Applied Mathematics-Biology

The Applied Math - Biology concentration recognizes that mathematics is essential to address many modern biological problems in the post genomic era. Specifically, high throughput technologies have rendered vast new biological data sets that require novel analytical skills for the most basic analyses. These technologies are spawning a new "data-driven" paradigm in the biological sciences and the fields of bioinformatics and systems biology. The foundations of these new fields are inherently mathematical, with a focus on probability, statistical inference, and systems dynamics. These mathematical methods apply very broadly in many biological fields including some like population growth, spread of disease, that predate the genomics revolution. Nevertheless, the application of these methods in areas of biology from molecular genetics to evolutionary biology has grown very rapidly in with the availability of vast amounts of genomic sequence data. Required coursework in this program aims at ensuring expertise in mathematical and statistical sciences, and their application in biology. The students will focus in particular areas of biology. The program culminates in a senior capstone experience that pairs student and faculty in creative research collaborations.

Standard program for the Sc.B. degree

Required coursework in this program aims at ensuring expertise in mathematical and statistical sciences, and their application in biology. The students will focus in particular areas of biology. The program culminates in a senior capstone experience that pairs student and faculty in creative research collaborations. Applied Math – Biology concentrators are prepared for careers in medicine, public health, industry and academic research.

Required Courses:

Students are required to take all of the following courses.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 0090</td>
<td>Introductory Calculus, Part I</td>
<td>1</td>
</tr>
<tr>
<td>MATH 0100</td>
<td>Introductory Calculus, Part II</td>
<td>1</td>
</tr>
<tr>
<td>MATH 0170</td>
<td>Advanced Placement Calculus</td>
<td>1</td>
</tr>
<tr>
<td>MATH 0180</td>
<td>Intermediate Calculus (or equivalent placement)</td>
<td>1</td>
</tr>
<tr>
<td>MATH 0520</td>
<td>Linear Algebra</td>
<td>1</td>
</tr>
<tr>
<td>or MATH 0540</td>
<td>Honors Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>CHEM 0330</td>
<td>Equilibrium, Rate, and Structure</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 0030</td>
<td>Basic Physics A</td>
<td>1</td>
</tr>
<tr>
<td>or PHYS 0050</td>
<td>Foundations of Mechanics</td>
<td></td>
</tr>
</tbody>
</table>

Select one of the following sequences:

<table>
<thead>
<tr>
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<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>APMA 0350</td>
<td>Applied Ordinary Differential Equations</td>
<td>2</td>
</tr>
<tr>
<td>APMA 0360</td>
<td>Applied Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>&amp; APMA 0340</td>
<td>Methods of Applied Mathematics I</td>
<td></td>
</tr>
<tr>
<td>&amp; APMA 0340</td>
<td>Methods of Applied Mathematics II</td>
<td></td>
</tr>
<tr>
<td>APMA 1650</td>
<td>Statistical Inference I</td>
<td>1</td>
</tr>
<tr>
<td>or APMA 1655</td>
<td>Honors Statistical Inference I</td>
<td></td>
</tr>
<tr>
<td>APMA 1070</td>
<td>Quantitative Models of Biological Systems</td>
<td>1</td>
</tr>
<tr>
<td>APMA 1080</td>
<td>Inference in Genomics and Molecular Biology</td>
<td>1</td>
</tr>
<tr>
<td>or NEUR 2110</td>
<td>Statistical Neuroscience</td>
<td></td>
</tr>
<tr>
<td>BIOL 0200</td>
<td>The Foundation of Living Systems (or equivalent)</td>
<td>1</td>
</tr>
</tbody>
</table>

Additional Courses

One additional course in Applied Math or Biology

We strongly recommend that Applied Mathematics-Biology concentrators take one of the programming courses on or before their first semester as a concentrator. Those who do can use it to satisfy this requirement:

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<tr>
<th>Course Code</th>
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<th>Units</th>
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</thead>
<tbody>
<tr>
<td>APMA 0160</td>
<td>Introduction to Computing Sciences</td>
<td></td>
</tr>
<tr>
<td>CSCI 0040</td>
<td>Introduction to Scientific Computing and Problem Solving</td>
<td></td>
</tr>
<tr>
<td>CSCI 0111</td>
<td>Computing Foundations: Data</td>
<td></td>
</tr>
<tr>
<td>CSCI 0150</td>
<td>Introduction to Object-Oriented Programming and Computer Science</td>
<td></td>
</tr>
<tr>
<td>CSCI 0170</td>
<td>Computer Science: An Integrated Introduction</td>
<td></td>
</tr>
<tr>
<td>CSCI 0190</td>
<td>Accelerated Introduction to Computer Science</td>
<td></td>
</tr>
<tr>
<td>CLPS 0950</td>
<td>Introduction to programming</td>
<td></td>
</tr>
</tbody>
</table>

One research-related course in Applied Math or Biology. For example:

- A senior seminar course from the APMA 193X, 194X series
- A directed research/independent study course from the APMA 1970, 1971, or BIOL 1950, 1960, or NEUR 1970 series
- A directed research/independent study course in a related discipline (i.e., STEM disciplines, ENVS, PHP, etc.) if the student's learning goals in the concentration and with approval from the concentration advisor.
- A pre-approved course that satisfies the Biology AB capstone requirement: BIOL 1100, 1250, 1515, 1555, 1565, 1575, 1600, 1820, 1970.
- A relevant CURE (Course-based Undergraduate Research Experience) course: BIOL 0190R, 0190S, 0285, 0440, 0600, 0940G, 1515, 1555; NEUR 1630, CLPS 1195.
- A non-research course related to the concentration along with a research experience equivalent in scope and scale to the student's learning goals in the concentration and with approval from the concentration advisor.

Other equivalent opportunities not listed - with approval from the concentration advisor.

Four classes in the biological sciences agreed upon by the student and advisor. These four courses should form a cohesive grouping in a specific area of emphasis, at least two of which should be at the 1000-level. Some example groupings are below:

Areas of Emphasis and Suggested Courses:

Some areas of possible emphasis for focusing of elective courses are listed below. Given the large number of course offerings in the biosciences and neuroscience, students are free to explore classes in these areas that are not listed below. However, all classes must be approved by the concentration advisor. APMA 1910 cannot be used as an elective.

Biochemistry

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIOL 0280</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>BIOL 1270</td>
<td>Advanced Biochemistry</td>
</tr>
</tbody>
</table>

Biotechnology and Physiology

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 0800</td>
<td>Principles of Physiology</td>
</tr>
<tr>
<td>BIOL 1100</td>
<td>Cell Physiology and Biophysics</td>
</tr>
<tr>
<td>&amp; BIOL 1210</td>
<td>Synthetic Biological Systems</td>
</tr>
</tbody>
</table>

Ecology, Evolution, and Genetics

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<th>Course Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>BIOL 0410</td>
<td>Invertebrate Zoology</td>
</tr>
<tr>
<td>&amp; BIOL 0480</td>
<td>Evolutionary Biology</td>
</tr>
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</table>

Other courses in the concentration advisor's discretion.

APMA 1910 cannot be used as an elective.

Other equivalent opportunities not listed - with approval from the concentration advisor.

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The writing of a thesis which is reviewed by the thesis advisor and a second reader. It is essential that the student have one advisor from the biological sciences and one in Applied Mathematics. The thesis work must be presented in the form of an oral presentation (arranged with the primary thesis advisor) or posted at the annual Undergraduate Research Day in either Applied Mathematics or Biology. For information on registering for BIOL 1950/BIOL 1960, please see https://www.brown.edu/academics/biology/undergraduate-education/undergraduate-research or https://www.brown.edu/academics/biology/undergraduate-education/undergraduate-research/

The concentrations in Applied Math (including joint concentrations) require that honors students demonstrate excellence in grades for courses in the concentration. Students must have earned grades of A or S-with-distinction in at least 70% of the courses used for concentration credit, excluding calculus and linear algebra, or be in the upper 20% of the student's cohort (as measured by the fraction of grades of A or S-with-distinction among courses used for concentration credit, excluding calculus and linear algebra). Since S with distinctions do not appear on the internal academic record or the official transcript, the department will consult directly with the Registrar's Office to confirm a student's grades in concentration courses. Additional guidelines and requirements for honors are published on the department website (https://www.brown.edu/academics/applied-mathematics/undergraduate-program/honors/)

The deadline for applying to graduate with honors in the concentration are the same as those of the biology concentrations. However, students in the joint concentration must inform the undergraduate chair in Applied Mathematics of their intention to apply for honors by these dates.

### Honors
Requirements and Process: Honors in the Applied Math-Biology concentration is based primarily upon an in-depth, original research project carried out under the guidance of a Brown (and usually Applied Math or BioMed) affiliated faculty advisor. Projects must be conducted for no less than two full semesters, and students must register for two semesters of credit for the project via APMA 1970 or BIOL 1950/BIOL 1960 or similar independent study courses. One of these courses can be used to fulfill the research-related course requirement, but the other cannot be used elsewhere in the concentration. The project culminates in the writing of a thesis which is reviewed by the thesis advisor and a second reader. It is essential that the student have one advisor from the biological sciences and one in Applied Mathematics. The thesis work must be presented in the form of an oral presentation (arranged with the primary thesis advisor) or posted at the annual Undergraduate Research Day in either Applied Mathematics or Biology. For information on registering for BIOL 1950/BIOL 1960, please see https://www.brown.edu/academics/biology/undergraduate-education/undergraduate-research or https://www.brown.edu/academics/biology/undergraduate-education/undergraduate-research/

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### Professional Tracks
The requirements for the professional tracks include all those of each of the standard tracks, as well as the following:

Students must complete full-time professional experiences doing work that is related to their concentration programs, totaling 2-6 months, whereby each internship must be at least one month in duration in cases where students choose to do more than one internship experience. Such work is normally done at a company, but may also be at a university under the supervision of a faculty member. Internships that take place between the end of the fall and the start of the spring semesters cannot be used to fulfill this requirement. On completion of each professional experience, the student must write and upload to ASK a reflective essay about the experience, to be approved by the student's concentration advisor.

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- Which courses were put to use in your summer's work? Which topics, in particular, were important?
- In retrospect, which courses should you have taken before embarking on your summer experience? What are the topics from these courses that would have helped you over the summer if you had been more familiar with them?
- Are there topics you should have been familiar with in preparation for your summer experience, but are not taught at Brown? What are these topics?
- What did you learn from the experience that probably could not have been picked up from course work?
- Is the sort of work you did over the summer something you would like to continue doing once you graduate? Explain.
- Would you recommend your summer experience to other Brown students? Explain.

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