NSM Art: NSM

L41 Biol 2950 Introduction to Environmental Biology
This course introduces students to our major environmental problems, and gives examples about how research in biology, chemistry, physics and math is necessary to solve these problems. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 2960 Principles of Biology I
The course provides an introduction to cellular, molecular and developmental biology. An understanding of cellular architecture and the properties of biological macromolecules is integrated with discussion of the flow of genetic information within cells. The final section of the course covers investigation and manipulation of genetic information by molecular genetic technologies, as well as developmental strategies employed by multicellular eukaryotes. Weekly labs reinforce concepts from lectures and explore common laboratory techniques and computer-based resources. Prerequisites: Chem 111 and Chem 112 (concurrently). Three hours of lecture and two hours of lab per week. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 2961 Collaborative Phage Bioinformatics
A research-based laboratory for those enrolled in Biol 2960, this class provides an opportunity to join a research team with the goal of genomic characterization of a locally isolated phage (a virus that infects a bacterial host). Similar to Biol 192, but using a condensed format and a larger team to tackle each phage. Lab work focuses on learning computer-based tools
for genome analysis, followed by careful annotation of several genes from your phage, and in-depth investigation of one gene. Requires concurrent enrollment in Biol 2960 Principles of Biology I; not open to students enrolled in Biol 192. One 2-hour pre-class online review/preparation session, two 2-hour laboratory sessions, and a final poster presentation. (Lab does not meet in weeks with a scheduled Biol 2960 midterm.) May be taken for a letter grade or Credit/No Credit. Credit 1 unit. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 2962 Biomolecules in the Third Dimension
A computer-based laboratory for students enrolled in Biol 2960. This class gives students the opportunity to learn biology in a new way. Students are exposed to experimental data and software visualization tools currently used in cutting-edge research. Each week, biomolecules presented in Biol 2960 lecture will be downloaded, viewed and manipulated in 3-D using the molecular viewer PyMOL. Students will be able to study molecular interactions in greater depth than is possible in lecture. Ultimately, the laboratory is designed to help students develop their visuospatial thinking skills and to gain a deeper understanding of the macromolecules discussed in lecture. The class is highly recommended to students who identify themselves as visual/interactive learners. Topics include: protein and nucleic acid structure, signal transduction, energy transfer, replication, transcription and translation. Requires concurrent enrollment in Biol 2960 Principles of Biology I. Lab does not meet in weeks with a biology exam. Class taken for Credit/No Credit. Credit 1 unit. A&S: NS A&S IQ: NSM

L41 Biol 2970 Principles of Biology II
A broad overview of genetics, including Mendelian assortment, linkage, chromosomal aberrations, variations in chromosome number, mutation, developmental genetics, quantitative genetics, population genetics, mechanisms of evolution, and phylogenetics. Three lectures and one laboratory period each week. Does not fulfill the laboratory requirement of the biology major. Students must sign up for a lab during preregistration. Prerequisite: Biol 2960 or permission of instructor. Examination schedule: tests, at which attendance is required, are to be announced. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3010 Biotechnology Project
This second-year Biotech Explorers Pathway (BEP) course introduces students to the process used to generate project ideas, write proposals, and evaluate concepts, with peer evaluation applied at all steps of the process. Students completing Biol 3010 will gain experience in science proposal writing with peer review, public speaking, team building, and leadership training. The first four weeks of the course will focus on individual pre-proposal brainstorming, writing and pitching, while the remainder of the course will be dedicated to the development of full proposals by teams of students. This 3-credit project development course complements introductory courses by making connections between fields and building teams of students with experience in the process that nurtures ideas to products. Prerequisites: Students need to have completed Biol 2010: The Science of Biotechnology and Biol 2020: Biotech Entrepreneurs Seminar for enrollment in this course. Limited to 20 students. Credit 3 units. A&S IQ: NSM, WI

L41 Biol 303A Human Biology
How did Elvis, Socrates and Babe Ruth die? How did David Letterman and Dick Cheney survive? In this course we work toward understanding the biology behind human health and disease. We examine cases from the news, literature and history. We work like detectives to understand how and why the characters were affected and healed or died. This course is designed for students who do not plan to major in science, and no prior science background is expected. Prerequisite: sophomore standing or permission of instructor. A student may not receive credit for both Biol 303A and Biol 100A, 2960, 2970, or UCollege B320, B3201, B321, B3211. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3041 Plant Biology and Genetic Engineering
A 4-credit lecture course that provides an introduction to plant development, genetics, physiology and biochemistry with emphasis on processes that can be manipulated or better understood through genetic engineering. The course is divided into three sections. The first section of the course discusses basic plant biology, development and genetics. The second part emphasizes gene structure, expression and cloning as well as methods for introducing foreign DNA into plant cells and regenerating fertile plants in tissue culture. During the third part of the course we discuss a variety of examples of genetically engineered traits, including: herbicide resistance; fruit ripening; pathogen and/or insect resistance; and the use of plants for production of industrial and pharmaceutical compounds. Friday discussion sections focus on critical reading of the primary literature related to the material covered in lecture. Prerequisites: Biol 2960 and Biol 2970. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3058 Physiological Control Systems
Systems physiology with emphasis on human physiology. Prerequisites: Biol 2960 and Chem 112A. Credit 2 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 307A Human Variation
A survey of human biological diversity, considering its adaptive and taxonomic significance from the perspective of origins and distribution of traits and adaptation. Prerequisite: Anthro 150A or introductory biology. Same as L48 Anthro 307A Credit 3 units. A&S: NS, SD, QA A&S IQ: NSM, AN, SD Arch: NSM Art: NSM BU: SCI

L41 Biol 3100 R Workshop in Biology
Biologists in all areas increasingly find that they have the need and opportunity to work with large data sets. The goal of this 1-credit course is to provide students with an opportunity to gain skills in data analysis and presentation using R, a free software environment for statistical computing and graphics (http://www.r-project.org). Topics include an introduction to basic programming in R, data types and manipulation, graphics, hypothesis testing and statistics, and applications to various fields of biology ranging from ecology to genomics. The course consists of ten 2-hour workshops that include a brief introduction to key concepts in R and applications in biology, followed by interactive, hands-on tutorials. Prerequisites: concurrent or prior course in statistics (Math 2200 or Math 3200 recommended) or permission of instructor. Credit 1 unit. A&S: NS
L41 Biol 3110 Vertebrate Structure Laboratory
A lecture/laboratory course designed to provide an integrative framework for how vertebrate form and function evolved. Weekly lectures emphasize development and the relationship between the structural and functional design of organ systems, the importance of these relationships in maintaining homeostasis while providing opportunity for adaptation, and examples of how vertebrate organ systems communicate to accomplish functional and physiological integration. 1.5 hour lecture and 5 hours lab each week. Prerequisite: Biol 2970. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3151 Endocrinology
An overview of mammalian endocrine systems with an emphasis on human physiology and development. The interplay between systemic, local cell and tissue interactions as well as the cell and molecular events associated with hormone action are discussed. Examples of endocrine evolution and pathological conditions related to endocrine imbalances also are included. Prerequisite: Biol 2970. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 328 Principles in Human Physiology
This course is designed to provide students with an understanding of the function, regulation and integration of the major organ systems of the body. Course content includes neural and hormonal homeostatic mechanisms, and study of the circulatory, respiratory, digestive, urinary, musculoskeletal, nervous, endocrine, immune and reproductive organ systems. Mechnisms of exercise physiology are integrated throughout the course. Prerequisite: Biol 3058 or equivalent. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 334 Cell Biology
Eukaryotic cell structure and function viewed from the perspective of modern cell biology. Lectures cover such topics as membrane transport; endocytosis and secretion; intracellular trafficking; hormones and signal transduction; extracellular matrix and tissue formation; cytoskeleton and motility; and cell cycle, apoptosis and the cellular basis of disease. Prerequisite: Biol 2970. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3371 Eukaryotic Genomes
An advanced exploration of the structure and function of DNA within the eukaryotic nucleus. Lecture and discussion cover topics of chromatin and chromosome structure, control of gene transcription, RNA processing, and DNA replication and repair. The relevance of these topics to the genetic basis of human disease is discussed. Throughout, the experimental data that shape our current understanding are emphasized. Course grades based on exams, problem sets and short papers. Lecture three hours per week plus required discussion section meeting every other week. Prerequisites: Biol 2970, Chem 251 (may be taken concurrently). Offered every other fall in even-numbered years. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3411 Principles of the Nervous System
The basic anatomical, physiological and chemical organization of the nervous system; how nerve cells communicate with each other, the ionic basis of nerve signals, the function and properties of chemical agents in the nervous system, the development of neural circuitry, and how neurons interact to produce behavior. Prerequisite: Biol 2960; Biol 2970 recommended. Biol 3058 recommended or Psych 3401 and permission of instructor. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3421 Introduction to Neuroethology
The neural mechanisms of animal behavior from an evolutionary and ecological perspective. Topics include: contributions of model systems to understanding fundamental properties of nervous system structure and function; electrical signals of sensory cells, neurons and muscle; neural processing of sensory input; neural control of behavioral output; anatomy and physiology of sensory and motor systems; learning and memory; evolution of neural circuits. Prerequisite: one of the following courses: Biol 3058, Biol 3411 or Psych 3401. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3422 Genes, Brains and Behavior
Genetic studies of physiological systems underlying animal behavior, including the genetic basis for normal and abnormal behaviors in animals and humans. Topics include: history of behavioral genetics; the ongoing debate about "nature vs. nurture"; contributions of genetic model systems including the nematode Caenorhabditis elegans, the fruit fly Drosophila melanogaster, zebrafish, the mouse Mus musculus and other animal models; molecular mechanisms underlying the evolution of behavioral properties; the emerging role of epigenetics in regulating nervous-system functions and behavior; the use of genetic and genomic analyses in studies of human behavior and psychiatric disorders. Prerequisite: Biol 2970. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 349 Microbiology
This 4-credit lecture course focuses on the molecular biology of bacteria, archaea and viruses. Topics include: the bacterial cell cycle, gene regulation, stress response, cell-cell communication, viral and bacterial pathogenesis, microbial ecology, and metabolic diversity. Friday tutorials stress analysis of the primary literature with an emphasis on current research related to material covered in lecture. Prerequisites: Biol 2960 and 2970, or permission of instructor. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3491 Microbiology Laboratory
After introducing students to the basics of bacterial growth and maintenance, this laboratory class uses genetics, cell biology and genomics to explore various aspects of bacterial physiology, identification, gene structure and mutational analysis of physiological pathways. Prerequisite: Biol 349 required; may be taken concurrently. One-hour lecture and five hours of laboratory per week. Fulfills the upper-level laboratory requirement for the biology major. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3492 Laboratory Experiments with Eukaryotic Microbes
This research-intensive course provides an introduction to diverse molecular and cell biology techniques used in model experimental organisms to explore fundamental biological questions. Experiments are performed using selected fungi and protozoans commonly used in major research efforts. Emphasis
is placed on choosing the appropriate organism for the question posed using the most current technologies. Each semester, one cellular process is studied in detail and original research is carried out. Prerequisites: Biol 2960 and 2970 and permission of instructor — contact early to ensure enrollment. One hour of lecture and six hours of laboratory a week. Fulfills the upper-level laboratory requirement for the biology major. Enrollment limited to 12.
Credit 3 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM BU: SCI

L41 Biol 3493 Bacterial Bioprospecting and Biotechnology
Many bacteria are essential in food industry (fermentation of meats, cheeses and beverages), agriculture (crop protection against weeds, pathogenic bacteria, and fungi), biotechnology (producing fine chemicals, cofactors, amino acids, and industrial enzymes) and the pharmaceutical industry (producing clinical antibiotics, anticancer, antiviral, veterinary, and immunomodulatory drugs). This laboratory course examines how basic biological understanding can lead to discovery of bacterial products, enzymes and activities useful to humankind. We combine core concepts from biochemistry, bacterial genetics, bioinformatics, chemistry and enzymology to study bacteria from the genus Streptomyces and close relatives. Lines of inquiry include environmental isolations, molecular toolbox and host development, plus bioinformatic and laboratory-based analyses of secreted proteins and antibiotics. Prerequisites: Biol 2960 and 2970. One hour of lecture and six hours of laboratory per week. This course fulfills the laboratory requirement for the biology major. Enrollment limited to 16.
Credit 3 units. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3501 Evolution
A general survey of organic evolution covering both micro and macroevolution. Topics include natural selection, adaptation, evolution of pathogens, formation of species and phylogeny. Prerequisite: Biol 2970.
Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 360 Biophysics Laboratory
This laboratory course consists of "table-top" experiments in biological physics that are designed to introduce the student to concepts, methods and biological model systems in biophysics. Most experiments combine experimentation with computer simulations. The list of available experiments includes electrophysiology, human bioelectricity, optical tweezers, ultrasonic imaging, mass spectrometer, and viscosity measurements. Prerequisites: prior completion of Physics 117A-118A, Physics 197-198 or permission of instructor.
Same as L31 Physics 360
Credit 3 units. A&S: NS A&S IQ: NSM, AN Art: NSM

L41 Biol 373 Laboratory on the Evolution of Animal Behavior
This course explores the costs, benefits and constraints that drive the evolution of animal behavior. It is divided into four modules: a brief overview of basic statistics, a lab on agonistic behavior, a lab on animal communication, and a lab on sexual selection by female choice. Laboratory modules are hands-on and student driven. They begin with an overview of relevant literature and a discussion of key questions that have been addressed experimentally in that field. Students are then encouraged to apply these concepts into the design, execution and analysis of a research project aimed at answering a question of their own choosing through the use of house crickets as a study system. A majority of class time is devoted to active learning through the collection and analysis of data (each lab module lasts four weeks). In addition, the course includes weekly presentations by the instructor and class discussions on topics that help place the students’ work into the broader context of evolutionary theory. Prerequisites: Biol 2970 and Psych 100B or permission of instructor
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 374 Drugs, Brain and Behavior
This course reviews information pertaining both to medications used to treat psychiatric disorders and to psychoactive drugs of abuse. By learning principles of pharmacology and mechanisms of action of these agents, students develop an enhanced knowledge of the brain mechanisms underlying abnormal human behavior. Prerequisites: Psych 100B and one of the following: Psych 354 or 3401 or 344.
Same as L33 Psych 374
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 381 Introduction to Ecology
This course explores the science of ecology, including factors that control the distribution and population dynamics of organisms, the structure and function of biological communities, how energy and nutrients flow across ecosystems, and what principles govern ecological responses to global climatic and other environmental changes. The class format includes lectures, discussions and small group exercises. Assignments include quantitative data analysis, ecological modeling and scientific writing.
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 387 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/no credit only.
Credit variable, maximum 3 units. A&S: NS A&S IQ: NSM

L41 Biol 388 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/No Credit only.
Credit variable, maximum 3 units. A&S: NS A&S IQ: NSM

L41 Biol 4023 How Plants Work: Physiology, Growth and Metabolism
This course introduces students to the fundamentals of how plants grow, metabolize and respond to their environment. Topics covered include the conversion of light energy into chemical energy through photosynthesis and carbon fixation, nitrogen assimilation, water and mineral uptake and transport, source-sink relationships and long-distance transport of carbon
A rigorous introduction to the study of evolution at the molecular level. Topics include the origin, amount, distribution and significance of molecular genetic variation within species, and use of molecular data in systematics and in testing macroevolutionary hypotheses. Prerequisite: Biol 2970 or permission of instructor.

Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 4202 Evolutionary Genetics
This course examines the principles of evolutionary genetics as applied to complex characters such as morphology, behavior, life history and disease. Mathematical models of quantitative inheritance and evolution are discussed. Special topics include kin selection, sexual dimorphism and conservation genetics. Prerequisite: Anthro 150A or introductory biology. Same as L48 Anthro 4202
Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 424 Immunology
Basic molecular and cellular aspects of the vertebrate immune system with emphasis upon the interrelationships of nonspecific and specific host defense against disease, the nature of immunological specificity and its underlying molecular biology. Includes complement systems, immunohemistry and immunossay, systems, the nature of cellular activation and effector generation, immunodeficiency, tolerance, tissue transplantation, hypersensitivity, immune regulation and specific diseases illustrative of the successes and failures of the immune system. Prerequisites: Biol 2970 and Chem 252.
Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 4241 Immunology Laboratory
The Immunology Laboratory introduces students to a variety of common, broadly useful immunological techniques and then allow each student to employ most of the learned techniques in addressing a current research question. Experiments employ
mouse cells in vitro and emphasize quantitative analysis of the data. Prerequisites: Biol 424 and permission of instructor. Credit 3 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 427 Problem-Based Learning in Biomedical Sciences
Groups of five to eight students are presented with medical case studies that are then researched and discussed under faculty guidance. Students take major responsibility for their own learning within their team. Enrollment limited to 30 students. Prerequisites: Biol 3050 and some experience in molecular biology. A biology or science background is required. Credit 4 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM

L41 Biol 429 Cellular Transformations
Cellular Transformations is a course developed for students interested in using emerging technologies and cross-disciplinary approaches in design production and implementation. This course allows each student to develop abstract thinking and learn modern design and fabrication processes including digital media and 3-D technologies. In this course, students learn the basic principles underlying biological architecture, with a particular emphasis on structures and processes responsible for complex architectures within cells. Students then use biological design principles as inspiration for their individual projects. Through digital modeling and scanning of biological structures, each student develops a transformation process that analyzes the performative aspects of a new emerging design. These designs are modeled through CADCAM (laser cutting) and Rapid Prototyping (3-D Printing) for physical outputs. Prerequisites: Biol 2970 or Biol 334. Credit 3 units. A&S: NS A&S IQ: NSM BU: SCI

L41 Biol 431 Algae: Cell Biology and Molecular Evolution
Algae are ubiquitous and highly diverse photosynthetic organisms: They are prokaryotic (cyanobacteria) and eukaryotic, unicellular and multicellular, and central to soil, fresh water, and marine ecosystems. This course considers their molecular taxonomy and evolution, specific lineage adaptations (e.g., silicon in diatoms), life cycles, cell cycle and cell-division mechanisms, light and nutrient acquisition, storage products, cell and cell-wall organization, ecological habitats and symbioses (e.g., lichens), and commercial applications (e.g., carotene, omega-3 fatty acids and other nutraceuticals; biodiesel). A course for upper-level biology and bioengineering undergraduates and graduate students. Tu/Th 3:30-5:30 until spring break, where a second course, Biol 4830, is highly recommended as a sequel. Assigned readings of research literature pertaining to each lecture topic; final take-home exam covering lecture and reading material. Prerequisite: Biol 334 or Biol 4810 or instructor’s permission. Credit 2 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 4342 Research Explorations in Genomics
A collaborative laboratory-investigation of a problem in comparative genomics, utilizing a variety of bioinformatics tools to manage and investigate large data sets (currently including genomic sequences, gene predictions, sequence conservation, gene expression). In spring ’17 the research problem involves improving the sequence of a region of the Drosophila biarmipes or Drosophila elegans genome, and working with one of these sequences to examine patterns of genome organization, gene structure and gene regulation. Class will meet at the WU Genome Institute during the first third of the semester, and in the biology department the remainder of the semester. Prerequisites: Biol 2970, Chemistry 111/112, 151/152. While Biol 3371 or Biol 437, and some familiarity with computers would be advantageous, this is not required. Permission of Dr. Sarah Elgin is required. Fulfills the upper-level laboratory requirement for the biology major. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 434W Research Explorations in Genomics (Writing-Intensive)
Content equivalent to Biol 4342. Students electing the writing option are required to revise each of three papers (on finishing of their fosmid; gene finding in a human/chip comparison; and annotating their fosmid) at least once. Credit 4 units. A&S: NS, WI A&S IQ: NSM, WI Art: NSM

L41 Biol 437 Laboratory on DNA Manipulation
A study of structure-function relationships as applied to carbohydrate, proteins and lipids; intermediary metabolism of principal cellular components; and general aspects of regulation. Prerequisites: Biol 2960 and Biol 2970. One hour of lecture and eight hours of laboratory each week. This course fulfills the upper-level laboratory requirement for the biology major. Enrollment is limited to 12. A laboratory fee is required for students who are not full-time Washington University undergraduates. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 4492 Infectious Diseases: History, Pathology, and Prevention
Leveraging the primary research literature, this course examines the history and pathology of infectious disease, the development of antibiotics and vaccines, the rise of antibiotic resistance, and the emergence and reemergence of diseases including Zika virus, Ebola and Tuberculosis. In addition to gaining insights into the underlying causes and treatment of infectious disease, students will hone their ability to identify important biological questions, develop testable hypotheses, design experiments tailored to particular questions, and evaluate results. Through a series of written and oral assignments, students develop the skills to communicate about science effectively to both the research community and the general public. Prerequisites: Biol 2960, 2970; Chem 261, 262, and Biol 500 or permission of the instructor. Area A. Credit 3 units. A&S IQ: NSM BU: SCI

L41 Biol 451 General Biochemistry
A study of structure-function relationships as applied to carbohydrates, proteins and lipids; intermediary metabolism of principal cellular components; and general aspects of regulation. Prerequisites: Biol 2970 and Chem 252 and permission of department. Recommended for students who have achieved grades of B or better in the prerequisites. Students may not receive credit for both Biol 4801 and Biol 451. Small class. Credit 4 units. A&S: NS A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 4520 Protein Function in Model Cellular Systems
The goal of this 3-credit laboratory course is to train students in the scientific method. Throughout this course, they study a protein involved in a cellular process. Students, working in small groups, use bioinformatics to identify this protein in a number of
species, then use this information to hypothesize which residues of the protein are important for its function. Over the course of the semester, students test their hypotheses in two model systems for studying cellular function — the unicellular eukaryote Saccharomyces cerevisiae and the multicellular eukaryote Physcomitrella patens. The weekly lecture gives students the background necessary to understand and perform their experiments, including information on a variety of bioinformatics tools, phylogeny, protein structure, molecular techniques, cell biology, and microscopy. In addition, students use primary literature to understand the role their assigned protein plays in their cellular process. Prerequisites: Biol 2960 and Biol 2970. Credit 4 units. A&S: NS A&S IQ: NSM BU: SCI

L41 Biol 4580 Principles of Human Anatomy and Development
This course is designed for both undergraduate and graduate students in the anthropological, biological, and/or pre-medical sciences who wish to learn about human anatomy from various evolutionary, functional, developmental, and clinical perspectives. Lectures will emphasize the organizational and developmental principles of various organ systems of the human body. The course will also make use of our extensive anatomy museum of labeled dissected human specimens as well as our cast collections of numerous specimens from the human fossil record where appropriate. Frequent use of X-rays, CT, and MRI scans will also be used to help students visualize human anatomy from a number of different imaging modalities. Prerequisites: Undergraduate or graduate students in the anthropological, biological, and/or pre-medical sciences who have had at least one course in physical anthropology and/or biology, or consent of instructor. Same as L48 Anthro 4581 Credit 3 units. A&S: NS A&S IQ: NSM BU: SCI

L41 Biol 4524 Structural Bioinformatics of Proteins
Students have access to high-quality, experimentally determined, three-dimensional structures of proteins provided by the Seattle Structural Genomics Center for Experimental Disease and contribute to this ongoing project by using cutting-edge structural bioinformatics tools and methods to analyze and to interpret these structures. Students who provide outstanding analyses are eligible to co-author a scientific paper. Topics include: structural quality assurance and validation, protein-structure prediction, domain and motif recognition, secondary structure prediction, protein and structure-based sequence analyses, inferring protein function from structure, electrostatic interactions, threading and homology modeling. One hour of lecture and six hours of computer laboratory per week. Fulfills upper-level laboratory requirement for the biology major. Credit 4 units. A&S: NS A&S IQ: NSM BU: SCI

L41 Biol 4522 Laboratory in Protein Analysis, Proteomics and Protein Structure
In this laboratory course, students learn principles and methods of protein quantitation, protein purification, assessment of purity using SDS-polyacrylamide gel electrophoresis, separation of complex protein mixtures by 2-dimensional gel electrophoresis, definition of units of enzymatic activity, and identification of proteins using antibodies and/or mass spectrometry. The final part of the course introduces students to concepts of structural biology including protein crystalization, X-ray crystallography and computer modeling of protein structures. Fulfills the upper-level laboratory requirement for the biology major. Prerequisites: Chem 252 and either Biol 451 or Biol 4501/Chem 456. Permission of instructor required. Limit: eight students. Eight hours of laboratory/lecture per week. Credit 3 units. A&S: NS A&S IQ: NSM BU: SCI

L41 Biol 4523 Mutagenesis and Enzyme Analysis
Molecular Methods in Enzyme Analysis. Understanding enzyme structure and function is essential in many important drug design projects. This course focuses on common methods used to investigate enzyme active sites to elucidate binding interactions between small molecules and enzymes. Students use 3-D protein viewing software to design and model modifications to enzymes and purify proteins, and use UV spectroscopy to analyze enzyme activity. This is an investigative course in which students perform collaborative research projects in small groups. Fulfills the upper-level laboratory requirement for the generic biology major and the biochemistry track; intended for students who have no other courses that fulfill these requirements. Prerequisite: Biol 2970. Limit 12 Credit 4 units. A&S: NS A&S IQ: NSM BU: SCI

L41 Biol 4810 General Biochemistry I
Continuation of General Biochemistry I. Topics include carbohydrate, lipid and amino acid metabolism, signal transduction, transport across membranes, DNA replication and repair, transcription and translation, molecular motors, mechanisms of drug action and natural products biosynthesis. Prerequisite: Chem 481 or Biol 481. Same as L07 Chem 481 Credit 3 units. A&S: NS A&S IQ: NSM Arch: NSM BU: SCI

L41 Biol 4820 General Biochemistry II
Continuation of General Biochemistry I. Topics include carbohydrate, lipid and amino acid metabolism, signal transduction, transport across membranes, DNA replication and repair, transcription and translation, molecular motors, mechanisms of drug action and natural products biosynthesis. Prerequisite: Chem 481 or Biol 481. Same as L07 Chem 482 Credit 3 units. A&S: NS A&S IQ: NSM Arch: NSM BU: SCI

L41 Biol 4830 Bioenergy
A broad overview of the flow of energy, captured from sunlight during photosynthesis, in biological systems and current approaches to utilize the metabolic potentials of microbes and plants to produce biofuels and other valuable chemical products. An overall emphasis is placed on the use of large-scale genomic, transcriptomic and metabolomic datasets in
biochemistry. The topics covered include photosynthesis; central metabolism; structure and degradation of plant lignocellulose; and microbial production of liquid alcohol, biodiesel, hydrogen and other advanced fuels. Course meets during the second half of the spring semester. Prerequisite: Biol 4810 or permission of instructor.
Credit 2 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 4832 Molecular Mechanisms of Photosynthesis and Respiration
Photosynthesis is a biological process whereby the Sun’s energy is captured and stored by a series of events that convert the pure energy of light into the free energy needed to power life. Respiration is a biological process that extracts energy in a usable form from high-energy compounds produced by photosynthesis. This course examines these essential biological processes at the molecular level in both bacterial and eukaryotic organisms. Emphasis is on chemiosmotic principles as well as the structure and mechanism of action of the protein complexes that carry out photosynthesis and respiration. Additional topics include the assembly and regulation of these protein complexes and the origin and evolution of these processes. Prerequisite: Chem 482, Biol 4820 or Biol 451 or permission of instructor.
Credit 3 units. A&S: NS A&S IQ: NSM

L41 Biol 487 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/No credit only.
Credit variable, maximum 3 units. A&S: NS Art: NSM

L41 Biol 488 Undergraduate Teaching
Exceptional undergraduates serve as teaching assistants for laboratory and/or discussion sections in departmental courses. Normally 2 or 3 units are given per semester, subject to the approval of the instructor and the department. Credit may not be counted toward fulfilling the biology major; application form in Department of Biology Student Affairs office. Prerequisite: permission of instructor. Credit/No credit only.
Credit variable, maximum 3 units. A&S: NS

L41 Biol 493 Seminar in Advanced Biology
In special cases, credit may be given for individual study. Topics of study and credit must be arranged with a faculty sponsor and approved by the department.
Credit variable, maximum 4 units. A&S: NS A&S IQ: NSM Art: NSM

L41 Biol 4933 Molecular Biology on the Cutting Edge
Recent biomedical discoveries have been greatly advanced through the development of innovative, state-of-the-art techniques. For example, Nuclear Magnetic Resonance (NMR) has proved to be an invaluable tool in both efforts to determine the atomic structure of proteins and small molecules, as well as in clinical settings, as MRI to identify tumors that would otherwise go unnoticed. This course introduces students to a variety of cutting-edge laboratory techniques, and discusses the impact of these techniques on biology and medicine. Students have the unique opportunity to learn from graduate students employing these approaches in their doctoral studies. Topics to be covered include: high-throughput sequencing of genetic disorders, x-ray crystallography, and single molecule force spectroscopy by AFM. Weekly classes consist of a 30-45 minute presentation on a particular technique, followed by a 60-minute discussion of the assigned readings. Prerequisites: Biol 2960 and 2970 and at least one semester of Biol 500 or equivalent research experience approved by the course master.
Credit 2 units. A&S: NS A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4934 Neuroscience Futures 2
Students in this course engage with the neuroscience community both at Washington University and beyond by attending, summarizing and discussing neuroscience seminars on campus throughout the semester. Specifically, students are expected to attend three neuroscience seminars over the course of the semester and submit summaries of each seminar. Students meet twice during the semester, in week 5 and week 11, for guided discussion of the science in the seminars they attended. Additionally, students in this seminar attend two combined classes with Neuroscience Futures 1 during the first and last weeks of the semester. In both meetings, students have an opportunity to give brief presentations on their own research. The last class combines short student presentations with a keynote address from an invited speaker from within or outside the Washington University neuroscience community.
Credit 1 unit. BU: SCI

L41 Biol 4935 Undergraduate Research Perspectives
The purpose of this course is for undergraduates to acquire a broad perspective on their hands-on research. What are your big questions? How will you communicate your discoveries? How do your results fit with what has gone before? Each semester will have a focus, which might be science communication, statistics or critical reading, for example. Required activities may include weekly writing, participation in the undergraduate poster session, research, presentations and attendance. Enrollment is by permission only from Joan Strassmann. This course is required for undergraduates conducting research in the Queller/Strassmann laboratories and is open to other students involved in research. Joan Strassmann, David Queller, and selected postdoctoral fellows.
Credit variable, maximum 3 units. A&S: NS A&S IQ: NSM BU: SCi