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>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 0090</td>
<td>Introductory Calculus, Part I</td>
<td>1</td>
</tr>
<tr>
<td>MATH 0100 or 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>1</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>1</td>
</tr>
</tbody>
</table>

Select one of the following sequences:

- APMA 0330 & APMA 0340: Methods of Applied Mathematics I and Methods of Applied Mathematics II | 1
- APMA 1650 or APMA 1655: Statistical Inference I or Honors Statistical Inference I | 1
- APMA 1070: Quantitative Models of Biological Systems | 1
- APMA 1080 or NEUR 2110: Inference in Genomics and Molecular Biology or Statistical Neurosciences | 1
- BIOL 0200: The Foundation of Living Systems (or equivalent) | 1

**Additional Courses**

One additional course in Applied Math or Biology | 1

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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<tbody>
<tr>
<td>APMA 0160</td>
<td>Introduction to Computing Sciences</td>
</tr>
<tr>
<td>CSCI 0040</td>
<td>Introduction to Scientific Computing and Problem Solving</td>
</tr>
<tr>
<td>CSCI 0111</td>
<td>Computing Foundations: Data</td>
</tr>
<tr>
<td>CSCI 0150</td>
<td>Introduction to Object-Oriented Programming and Computer Science</td>
</tr>
<tr>
<td>CSCI 0170</td>
<td>Computer Science: An Integrated Introduction</td>
</tr>
<tr>
<td>CSCI 0190</td>
<td>Accelerated Introduction to Computer Science</td>
</tr>
<tr>
<td>CLPS 0950</td>
<td>Introduction to programming</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, ENV, PHP, etc.) if the project is relevant to 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 work the student would pursue in an Applied Math or Biology independent study course. Examples include UTRAs, LINK awards, research programs at other institutions, etc.

This requires approval from the concentration advisor and appropriate documentation.

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**

- BIOL 0280: Biochemistry
- BIOL 1270: Advanced Biochemistry
- CHEM 0350/0360: Organic Chemistry
- CHEM 1230: Chemical Biology

**Biotechnology and Physiology**

- BIOL 0800: Principles of Physiology
- BIOL 1100: Cell Physiology and Biophysics
- BIOL 1240: Polymer Science for Biomaterials
- BIOL 1220: Biomaterials
- BIOL 1140: Tissue Engineering
- BIOL 1150: Stem Cell Engineering
- BIOL 1210: Synthetic Biological Systems

**Ecology, Evolution, and Genetics**

- BIOL 0410: Invertebrate Zoology
- & BIOL 0480: and Evolutionary Biology
The writing of a thesis which is reviewed by the thesis advisor and a
be used elsewhere in the concentration. The project culminates in
to fulfill the research-related course requirement, but the other cannot
similar independent study courses. One of these courses can be used
of credit for the project via
than two full semesters, and students must register for two semesters
BioMed) affiliated faculty advisor. Projects must be conducted for no less
concentration is based primarily upon an in-depth, original research project
Requirements and Process: Honors in the Applied Math-Biology
Honors
• Students whose independent study is expected to be in an experimental
field are strongly encouraged to take APMA 1660, which covers
experimental design and the analysis of variance (ANOVA), a method
commonly used in the analysis of experimental data.

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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write and upload to ASK a reflective essay about the experience, to be
approved by the student’s concentration advisor:

• 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.

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
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BIOL 0420 Principles of Ecology
& BIOL 0430 and The Evolution of Plant Diversity
BIOL 0470 Genetics
BIOL 1420 Experimental Design in Ecology
BIOL 1430 Foundations of Population Genetics
BIOL 1465 Human Population Genomics
BIOL 1540 Molecular Genetics

Neuroscience
APMA 0410 Mathematical Methods in the Brain Sciences
Neurosciences courses: See https://www.brown.edu/
academics/neuroscience/undergraduate/neuroscience-concentration-requirements
BIOL 1100 Cell Physiology and Biophysics
BIOL 1110 Topics in Signal Transduction
BIOL 1190 Synaptic Transmission and Plasticity

Total Credits 18

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field are strongly encouraged to take APMA 1660, which covers
experimental design and the analysis of variance (ANOVA), a method
commonly used in the analysis of experimental data.

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.

Applied Mathematics-Biology

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