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As the number of programs in mathematical biology has grown over the past five to ten years, we thought some information about the available programs would be helpful for those of us who are helping students to find pathways to their future careers. In particular, we sought information for a mathematics student who is interested in a PhD program that includes biomathematics. We asked three questions to about twenty-five PhD programs in mathematical or computational biology, and received ten responses, which we detail below. The italicized responses are in the words of a representative from each program, and any edits have the italics removed.

Academic careers available to PhDs in mathematical biology are still predominantly in single-discipline departments. Therefore, PhD programs in mathematical biology are typically offered either under an umbrella of mathematics or biology, or through a much more pointedly multidisciplinary approach. We note that the academic job placements listed in the responses below are compelling, and that the interdisciplinary programs have a larger proportion of graduates working outside of academia. We hope that the answers from this diverse set of institutions to our simple questions can inspire future PhD students with the broad range of programs and careers that are now available. Please see the SMB webpages for a more complete list of available programs. Readers may also enjoy a recent article in The Scientist Magazine about interdisciplinary biomathematics programs.

University of Pittsburgh: PhD in Mathematics specializing in Mathematical Biology

What careers are your program’s graduates entering?

Over the past several years our graduates have gone mostly to academic careers. Several have found tenure-track positions (University of Tennessee Knoxville, Virginia Commonwealth University, Frostburg State University), several currently have postdocs (MBI, NIH, UC Boulder, and Northwestern U). Two students ended up in industry/consulting (Citibank and L.I.F.E. financial services). Our former postdocs, some of whom we have supported using RTG funds, have found tenure-track faculty positions (University of Notre Dame, IUPUI, University of Houston, and University of Alaska).

What coursework and summer experiences best prepare undergraduates for admission to your program?

Our graduate students are required to pass the Departmental preliminary exam which is the same for students in all fields of mathematics. Good preparation for that is an advanced calculus/real analysis course and advanced linear algebra. To prepare for mathematical biology research, the optimal coursework should include ODE, PDE courses, some knowledge of numerical mathematics, and probability theory (for stochastic modeling). Background in biology is welcome but not required. In applications we look for good grades, scientific maturity, and experience with research which can be obtained, for example, in one of many REU programs in math biology. Note that we have weekly Math Biology group meetings within the department, so that entering students have plenty of opportunity to learn about the types of research being done in our group and the biological applications being studied.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

At the University of Pittsburgh we do not make this distinction. Our students enter the graduate program in mathematics and obtain a PhD in Mathematics, regardless of their orientation and/or research direction. This result means that our graduates have a natural academic home within Mathematics Departments, if they wish to pursue academic career paths, and have the opportunity to take a full range of Mathematics courses during their studies. We have four core faculty in Mathematical Biology working in a variety of different areas including neuroscience, immunology, cellular and molecular biology. Many of our students work closely with experimentalists and clinicians and in many cases, the modeling and mathematics are driven by biological questions. Occasionally, interested students will do a rotation in an experimental lab.
University of Washington: PhD in Applied Mathematics specializing in Mathematical Biology

What careers are your program’s graduates entering?

Basic research at research institute: example -- Allen Institute for Brain Science
Academic research and teaching: example -- Center for Neural Science and Courant Institute for Mathematical Sciences, NYU
4 year college teaching: example -- Seattle University department of mathematics

What coursework and summer experiences best prepare undergraduates for admission to your program?

These courses are recommended as good preparation: Probability theory and stochastic processes, Dynamical systems, ordinary differential equations, Partial differential equations, Linear algebra, and scientific computing.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

I believe it depends on how the coursework, exams, and research communities are matched to a student’s goals. This will vary widely from program to program — a biomathematics program can provide valuable focus and a wonderful research environment — and a great connection to research careers in our discipline. On the other hand, a degree in applied mathematics can indicate an even wider range of careers is often received very favorably by future employers who are closer to the “biology side.” There is a large and increasing demand for mathematical and computational skills in (largely) experimental labs, and students who have shown they can work collaboratively across disciplines in their PhD or MS work will be recruited, regardless of whether they have a “bio” in their degree. An interesting option is provided by programs such as the UW Training Program in Computational Neuroscience (compneuro.washington.edu). Here, students receive a PhD in a discipline like applied mathematics, physics, or neuroscience, but have special coursework and research events (and support) in their field of mathematical biology.

Florida State University: Biomathematics Graduate Program

What careers are your program’s graduates entering?

The majority of our PhD graduates go into academia. Most take postdoctoral positions after leaving FSU. For example, recent PhDs have taken postdoctoral positions at University of Chicago, VA Connecticut Healthcare System, University of Michigan, National Institutes of Health, and the Mathematical Biosciences Institute. Many former students hold tenure-track positions, for example, at Washington & Lee University, Polk State College, Cleveland State College, San Francisco State University, and the University of Georgia. Several PhD graduates have gone into industry or have taken long-term research positions. Examples include Wells Fargo, Mercuria Energy Trading Inc., and City of Hope National Medical Center.

What coursework and summer experiences best prepare undergraduates for admission to your program?

The most important preparation is an undergraduate degree in mathematics or a closely related field. Participation in a summer research program looks good on the application, and gives the student an invaluable opportunity to see what doing research is all about. Some biology courses are also helpful, though not required. Particularly useful is a course in genetics. Also, a solid course in computer programming is very useful.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

At FSU the student picks a program when applying to the university. Some students move from one program to the other once they arrive, but it is best to pick the most appropriate program from the beginning. Our biomathematics curriculum overlaps significantly with our applied mathematics program, but each semester there is a specialized course in biomathematics. We also have a very active biomathematics seminar. It is best to enroll in these upon arrival at FSU.
University of Utah: PhD in Mathematics specializing in Mathematical Biology

What careers are your program’s graduates entering?

Our graduates currently hold faculty positions at University of Alaska Fairbanks, U British Columbia, UC Davis, UC Merced, Pepperdine University, Pomona College, University of Idaho, Eastern Washington U, Walla Walla University, Montana State, Utah State, Brigham Young U, U Houston, Augsburg College, U Maryland Baltimore County, Florida State U, Appalachian State U, Smith College, U Central Oklahoma. We also have former students in government labs and research institutions, including Lawrence Livermore, Sandia Labs, St. Jude’s Hospital, and some in the biotech industry: BioFire Diagnostics, Roche Pharmaceuticals.

What coursework and summer experiences best prepare undergraduates for admission to your program?

Our program receives a variety of students, ranging from those with essentially no biology background to double majors with extensive laboratory research experience. For many, a summer REU in math biology has provided the key perspective and motivation, and provides one of the three keys to success: strong mathematical background, computing experience, and an appreciation for the challenges and excitement of research.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

Our program follows the philosophy that effective graduate training in mathematical biology requires consistent pairing of mathematical and biological content, with constant attention to how these inform each other. Whatever their background, studying biology immediately upon entrance to a program is key to developing the scientific vision needed to make substantial contributions to both fields.

NC State University: Biomathematics Graduate Program

What careers are your program’s graduates entering?

Our graduates take a variety of career routes: about two thirds go into an academic career, either initially as a postdoc (recent institutions include Boston University, Tulane, Pittsburgh, UCLA, University of New Mexico and the Australian National University, Canberra) or straight into a faculty position (Cal State Monterey Bay). The remainder go into industry (e.g. Eli Lilly, RTI International or Constella) or government labs (e.g. EPA).

What coursework and summer experiences best prepare undergraduates for admission to your program?

Our program looks for students who show interest in both mathematics and biology. For a mathematics undergraduate, we would be looking for some biological coursework beyond introductory level courses and/or research experience(s) that involve the application of mathematics or statistics to a biological problem. An increasing number of our applicants have a minor in biology or even a double major. Summer REU programs (such as the one in the NC State Department of Mathematics!) provide a great opportunity for getting deeply involved with a research project and discovering whether a PhD program is how you would like to spend five years of your life.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

Perhaps it’s a bit easier for me to talk about how our program differs from (or can be similar to) a traditional applied math program: Our program recognizes that mathematical biologists need to have a broad set of mathematical, statistical and biological skills to be able to understand the biology of their system, to develop and analyze models and to parameterize and test those models against data. Our students are often co-advised, having one mentor from the mathematical sciences and one from the biological sciences. Our curriculum emphasizes the importance of coursework in mathematics, statistics and biology to achieve this goal. Beyond a core set of biomathematics courses, the keyword of our program is flexibility: with input from their advisor(s), individual students' programs are tailored to what they will need to carry out their research. ... Under this flexible umbrella, a student could take the same set of courses taken by one of our applied mathematics students or could take something very different. ... Our program aims to allow students to find their niche to work at the interface between mathematics and biology.
Joint Carnegie Mellon / University of Pittsburgh: Computational Biology Graduate Program

What careers are your program’s graduates entering?

Since the program’s founding in 2005 and its selection the same year as one of ten HHMI-NIBIB Interfaces Initiative programs nationwide, about 30 students have graduated. Alumni are about evenly split between academic and industry jobs. Subsequent academic placements, typically postdoctoral, include U. Chicago, U. Michigan, and MIT. Industry placements include Apple, Mathworks, and Pfizer. One alumna is already in a faculty position and another alumnus will be starting a faculty position this year straight from our program.

What coursework and summer experiences best prepare undergraduates for admission to your program?

Our students currently come from many backgrounds ranging from more biological to more quantitative, but all students have a foot in both worlds to some extent. Applicants should have concrete exposure to biology through coursework and/or research if their undergraduate major was more quantitative.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

We believe that students seriously interested in biology should attend a program where there is an interdisciplinary culture truly balanced between quantitative and biological sciences. The CMU/Pitt program achieves this by its unique combination of the computing strength of CMU along with Pitt’s top biomedical research program located in what is effectively one fully walkable extended campus. Students will be exposed to opportunities in genomic analysis, bioimaging, drug design, structural biology, cell modeling, and epidemiological modeling.

UC Irvine: Mathematical, Computational, and Systems Biology Graduate Program

What careers are your program’s graduates entering?

Our MCSB is relatively new as it was established in 2007 winter. Not many students have graduated. Here are some examples on where the students went after graduation: 1) tenure-track faculty at Dartmouth; 2) postdocs at Salk Institute; 3) postdoc at Stanford U; 4) postdoc at MIT; 5) postdoc at Hawaii U; 6) engineer at Intel; 7) financial analyst at Investment company; 8) research scientist or engineering in companies.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

The unique feature of our program is its first year. The students from different undergraduate backgrounds join the program with fellowships (>30k/student - we have won the HHMI award in interdisciplinary training and NIH T32 training grants) in the first year, after one-year training in our program the students go to individual PhD programs in 10 affiliated departments that include math, five biology departments, computer science, physics, chemistry, biomedical engineering. We take the students from various undergraduate backgrounds including applied math, engineering, biology, physics, chemistry, computer science among others. The trainings we provide in the first year are mainly one-year sequence in biology and one-year sequence on modeling/computation/mathematics, and critical thinking in addition to lab rotations. A full PhD program on MCSB - a student can stay in the program with a PhD on MCSB after the first year in addition to the choice of going to the 10 departments - is expected to be officially approved next fall, 2015.

MIT: Computational and Systems Biology Graduate Program

What careers are your program’s graduates entering?

Our graduates are predominantly pursuing academic research careers. To date, we have had 29 PhD graduates (all in the past 5 years), and we are tracking the careers of our alumni closely. Current job positions of these graduates are distributed as follows: Assistant Professor: 4 (Duke, Univ. Colorado, Univ. Montreal, Chulalongkorn Univ Thailand); Postdoc/Research Fellow in academic setting: 16; Scientist in industry: 5 (Pharma, Biotech, Software); Pursuing additional degree: 2 (MD, JD); Consulting: 1; Unknown: 1.
What coursework and summer experiences best prepare undergraduates for admission to your program?

The quality and depth of research experience is probably the most important factor that distinguishes admitted students from other applicants with comparable educational backgrounds. The research can be in any area of math/science/engineering, though it is helpful for students to expose themselves to research in computational/systems biology if possible. For students at universities or colleges with limited research, we recommend seeking research experiences off campus in the summer, e.g., at a research university, or government lab. Besides research, we look for some balance of coursework between quantitative disciplines (math, statistics, physics, computer science, engineering) and life sciences (biology, chemistry, etc.), with some interdisciplinary coursework (e.g., computational/systems biology) a plus but not required. For students who were math majors, we look at whether they also made an effort to take some chemistry and biology and whether they have some understanding of the field of computational biology.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

The extent of interest in biological questions versus mathematical topics is an important factor. Students interested in networks, modeling, stochastic processes, statistics and algorithms will find many applications of these areas in computational/systems biology. Another factor is whether the student desires an academic research/teaching career in (i) a traditional applied math department, or (ii) a biology, bioengineering or interdisciplinary (e.g., bioinformatics or systems biology) department. For students interested in industrial careers, either type of program could be a good fit.

Princeton: Quantitative and Computational Biology Graduate Program

What careers are your program’s graduates entering?

Our graduate program is young and so we’ve only had a few students finish. They went on to postdocs.

What coursework and summer experiences best prepare undergraduates for admission to your program?

Our program is more of a computational one than a mathematical one per se. Most of our students come in with a decent background both in bio and computer science. The rare student who lacks coursework in these two areas seems to struggle. We also find that statistics is very important, but only some of our students come in with a strong background in stats.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

I don’t think this really applies to our program. We are very bio-focused and I don’t think true applied math students would be interested.

Weill Cornell Medical College / Memorial Sloan-Kettering Cancer Center / Cornell University: Computational Biology & Medicine Tri-Institutional Training Program

What careers are your program’s graduates entering?

Our program is 11 years old. Our first graduate was in 2009. We have 23 PhD graduates to date. Our graduates are splitting about 50/50 between academia and industry. Those in academia have gone into postdocs at some outstanding institutions, including the Broad Institute (Harvard/MIT), Stanford, Harvard, Cold Spring Harbor Laboratory, ETH (Zurich). Of those, two have advanced to tenure-track assistant professor positions so far: One is at Mount Sinai School of Medicine (NYC) and the other is at SungKyunKwan University (Korea). Those who have entered the private sector have obtained exciting jobs. For example:

- Blue Print Medicines (Cambridge, MA); Director of Computational Biology
- Knewton Inc.; data analytics team
- Tumblr
- nRelate (an online media company)
- New York Genome Center; business analyst

What coursework and summer experiences best prepare undergraduates for admission to your program?
Courses: We have no set requirements, but we find that our top students have some experience in quantitative (math, computer science, engineering) and biological sciences. Since those affiliated with SMB are likely to be solid in the quantitative areas, I'll limit my recommendations to the biological sciences: biology, biochemistry, physiology, genetics, computational biology, bioinformatics. Again, I stress that none of these are required, but each of them is useful in its own way. Summer experience: research experience in biology or mathematics, preferably at least one experience in an institution or company other than the undergraduate institution.

When should a student enter a mathematical biology MS or PhD program versus an Applied Mathematics program in which the student specializes in biomathematics?

Our program doesn’t really fit into your description. But what I could say is that our program is really for students who want to make an impact in biology and/or biomedicine using math/computation. Many of our students are particularly excited about training in a scientifically/computationally rigorous program while performing their research immersed within a major medical center(s). It is very easy for them to see the impact of their work in medicine and disease.