Biology

Biology is an exciting, diverse field that ranges 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 they 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 test biological hypotheses, and the technical skills needed to conduct 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, to identify ambiguities and uncertainties in the 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, the Children's Discovery Institute, the National Science Foundation, and the Washington University Office of Undergraduate Research. Detailed information about finding a research mentor (https://pages.wustl.edu/Bio_200-500_independent_research/bio-200500-course-information-page) is available online.

Phone: 314-935-6860
Email: webmaster@biology.wustl.edu
Website: http://wubio.wustl.edu

Faculty

Chair
Joseph Jez (https://biology.wustl.edu/people/joseph-jez)
PhD, University of Pennsylvania

Endowed Professors
Jonathan B. Losos (https://biology.wustl.edu/people/jonathan-losos)
William H. Danforth Distinguished Professor
PhD, University of California, Berkeley

Himadri B. Pakrasi (https://biology.wustl.edu/people/himadri-pakrasi)
Myron and Sonya Glassberg/Albert and Blanche Greensfelder Distinguished University Professor
PhD, University of Missouri-Columbia

David C. Queller (https://biology.wustl.edu/people/david-queller)
Spencer T. Olin Professor of Biology
PhD, University of Michigan

Barbara A. Schaal (https://biology.wustl.edu/people/barbara-schaal)
Mary-Dell Chilton Distinguished Professor in Arts & Sciences
PhD, Yale University

Joan E. Strassmann (https://biology.wustl.edu/people/joan-strassmann)
Charles Rebstock Professor of Biology
PhD, University of Texas at Austin

Richard D. Vierstra (https://biology.wustl.edu/people/richard-d-vierstra)
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PhD, Michigan State University

Peter Wyse Jackson (https://biology.wustl.edu/people/peter-wyse.jackson)
George Engelmann Professor of Botany
PhD, Trinity College Dublin

Professors
Roger Beachy (https://biology.wustl.edu/people/roger-beachy)
PhD, Michigan State University

Douglas L. Chalker (https://biology.wustl.edu/people/douglas-chalker)
PhD, University of California, Irvine

Ian Duncan (https://biology.wustl.edu/people/ian-duncan)
PhD, University of Washington

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Philip A. Osdoby (https://biology.wustl.edu/people/philip-osdoby) PhD, Case Western Reserve University
Paul S.G. Stein (https://biology.wustl.edu/people/paul-stein) PhD, Stanford University

Associate Professors
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Ram Dixit (https://biology.wustl.edu/people/ram-dixit) PhD, Cornell University
Jonathan A. Myers (https://biology.wustl.edu/people/jonathan-myers) PhD, Louisiana State University
Hani Zaher (https://biology.wustl.edu/people/hani-zaher) PhD, Simon Fraser University

Assistant Professors
Joshua Blodgett (https://biology.wustl.edu/people/joshua-blodgett) PhD, University of Illinois
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Carlos A. Botero (https://biology.wustl.edu/people/carlos-botero) PhD, Cornell University
Swanne Gordon PhD, University of California, Riverside
Keith B. Hengen (https://biology.wustl.edu/people/keith-hengen) PhD, University of Wisconsin-Madison
Michael Landis (https://biology.wustl.edu/people/michael-landis) PhD, University of California, Berkeley
Andrés López-Sepulcre PhD, University of Jyväskylä

Scott A. Mangan (https://biology.wustl.edu/people/scott-mangan) PhD, Indiana University
Rachel M. Penczykowski (https://biology.wustl.edu/people/rachel-penczykowski) PhD, Georgia Institute of Technology

Joint Professors
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Professors Emeriti
Robert E. Blankenship (https://biology.wustl.edu/people/robert-blankenship) PhD, University of California, Berkeley
Sarah C.R. Elgin (https://biology.wustl.edu/people/sarah-elgin) PhD, California Institute of Technology
Ursula W. Goodenough (https://biology.wustl.edu/people/ursula-goodenough) PhD, Harvard University
Tuan-hua David Ho (https://biology.wustl.edu/people/tuan-hua-david-ho) PhD, Michigan State University
George B. Johnson (https://biology.wustl.edu/people/george-johnson) PhD, University of Virginia
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Peter H. Raven (https://biology.wustl.edu/people/peter-raven) PhD, University of California, Los Angeles
Nobuo Suga (https://biology.wustl.edu/people/nobuo-suga) PhD, Tokyo Metropolitan University
Alan R. Templeton (https://biology.wustl.edu/people/alan-templeton) PhD, University of Michigan
Majors
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>
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<tr>
<td>or Chem 105</td>
<td>Introductory General Chemistry I</td>
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</tr>
<tr>
<td>Chem 112A</td>
<td>General Chemistry II (or Chem 106)</td>
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<tr>
<td>Introductory General Chemistry II)</td>
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<td></td>
</tr>
<tr>
<td>Chem 151</td>
<td>General Chemistry Laboratory I</td>
<td>2</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>
<tr>
<td>Math 132</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>Math 2200</td>
<td>Elementary Probability and Statistics</td>
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</tr>
<tr>
<td>or Math 233</td>
<td>Calculus III</td>
<td></td>
</tr>
<tr>
<td>or Math 3200</td>
<td>Elementary to Intermediate Statistics</td>
<td></td>
</tr>
<tr>
<td>Data Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics 191</td>
<td>Physics I</td>
<td>3</td>
</tr>
<tr>
<td>Physics 191L</td>
<td>Physics I Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>Physics 192</td>
<td>Physics II</td>
<td>3</td>
</tr>
<tr>
<td>Physics 192L</td>
<td>Physics II Laboratory</td>
<td>1</td>
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<tr>
<td>Total Units</td>
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<td>40</td>
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</table>

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 the 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 374, Biol 387, Biol 388, Biol 4202, Biol 429, Biol 487 or Biol 488; cross-listed courses originating in other departments (except Biol 360, Biol 4580, Biol 4810, Biol 4820 and Biol 4833, 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 the following 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 324</td>
<td>Human Genetics</td>
<td>3</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 370</td>
<td>Animal Behavior</td>
<td>3</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>3</td>
</tr>
<tr>
<td>Biol 4195</td>
<td>Disease Ecology</td>
<td>4</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:
The Major in Biology: Genomics and Computational Biology Track

Additional requirements include Biol 3371 (or Biol 324 or Biol 4183 or Biol 548), Math 2200 or Math 3200, and two outside electives (CSE 131 and CSE 247). CSE 240 is strongly recommended. The course used to fulfill the advanced laboratory requirement for the major must be Biol 3492, Biol 4342, Biol 434W, Biol 437 or Biol 4525. 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 Math 217 and Math 309.

The Major in Biology: Microbiology Track

Additional requirements include Biol 349, which should be taken during the spring of the 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 or Biol 4520. At least one of the following must be taken as an advanced microbiology elective: Biol 4492, Biol 4832 or 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 or EPSc 323. Biol 3501 is highly recommended as the course used to fulfill biology major area C. The total number of 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 as well as one of the following: 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 or Biol 4525. Additional biology courses recommended for students in this track include Biol 3041, Biol 4023, Biol 4071, Biol 4183, Biol 4832, Biol 4833 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), and any course in area C. Students must then choose one of the following laboratory pathways: (1) Laboratory Pathway 1: one of the following courses: Biol 360, Biol 373W or Biol 404; or (2) Laboratory Pathway 2: any other upper-level biology laboratory course on the list of approved laboratory courses for the biology major plus 6 credits of Biol 500N and/or Biol 500U (Independent Research in Neuroscience). 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 355 or Physics 360) or psychology (Psych 330, Psych 360 or Psych 364). Math 2200 or Math 3200 is recommended. Optional seminar courses in neuroscience include Biol 171 and Biol 4934. Physics 360 may count either as the advanced laboratory requirement or the outside elective course but not for both requirements.

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/artsci/philosophyneurosciencepsychology/#majors) and philosophy of science (http://bulletin.wustl.edu/undergrad/artsci/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 first year of study, although it may be taken later. A 400-level course 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>
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</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>
<tr>
<td>Chem 111A or Chem 105</td>
<td>General Chemistry I (lecture and lab)</td>
<td>3</td>
</tr>
<tr>
<td>Chem 112A</td>
<td>General Chemistry II (or Chem 106 Introductory General Chemistry I)</td>
<td>3</td>
</tr>
<tr>
<td>Chem 151</td>
<td>General Chemistry Laboratory I</td>
<td>2</td>
</tr>
<tr>
<td>Chem 152</td>
<td>General Chemistry Laboratory II</td>
<td>2</td>
</tr>
<tr>
<td>EPSc 201</td>
<td>Earth and the Environment (lecture and lab)</td>
<td>4</td>
</tr>
<tr>
<td>or EPSc 219</td>
<td>Energy and the Environment</td>
<td></td>
</tr>
<tr>
<td>Math 131</td>
<td>Calculus I</td>
<td>3</td>
</tr>
<tr>
<td>Math 132</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>Physics 191</td>
<td>Physics I</td>
<td>3</td>
</tr>
<tr>
<td>Physics 191L</td>
<td>Physics I Laboratory</td>
<td>1</td>
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</table>

**Total Units**

38

**One of the following chemistry courses:**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Chem 261</td>
<td>Organic Chemistry I with Lab</td>
<td>4</td>
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<tr>
<td>EPSc 323</td>
<td>Biogeochemistry</td>
<td>3</td>
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<tr>
<td>EECE 210</td>
<td>Introduction to Environmental Engineering</td>
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<tr>
<td>EECE 505</td>
<td>Aquatic Chemistry</td>
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</tr>
<tr>
<td>EECE 531</td>
<td>Environmental Organic Chemistry</td>
<td>3</td>
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</table>

**One of the following courses in statistics or GIS:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 2200</td>
<td>Elementary Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 3200</td>
<td>Elementary to Intermediate Statistics and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EnSt 380</td>
<td>Applications in GIS</td>
<td>3</td>
</tr>
</tbody>
</table>

**One upper-level biology lab course:**

Any course that fulfills the advanced laboratory requirement of the biology major is acceptable; we recommend Biol 4193 Experimental Ecology Laboratory (4 credits, writing intensive).

**One of the following Biol 300+ courses (Areas A and B in 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 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 334</td>
<td>Cell Biology</td>
<td>3</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 349</td>
<td>Microbiology</td>
<td>4</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 451</td>
<td>General Biochemistry</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4580</td>
<td>Principles of Human Anatomy and Development</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4810</td>
<td>General Biochemistry I</td>
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</tr>
</tbody>
</table>

**One of the following Biol 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 370</td>
<td>Animal Behavior</td>
<td>3</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>3</td>
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</tbody>
</table>
**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</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 (or 106)</td>
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</tr>
<tr>
<td>Chem 151</td>
<td>General Chemistry Laboratory I</td>
<td>2</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>
</tbody>
</table>

**Total Units:** 22

**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>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3010</td>
<td>Biotechnology Project</td>
<td>3</td>
</tr>
<tr>
<td>Biol 3041</td>
<td>Plant Biology and Genetic Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Biol 3058</td>
<td>Physiological Control Systems</td>
<td>2</td>
</tr>
<tr>
<td>Biol 3100</td>
<td>R Workshop in Biology</td>
<td>1</td>
</tr>
<tr>
<td>Biol 3110</td>
<td>Vertebrate Structure Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>Biol 3151</td>
<td>Endocrinology</td>
<td>3</td>
</tr>
<tr>
<td>Biol 324</td>
<td>Human Genetics</td>
<td>3</td>
</tr>
<tr>
<td>Biol 328</td>
<td>Principles in Human Physiology</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 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 347</td>
<td>Darwin and Evolutionary Controversies</td>
<td>3</td>
</tr>
<tr>
<td>Biol 349</td>
<td>Microbiology</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 3501</td>
<td>Evolution</td>
<td>4</td>
</tr>
<tr>
<td>Biol 360</td>
<td>Biophysics Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Biol 370</td>
<td>Animal Behavior</td>
<td>3</td>
</tr>
</tbody>
</table>

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**Additional Information**

**Research:** Research opportunities are available during the student's first and second years through Biol 200; such opportunities are available during 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 as a research milestone.

**Senior Honors:** Biology majors are encouraged to work for senior honors, which require a 3.30 grade-point average in biology, a 3.30 GPA in nonbiological sciences (mathematics, chemistry and physics courses), and a 3.65 overall GPA 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 the spring of the junior year.

The Biology department awards the Marian Smith Spector Prize to an undergraduate who has an excellent academic record and who submits an outstanding honors thesis as well as the Ralph S. Quatrano Prize to the student whose thesis shows the greatest evidence of creativity in design, research methodology and/or broader scientific implications. It also awards the Harrison D. Stalker Prize to a graduating senior whose college career is distinguished by scholarship, service and breadth of interest.
### Additional Information

All courses used 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.

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### The Minor in Bioinformatics

Mindful of the emerging opportunities at the interface of biology and computer science, the Department of Biology and the Department of Computer Science & Engineering have fashioned the minor in bioinformatics. This program serves students from both departments as well as other students from the natural sciences and engineering with an interest in this field.

**Units required:** 23-24 units, as described below

### Core 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>CSE 131</td>
<td>Introduction to Computer Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 247</td>
<td>Data Structures and Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>ESE 326</td>
<td>Probability and Statistics for Engineering</td>
<td>3</td>
</tr>
<tr>
<td>or Math 3200</td>
<td>Elementary to Intermediate Statistics and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Analysis</td>
<td></td>
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<tr>
<td>or DAT 120 &amp; DAT 121</td>
<td>Managerial Statistics I and Managerial Statistics II</td>
<td></td>
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</tbody>
</table>

**Total Units:** 17

### Advanced biology elective: Choose one of the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 3492</td>
<td>Laboratory Experiments with Eukaryotic Microbes</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4181</td>
<td>Population Genetics</td>
<td>3</td>
</tr>
<tr>
<td>Biol 4342</td>
<td>Research Explorations in Genomics</td>
<td>4</td>
</tr>
<tr>
<td>Biol 437</td>
<td>Laboratory on DNA Manipulation</td>
<td>4</td>
</tr>
<tr>
<td>Biol 4525</td>
<td>Structural Bioinformatics of Proteins (Writing Intensive)</td>
<td>4</td>
</tr>
</tbody>
</table>

### Computer Science & Engineering elective: Choose one of the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 514A</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>CSE 584A</td>
<td>Algorithms for Biosequence Comparison</td>
<td>3</td>
</tr>
<tr>
<td>or L41 Biol 5504</td>
<td>Algorithms for Biosequence Comparison</td>
<td></td>
</tr>
<tr>
<td>CSE 587A</td>
<td>Algorithms for Computational Biology</td>
<td>3</td>
</tr>
</tbody>
</table>

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used to fulfill the minor requirements may not be used to fulfill the requirements of another major or minor in Arts & Sciences. A minimum grade of C- is required for all courses to count toward the minor.

Courses


L41 Biol 112 First-Year Seminar: Introduction to Problem-Based Learning in Biology

In this course, students take responsibility for their own active, inquiry-based learning about biological problems. Instructors will guide small groups of four to six students in researching issues of biological importance using primary literature as their principal resource. Learning to read and interpret research articles from scientific literature is emphasized. Topics covered in this class have included neurological disorders, infectious diseases, CRISPR, cancer, and stem cell therapy, among others. Students should have a strong background in general biology. They will be challenged to use critical and creative thinking in both independent and group work. Enrollment is limited and intended for (but not limited to) prospective biology majors. Prerequisite: high school biology, preferably an Honors or AP class. Course is for first-year, non-transfer students only.
Credit 3 units. A&S: FYS & A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 1260 First-Year Seminar: 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 they 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 they have been modified by humans to provide food, fiber, and fuel; and how genetically modified (GMO) crops are made and their implications related to the environment and society. The overall goals are to enhance students' understanding and appreciation of the plant kingdom, to help young scientists understand the primary scientific literature, and to serve as a starting point for possible careers in plant biology. Class includes field trips to the Missouri Botanical Gardens and to a local plant biotech company/institute. Where appropriate, the class will also emphasize key differences between plants and animals. This course is primarily for first-year students 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, how 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. The course will have a lecture/discussion/hands-on format for two of the three hours per week. Students will present 20-minute papers discussing topics relevant to their interests for the remaining hour (two students per class).

Prerequisites: Students must have taken both biology and chemistry in high school and at least one of the AP or IP level, or they must have taken Biol 2960 or Chem 111/112. This course can be taken by both first-year and upper-level undergraduates, with a preference given to first-year students.
Credit 3 units. A&S: FYO & A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 144 First-Year Seminar: The Biology of Cancer

Cancer is the second-leading cause of death worldwide. Despite focused research efforts, cancer still poses a unique biomedical puzzle: it is now recognized that cancer is not a single disease but rather a collection of many disorders with underlying mechanistic complexities that can affect most tissues in the human body. This interactive first-year course provides an introductory overview of the biology, diagnosis, and treatment of human cancers. We touch upon background topics in DNA structure and replication, gene regulation and transcription, and mutations and DNA repair, but the primary focus is on the genetic events that lead to cancer. Students will learn how normal cells undergo during transformation into malignant cancer cells, emphasizing the dysfunction of essential biological processes like programmed cell death, cell proliferation, differentiation, and immune surveillance. Classical diagnosis and treatment methods are compared with newer strategies, such as targeted therapies. Finally, the growing role of "omics" technologies in tumor classification, patient prognosis, and therapy are discussed.
The course is a mix of lectures, student-led discussions/presentations, guest seminars, and activities (e.g., on-site visits to Siteman Cancer Center, a medical pathology lab, and the McDonnell Genome Institute). Lectures provide an overview of each topic, while activities and discussions of cutting-edge oncology topics in the news and primary literature familiarize students with current trends in cancer research/treatment and enhance students' reading and critical analytical skills. Students choose a specific type of cancer for further study, and, near the end of the semester, they prepare a presentation to the class on that type's molecular and cellular etiology, epidemiology, pathology, diagnosis, and current/future treatment options.
Prerequisite: high school biology. For first-year students only; recommended for those intending to pursue further studies in the biological sciences. Limited to 20 students.
Credit 3 units. A&S: FYS & A&S IQ: NSM BU: SCI

L41 Biol 171 First-Year Opportunity: Neuroscience Futures I: 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. Course is for first-year, non-transfer students only.
Credit 1 unit. A&S: FYO Arch: NSM Art: NSM BU: SCI

L41 Biol 1770 First-Year Opportunity: The Biology 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.
L41 Biol 1771 Special Topics in Biology: Plant-Associated Microbes — Friends or Foes?
This is a new research-based laboratory course offered by Dr. Barbara Kunkel in the Department of Biology. The small class size and the laboratory setting of the course are intended to foster the development of student-professor mentoring relationships. The main focus of this course will be the very important roles that microbial communities play in the lives of plants and animals. For example, in nature as well as in agricultural settings, the communities of microorganisms that grow on or near a plant influence the growth and overall health of that plant. These plant-associated microbial communities are highly complex, and they are comprised of thousands of different species, including bacteria and fungi. However, neither the role of individual microbial species within the larger microbial community nor how such a community is beneficial to plants is well understood. Natural microbial communities contain many potential pathogenic organisms that can potentially infect and cause disease on their hosts. This fact leads to the following question: How can these organisms grow in proximity to or even on their hosts without causing disease? One hypothesis is that these organisms may have additional roles in the context of a larger microbial community that can ultimately be of benefit to their host. We will investigate these questions by characterizing a collection of natural isolates of potential plant pathogenic bacterial strains from the genus Pseudomonas. Students will spend two hours per week in the lab characterizing the new Pseudomonas isolates. Over the course of the semester, students will be exposed to a variety of fundamental topics in biology, including microbiomes, beneficial and pathogenic plant-microbe interactions, bacterial cell biology and genetics, and key concepts in molecular biology and biochemistry. The students will also meet with Dr. Kunkel for one hour per week to discuss a variety of topics in the following areas: (1) basic concepts in chemistry, biochemistry and molecular biology; (2) learning and study strategies; and (3) other topics related to thriving at Washington University.
Credit 1 unit.

L41 Biol 181 First-Year Opportunity: Research and Conservation in Zoos and Botanical Gardens
An introduction to the world of zoos and botanical gardens. Students will learn of the diverse and cutting-edge ways in which scientists and conservationists study the world's biological diversity and work to conserve it. Taking advantage of two world-class institutions a short distance from the Danforth Campus, the class will meet every week at an off-campus site (primarily the Saint Louis Zoo and Missouri Botanical Garden, but also several other institutions) to hear lectures from leading authorities at these institutions and to tour facilities to see firsthand how research is conducted and how these institutions work to preserve endangered species. Students will write three short papers; each paper will be based on a class lecture and its associated readings. Must be taken credit/no credit. Course is for first-year, non-transfer students only.
Credit 2 units. A&S: FYO A&S IQ: NSM

L41 Biol 1811 First-Year Opportunity: Research and Conservation in Zoos and Botanical Gardens
An introduction to laboratory and field research in wildlife conservation. Students work under the supervision of a mentor in a setting of established, ongoing research. Prerequisites: less than 60 units completed; permission of mentor and the department. For online
Credit 3 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 191 Ampersand: 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 the isolation and purification of their own phage, DNA isolation and restriction mapping, and EM characterization of the phage. Several Washington University phages are selected for genome sequencing over winter break, and they are annotated during the spring in Biol 192. 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 of which is 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. Course is for first-year students in the Phage Hunters Program only.
Same as L61 FYP 1910
Credit 3 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 192 Ampersand: Phage Bioinformatics
This is 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 during the 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; preference given to those completing Biol 191 Phage Hunters. One hour lecture, one hour discussion, and three hours lab per week.
Same as L61 FYP 1920
Credit 3 units. A&S: AMP A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 200 Introduction to Research
This is an introduction to laboratory and field research in biology for first- and second-year students. Students work under the supervision of a mentor in a setting of established, ongoing research. Prerequisites: less than 60 units completed; permission of mentor and the department. For online
Credit 1 unit. A&S: FYO A&S IQ: NSM Art: NSM

L41 Biol 201 Introduction to Research
This is an introduction to laboratory and field research in biology for first- and second-year students. Students work under the supervision of a mentor in a setting of established, ongoing research. Prerequisites: less than 60 units completed; permission of mentor and the department. For online
Credit 1 unit. A&S: FYO A&S IQ: NSM Art: NSM

L41 Biol 202 Introduction to Research
This is an introduction to laboratory and field research in biology for first- and second-year students. Students work under the supervision of a mentor in a setting of established, ongoing research. Prerequisites: less than 60 units completed; permission of mentor and the department. For online
Credit 1 unit. A&S: FYO A&S IQ: NSM Art: NSM
enrollment instructions, visit the Bio 200/500 webpage (https://pages.wustl.edu/Bio_200-500_independent_research/register). Students are registered by the department after approval is granted. Registration may not appear in WebSTAC until mid-semester. Credit/no credit only. Credit variable, maximum 3 units. A&S IQ: NSM

L41 Biol 200S Summer Introduction to Research
Summer research under the supervision of a faculty mentor. Prerequisites: first-year or sophomore standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit during different summers. Credits are received during the fall semester after the summer research. The application deadline and registration information can be found on the Bio 200/500 course website (https://pages.wustl.edu/Bio_200-500_independent_research). Credit/no credit only. Credit variable, maximum 3 units. A&S IQ: NSM

L41 Biol 2010 Ampersand: 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 it teaches scientific concepts to business students considering careers in biotech management and entrepreneurship. Students who complete this course understand key science concepts. They also know how discoveries lead to applications that address global challenges, how to effectively use a variety of resources to explore connections between science and biotech business, how to synthesize information from different fields, how to exhibit strong teamwork skills, and how to communicate information in written and oral forms. In addition, this course serves as a gateway for students 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 three-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. Course is for students in the BEP only. Credit 1 unit. A&S: FYS A&S IQ: NSM BU: SCI

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: FYS A&S IQ: REQ

L41 Biol 2350 Introduction to Biological Reasoning
Students will work to develop a fluency in biological language, methods, and reasoning as applied to human health. We will study the molecular, cellular, and physiological perspectives for each health-related topic. We will zoom in to study processes at the molecular level, swing back out again to examine processes at the cell or physiological level, and examine data and methods that support this knowledge. We will emphasize problem-solving and reasoning as it applies to understanding biological processes. This course is for first-year students only. It does not count for credit toward the biology major. Prerequisite: permission of instructor. Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 2651 MedPrep I: The Lecture Series
MedPrep I is a unique lecture series taught by a physician, a former medical school course master, and a 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 about every step of the application and admissions process for medical school, the entire educational process (including medical school and residency training), and the pros and cons of life as a physician. MedPrep I is particularly useful for first-year students and sophomores in that it reviews the common pitfalls encountered by unsuccessful applicants to medical school and outlines the steps to take during each year of college to be a successful
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. Research Associates (RAs) 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 from 1:30-3:30 p.m. in conference room 10A of the Northwest Tower Building (across from Children's Hospital). Lectures are given by Emergency Department faculty members. This program offers students the unique opportunity to be a vital part of the Emergency Department research team. In addition, the RA's experience in the Emergency Department may help them determine if medicine is truly the career path they wish to choose. Prerequisite: sophomore level or higher and approval of instructor. Registration is done through the PEMRAP website (https://pages.wustl.edu/pemrap). May not be taken concurrently with Biol 2654 MedPrep II. Credit 1 unit.

L41 Biol 2654 MedPrep II: The Shadowing Experience: Emergency Medicine
MedPrep II offers students the 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. In addition to the shadowing, there is a required class session every other week. Because of the orientation material presented, excused absences will not be granted for the first two sessions for any reason whatsoever, including illness or emergency. There is no outside course work and no exams. A $25 course fee as well as HIPAA training and PPD testing are required. For more information and to register for this course, please visit the MedPrep Program website (http://pages.wustl.edu/medprep). Registration is done through the website, not through WebSTAC. Prerequisites: successful completion of Biol 2651 and sophomore standing or above. During the summer semester, students may take Biol 2651 and Biol 2654 concurrently. 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 inter-professional 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 Biol 2652 Pediatric Emergency Medicine Research Associates Program: Experiences in Life Sciences. Returning PEMRAP Research Associates (RAs) 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 Emergency Department (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 ED research team in the St. Louis Children's Hospital Emergency Department. Returning RAs assist in training and mentoring incoming PEMRAP students (Biol 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 for meeting hospital non-appointee requirements and staying current with new study protocols by attending or viewing new study presentations for PEMRAP students. These lectures are given by Pediatric Department faculty members to introduce the basics of the clinical research process, specific studies, and 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 2651, Biol 2652, or Biol 2654. Enrollment with permission of instructor. Prerequisite: Biol 2652 (PEMRAP I). Pass/fail, 1 to 2 units per semester. Credit variable, maximum 2 units.

L41 Biol 2659 MedPrep III: The Shadowing Experience: Inpatient Medicine
This is a new shadowing course that will take place on the inpatient wards of Barnes-Jewish Hospital, the main teaching hospital of the Washington University School of Medicine. For four hours every other week, students shadow physicians on a specialty service and remain with that service for the duration of the semester. Students will have the opportunity to rank order their preference of specialty but will be assigned based on availability. No guarantees can be made to place a student in their most preferred specialty. In order to participate, students must have one morning a week that they are completely free between 6 a.m. and 12 p.m. In addition to shadowing, there is a required class session every Wednesday from 6:30 to 7:30 p.m. Because of the orientation material presented, excused absences will not be granted for the first two sessions for any reason whatsoever, including illness or emergency. There is no outside course work and no exams. A $25 course fee as well as HIPAA training and tuberculosis testing are required. For more information and to register for this course, please visit the MedPrep website (http://pages.wustl.edu/medprep). Registration is done through the MedPrep website, not through WebSTAC.
Prerequisite: successful completion of MedPrep I (Bio 2651) and sophomore standing or above.
Credit 1 unit.

L41 Biol 2950 Introduction to Environmental Biology
Introduction to Environmental Biology is designed to teach important principles of environmental biology and general science literacy skills. We cover the foundational biological principles and contemporary issues within four main topics: human population growth, transfer of energy and carbon in the ecosystem, biodiversity, and food production. We focus on the biological principles involved as we examine these topics in the context of some contentious and confusing issues related to environmental biology in everyday life. The science literacy skills that you master in this course will help you address the issues you face in your everyday life regarding scientific and pseudoscientific claims about the environment and society and will form the foundation for your development as a critical consumer of science information in the media. This course is required for all environmental biology majors and environmental studies minors. We recommend you take this course in your first- or second-year if possible. If your interests align and your schedule allows, we recommend co-enrolling in EnSt 215: Introduction to Environmental Humanities.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 2960 Principles of Biology I
This course provides an introduction to biochemistry, cell biology, and molecular biology. An understanding of cellular architecture and mechanisms and of the properties of biological macromolecules are integrated with a discussion of the flow of genetic information within cells. The course ends with the application of this understanding to selected areas in modern biology. Weekly labs reinforce concepts from the lectures and explore common laboratory techniques and computer-based resources. The completion of Chem 111A and concurrent enrollment in Chem 112A are strongly recommended but not required. Three hours of lecture and two hours of lab per week. Large class and small lab sections.
Credit 4 units. A&S IQ: NSM Arch: 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, nine 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 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 3D 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 IQ: NSM Arch: NSM Art: 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.
Credit 4 units. A&S IQ: NSM Arch: 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: Biol 2010 and Biol 2020. Writing intensive. Limited to 20 students.
Credit 3 units. A&S IQ: NSM, WI BU: SCI

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 IQ: NSM Arch: 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 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 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 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 (https://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 10 two-hour workshops that include a brief introduction to key concepts in R and applications in biology, followed by interactive, hands-on tutorials. Prerequisite: concurrent or prior course in statistics (Math 2200 or Math 3200) or permission of instructor. Credit 1 unit.

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 4 units. 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 IQ: NSM Art: NSM BU: SCI

L41 Biol 324 Human Genetics
This course offers broad coverage of the role of genetics in medicine, with a focus on the application of genomic technologies to the understanding of human disease. Areas covered include the identification of human disease genes, modern cytogenetics, risk assessment in pedigrees, biochemical genetics, imprinting, mitochondrial genetics, gene therapy, complex inheritance, assisted reproduction, prenatal diagnosis, immunity, cancer, and pharmacogenetics. The profound ethical and legal considerations raised by modern genetic technologies are also discussed. Credit 3 units. 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. Mechanisms of exercise physiology are integrated throughout the course. Prerequisite: Biol 3058 or equivalent. Credit 4 units. 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 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 covers 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 3 hours per week plus required discussion section meeting every other week. Prerequisites: Biol 2970, Chem 261 (may be taken concurrently). Offered every other fall in even-numbered years. Credit 4 units. A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 3411 Principles of the Nervous System
This course will provide a broad introduction to neuroscience, starting at the level of cellular and molecular neuroscience and ultimately ending at systems and theoretical neuroscience, with emphasis on the organization of the mammalian central nervous system. Topics will include neuronal structure, the action potential, information transmission between neurons, sensory/motor systems, emotion, memory, disease, drugs, behavior, and network dynamics. A fundamental goal of this course is to provide students with the ability to approach complex problems using the scientific method and to understand
the limits of knowledge. This course will also expose students to some of the neuroscience community at Washington University. Prerequisites: Biol 2960, Biol 2970 (recommended), Biol 3058 (recommended) or Psych 3401 and permission of instructor. Credit 3 units. 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 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 phenotypes; 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 IQ: NSM Art: NSM BU: SCI

L41 Biol 347 Darwin and Evolutionary Controversies
This course's focus is on controversies in evolutionary biology from Darwin's day to the present. Most of the controversies concern scientific issues such as Kelvin's estimate of the age of the earth, Jenkins's argument against blending inheritance, neutral variations, effects of isolation on the role of selection, and mass extinction and "nemesis," but some address social issues such as evolutionary ethics and "scientific creationism." Emphasis in the readings is on primary sources, including Darwin's "Origin of Species." Writing intensive. Credit 3 units. A&S IQ: NSM WI: 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 IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3491 Microbiology Laboratory
After introducing students to the basics of bacterial growth and maintenance, this laboratory class employs microscopy, genetics, cell biology, and genomics to explore various aspects of bacterial physiology, structure, and identification. Students will present findings throughout the semester in both written and oral format. Roughly 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 IQ: NSM Arch: 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 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 IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 3501 Evolution
A general survey of evolutionary biology covering both microevolution and macroevolution. Topics include natural selection, genetic drift, gene flow, sexual selection, kin selection, pathogen evolution, speciation, phylogenetics, molecular evolution, and evolutionary-developmental biology. Weekly discussion sections focus on the analysis of recent studies related to lecture topics. Prerequisite: Biol 2970. Credit 4 units. 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 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 IQ: NSM AN: Art: NSM
L41 Biol 370 Animal Behavior
This course examines animal behavior from an evolutionary perspective and explores the relationships between animal behavior, ecology, and evolution. Topics include foraging behavior, mating systems, sexual selection, predator-prey relationships, cooperation and altruism, competition, and parental care. A student may not receive credit for more than one of the courses Biol 370, Biol 372, and Biol 472. Prerequisite: Biol 2970 or permission of instructor. Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 373W Laboratory on the Evolution of Animal Behavior (Writing Intensive)
This course explores the costs, benefits, and constraints that drive the evolution of animal behavior. It is divided into four modules that cover a range of common empirical and numerical tools in modern evolutionary biology. (Note: No prior experience in any of the following topics is necessary.) The modules discussed are as follows: (1) a brief overview of basic statistics and a tutorial in R; (2) an experimental lab on agonistic behavior in crickets; (3) a computer simulation lab on the evolution of animal communication; and (4) a phylogenetic comparative analysis lab exploring the topic of sexual selection. 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 and guided to apply these concepts to the design, execution, and analysis of individual and/or collaborative research projects. In the process, they learn how to apply some of the latest numerical and/or empirical research tools in evolutionary biology. A majority of class time is devoted to active learning through the collection and analysis of data (each lab module lasts four weeks). The course also includes weekly presentations by the instructor and class discussions on topics that help place the students' work into the broader context of evolutionary theory. Prerequisite: Biol 2970 and Psych 100B or permission of instructor. This course is writing intensive. Credit 3 units. A&S IQ: NSM, WI

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 IQ: 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 and the structure and function of biological communities. It regularly touches on the applications of these principles, such as ecological responses to global climate change, consequences of habitat fragmentation, and disease ecology/conservation medicine. Principles of experimental design, quantitative data analysis and interpretation, and mathematical models are critical to the field of ecology and are emphasized throughout the course. The class meetings have an active learning format that includes lectures, regular student interaction during small-group activities, discussions, and computer simulation labs. Assignments include regular homework reading, occasional problem sets, and computer pre- and post-lab activities. Prerequisite: Biol 2970 or Biol 2950 or permission of instructor. Same as L82 EnSt 381. Credit 3 units. A&S IQ: NSM Arch: 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 IQ: NSM Art: 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 IQ: NSM Art: 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 and nitrogen, cell growth and expansion, hormone physiology and physiological responses to a changing environment. Prerequisite: Biol 2970 or permission of instructors. Credit 3 units. A&S IQ: NSM BU: SCI

L41 Biol 4030 Biological Clocks
Biological clocks are the endogenous oscillators that coordinate physiological and behavioral rhythms in nearly all organisms. This course examines how these rhythms are generated and regulated. The material includes molecular, cellular and systems physiology and the relevance of biological timing to ecology and health in everything from protozoans to plants to people. Credit 3 units. A&S IQ: NSM BU: SCI

L41 Biol 404 Laboratory of Neurophysiology
Neurophysiology is the study of living neurons. Students record electrical activity of cells to learn principles of the nervous system including sensory transduction and coding, intercellular communication and motor control. The course meets for 9 hours each week. Students may leave the lab for up to 2 hours. Prerequisites: Biol 3411 or Psych 4411 and permission of Student Coordinator, Erin Gerrity. Biol 3411 may be taken concurrently. Credit 4 units. A&S IQ: NSM, WI Art: NSM
L41 Biol 4071 Developmental Biology
An introduction to the molecular and cell biology of animal development. The course is divided into three broad sections: (1) an introduction to the major cell-cell signaling systems used during development and their study in model organisms; (2) molecular studies of early vertebrate development; and (3) the biology of stem cells. The focus is on molecular approaches applied to important model systems but framed in classical concepts. Prerequisites: Biol 2970 and Biol 334, a course in biochemistry is recommended. Small class.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4106 Topics in Anthropology: Biomechanics
Humans, like all organisms, live and evolved in a world that is governed by the rules of physics. Such an engineered world has undoubtedly had a profound impact on the human evolutionary trajectory. Biomechanics is the science of understanding the natural world around us in a mechanistic fashion, and it has become a major pillar in the investigation of the human form and its function. Understanding how humans and our closest relatives behave in and interact with a physical world can lead to novel insights into the evolution of complex traits, whether through investigating the mechanics of the tissues and structures of the human body or understanding the principles of movement and locomotion. Through lecture, discussion, and hands-on experience, this course will introduce the biomechanics terms and principles that demonstrate how this discipline has contributed to biological anthropology.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4181 Population Genetics
An introduction to the basic principles of population and ecological genetics. Mechanisms of microevolutionary processes; integrated ecological and genetic approach to study the adaptive nature of the evolutionary process. Prerequisite: Biol 2970
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 4182 Macroevolution
An advanced introduction to the study of macroevolutionary patterns and processes with emphasis on the systematic methodology employed. Topics: theories of classification, phylogenetic reconstruction, testing of historical hypotheses, hierarchy theory, adaptation, extinction, speciation, developmental mechanisms of organismal evolution, biogeography. Prerequisite: permission of instructor.
Credit 3 units. A&S IQ: NSM Art: NSM

L41 Biol 4183 Molecular Evolution
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 IQ: NSM Art: NSM

L41 Biol 419 Community Ecology
Community ecology is an interdisciplinary field that bridges concepts in biodiversity science, biogeography, evolution, and conservation. This course provides an introduction to the study of pattern and process in ecological communities, with an emphasis on theoretical, statistical, and experimental approaches. Topics include ecological and evolutionary processes that create and maintain patterns of biodiversity; biodiversity and ecosystem function; island biogeography, metacommunity dynamics, niche, and neutral theory; species interactions (competition, predation, food webs); species coexistence; and environmental change. The class format includes lectures, discussions, and computer labs focused on analysis, modeling, and presentation of ecological data using the statistical program R. Prerequisite: Biol 2970 (required), Biol 381 (recommended), or permission of instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4193 Experimental Ecology Laboratory
The goal of this course is to provide skills in the design, interpretation, and written presentation of results of ecological experiments, with emphasis on hypothesis testing, sampling methodology, and data analysis. Students have opportunities to address a variety of ecological questions using field, greenhouse, or laboratory (microcosm) studies. The course is divided into a five-hour lab period (generally held at the Tyson Research Center) and a 1.5-hour lecture/discussion period held on campus. Occasional Saturday field trips to local sites (e.g., forests, wetlands, prairies, streams) for in-depth study might be scheduled. This is a writing-intensive course, and grades are based on written assignments, including final projects, and in-class participation. This course fulfills the upper-level laboratory requirement for the Biology major. Prerequisites: permission of instructor and at least one of the following: Biol 3501, Biol 372, Biol 381, Biol 419, or Biol 472. Enrollment is limited to 15 students.
Credit 4 units. A&S IQ: NSM, WI: NSM Arch: NSM Art: NSM

L41 Biol 4195 Disease Ecology
Disease ecology is an interdisciplinary field that bridges concepts from fields including population ecology, community ecology, landscape ecology, and evolutionary biology. This course provides an introduction to the study of infectious diseases, with an emphasis on theoretical, experimental, and quantitative approaches. The course will integrate studies of infectious diseases from across disciplines including human epidemiology, veterinary medicine, wildlife epidemiology, plant pathology, parasitology, and ecology. Prerequisites: Biol 2970 required, Biol 381 recommended, or permission of instructor.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4202 Anthropological 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 IQ: NSM Arch: 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, immunoochemistry and immunoassay, 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 IQ: NSM Arch: 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 IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4270 Problem Based Learning in Biomedical Sciences
Groups of 5-8 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. Prerequisite: Biol 2970; some experience in molecular biology. A biology or science background is required. Same content as discontinued course Biol 427, but not Writing Intensive. Not available to students who have credit for Biol 427. Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

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 3D 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 (3D Printing) for physical outputs. Prerequisites: Biol 2970 or Biol 334. Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4324 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, and gene expression). In spring 2018, the research problem involved improving the sequence of a region of the Drosophila eugracilis genome and working with one of these sequences to examine patterns of genome organization, gene structure, and gene regulation. Prerequisites: Biol 297A, Chem 111/112, Chem 151/152. Although Biol 3371 or Biol 437 and some familiarity with computers would be advantageous, this is not required. Fulfills the upper-level laboratory requirement for the biology major. Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4324W 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 IQ: NSM, WI Arch: NSM Art: NSM

L41 Biol 437 Laboratory on DNA Manipulation
This course provides investigation-driven research on the experimental manipulation of DNA and RNA molecules. This includes the construction, isolation, and analysis of plasmids, RNA, PCR products, and DNA sequencing. Molecular cloning (genetic engineering), gene knockouts (mutants), RNA isolation, RT-PCR, and microarray projects are performed. Prerequisites: Biol 2960 and Biol 2970. One hour of lecture and six 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 IQ: NSM Art: NSM

L41 Biol 4492 Infectious Diseases: History, Pathology, and Prevention
This course leverages the primary research literature to examine 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, malaria, 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 500 (one semester) and permission of instructor. Preference will be given to students who have completed Biol 349. Area A. Writing Intensive. Credit 3 units. A&S IQ: NSM, WI 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, Chem 262, 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. Credit 4 units. 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.
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 crystallization, 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 IQ: NSM Arch: NSM Art: NSM BU: SCI

L41 Biol 4523 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 3D protein-viewing software to design and model modifications to an enzyme active site, then perform those modifications using recombinant DNA technology and site-directed mutagenesis. This course also introduces other commonly used methods to assay active-site metals, characterize inhibitors, overexpress 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 IQ: NSM Arch: NSM BU: SCI

L41 Biol 4525 Structural Bioinformatics of Proteins (Writing Intensive)

In this investigative laboratory course, students will be given high-quality, experimentally determined, three-dimensional structural coordinates, and they will use cutting-edge bioinformatics tools and methods to evaluate and analyze these datasets. Some topics to be covered include structural validation, protein-structure prediction, domain and motif recognition, secondary structure prediction, protein-protein and protein-ligand interactions, protein and structure-based sequence alignments, inferring protein function from structure, electrostatic interactions, and threading and homology modeling. Upon completing their analyses, students will be responsible for writing a manuscript that will be submitted to a scientific journal for publication.

Prerequisites: Biol 2960 and Chem 262. This course fulfills the upper-level laboratory requirement for the biology major.
Credit 4 units. A&S IQ: NSM WI BU: SCI

L41 Biol 4580 Principles of Human Anatomy and Development

This course will discuss the anatomy of most of the functional systems of the human body. Topics covered will include the peripheral nervous system, respiration, circulation, the skeletal system, the gastro-intestinal tract, the urogenital system, the male and female reproductive systems, locomotion, manipulation, mastication, vocalization, the visual system, the auditory system and the olfactory system. Selected topics in human embryology will also be introduced. The course provides valuable preparation for any student interested in human biology, anthropology, medicine or the health sciences.

Same as L48 Anthro 4581
Credit 3 units. A&S IQ: NSM Art: NSM BU: SCI

L41 Biol 4582 The Physiology and Biophysics of Consciousness

This course will explore the questions surrounding the search to understand the biophysical substrate of consciousness. Some areas to be explored include the following: (1) Can consciousness be addressed like any other biological property in the sense that it has evolved by natural selection and that some elements of it are present in simple model systems, such as the fruit fly? Can insight be gained studying simple model systems? (2) Where in the brain is consciousness? What is the pattern of neurological events that occurs during consciousness? Is the brain activity that generates consciousness localized or distributed? Does it involve interacting brain regions? Does the brain activity that generates consciousness migrate to different brain regions? (3) How does the dynamic core hypothesis of Edelman relate to these questions? What can functional brain imaging add to these questions? Are gamma waves involved in higher mental activity, and do they promote synchronized firing of neurons from different brain areas? How does this relate to the binding problem? (4) How does the brain's ability to function as a computer relate to consciousness? In many respects, the brain functions like a computer using electrical signals called action potentials. Action potentials in neuronal networks function in a way that is analogous to how DC electrical impulses function in computer circuits. What is the output of computation in an electrical device? What are the theoretical limitations regarding what computation can achieve? Does electrical activity in the brain have a fundamentally different purpose in addition to computation? (5) Is our knowledge of the physical world too primitive and incomplete for us to understand consciousness? The brain is an electronic device, and consciousness clearly depends on its electrical activity. However, electrical forces are poorly understood, both in the context of classical physics and quantum physics. Will understanding consciousness have to wait for a unified theory that more accurately describes electrical forces? Prerequisites: Biol 3411 or equivalent; college-level physics, some knowledge of computers.
Credit 2 units. A&S IQ: NSM BU: SCI

L41 Biol 472 Behavioral Ecology

This course examines animal behavior from an evolutionary perspective and explores the relationships between animal behavior, ecology and evolution. Topics include mating systems, sexual selection, parental care, kin selection, and cooperation. There is a strong active learning component. Prerequisite: Biol 2970 or permission of instructor.
Credit 4 units. A&S IQ: NSM

L41 Biol 4810 General Biochemistry I

The first part of a two-semester survey of biochemistry. This course covers biological structures, enzymes, membranes, energy production and an introduction to metabolism.
Prerequisites: Biol 2960 and Chem 262. Large class.
Same as L07 Chem 481
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM
L41 Biol 4820 General Biochemistry II
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 the biosynthesis of natural products, biofuels, and biomaterials. Prerequisites: Biol 2960 and Chem 262. Large class. Same as L07 Chem 482
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L41 Biol 4830 Bioenergy
This course presents a broad overview of the flow of energy, captured from sunlight during photosynthesis, in biological systems, and it discusses the 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; the structure and degradation of plant lignocellulose; and the 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 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 IQ: NSM

L41 Biol 4833 Protein Biochemistry
The focus of this course is protein biochemistry, and is intended to build upon General Biochemistry (Chem 481). In this course we will focus on protein structure, folding, and techniques to purify and characterize protein activity. We will progress from initial studies to first understand protein fold and function to current efforts to better characterize protein structure-function relationships. We will also highlight human diseases that are underpinned by protein misfolding. This course will focus on reading and understanding primary literature, including landmark papers along with more recent work. During the second half of the semester, each student will select a paper and prepare a written analysis of that paper. The student will then present the paper and lead a journal club style discussion of the paper.
Prerequisites: Chem 481 or instructor's permission. Same as L07 Chem 483
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

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. 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.

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 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 IQ: NSM Arch: NSM Art: NSM

L41 Biol 4934 Neuroscience Futures II
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 weeks 5 and 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 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 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 IQ: NSM BU: SCI

L41 Biol 4936 Seminars in Ecology and Evolution
What: At least once a week there are seminars from researchers in ecology or evolution. These seminars are given by local people and by visitors. This semester there are also a number of presentations by job candidates. The point of these seminars is to learn about exciting research. What questions are they asking? What are they discovering? What new scientific stories can we hear about ecology or evolution? What makes up these fields anyway? The seminars are often followed by receptions which are a chance to get to know each other better and to ask questions. This course invites undergraduates to listen to these presentations and write about them. After all, this is a major part of the ideas climate at WashU. It would be a great idea to get in the habit of going to seminars, with this course, or without. In addition to attending seminars, we will meet three times during the semester, early on and a couple of times later. When: Most seminars are at 4:00 on Thursdays, though some are on other days. The three meetings will be arranged at a time that works for the students in the course. Small class. No final. Credit 1 unit.

L41 Biol 500 Independent Research
Research under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/No Credit or Audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. Because this course has a large number of sections, some sections are listed and enrolled as Bio 500A. If work is to be submitted for Latin honors, see p. 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: https://wustl.app.box.com/s/d63rx500xvygqt5sv899eyhax5v31gyy1a. Arrangements for registration should be completed no later than the end of Summer Session I through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit/No Credit or Audit grade options. Course may not be taken for a letter grade. 1-3 units Credit 3 units.

L41 Biol 500U Summer Independent Research in Neuroscience
Summer research in neuroscience under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit to be determined in each case, usually 3 units/summer; may be repeated for credit in different summers. Because this course has a large number of sections, some sections are listed and enrolled as Bio 500U. Credits are received in the fall semester following the summer research. If work is to be submitted for Latin honors, see page 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program. The handbook can be found online at: https://wustl.app.box.com/s/d63rx500xvygqt5sv899eyhax5v31gyy1a. Arrangements for registration should be completed no later than the end of Summer Session I through the Bio 500 course website: https://pages.wustl.edu/Bio_200-500_independent_research. Credit/No credit or audit grade options. Course may not be taken for a letter grade. 1-3 units Credit 3 units.

L41 Biol 500N Independent Research in Neuroscience
Research in neuroscience under the supervision of a faculty mentor. Prerequisites: junior or senior standing and permission of mentor and the department. Credit/no credit or audit grade options; credit to be determined in each case, usually 3 units/semester and not to exceed 3 units/semester; may be repeated for credit. If work is to be submitted for Latin honors, see page 3 of the Department of Biology Handbook for Majors, Latin Honors Through a Biology Major Program (PDF) (https://wustl.app.box.com/s/2n0gj01opcwiow6hs26y1j0wv09ig). Arrangements for registration should be completed during the preregistration period through the Biol 500 course website (https://pages.wustl.edu/Bio_200-500_independent_research). Credit variable, maximum 3 units.