Baby-Steps Bring More Computation (or at least "math") into Biology and more Biology into Math

A number of us at St. Olaf have been saying for years that mathematical prowess and tools are needed for successful biological research and understanding and that conversely more understanding of biological problems would enrich and expand the outlook and prospects for mathematics and computer science students. The first meetings occurred over ten years ago that highlighted three things: i) we ought to integrate more, ii) we were willing to give it a "go" and iii) we were actually so clueless that we were talking over and around each other not effectively across the disciplines. The good news was that we knew we should connect and we kept trying. The result is that as of today we are still trying, but several good things are "in place" including two formal courses with "math" and "bio" in their titles, bioinformatics from both perspectives, an interdisciplinary concentration at least one pair of courses with a cooperative interdisciplinary project, multiple examples of courses that formally include interdisciplinary modules in both departments. Here I will focus on the steps we've made emphasizing computation and quantitative literacy on the biology side. Finally, I will note that one of the challenges we currently face is choice of computer "language" – one of the reasons I'm at a MATLAB conference.

We began with joint department meetings that resulted in sections of calculus and much later, sections of introduction to computer science having a "biological" flavor. We made sure that an existing math course *The Mathematics Biology* was actually taught (but note mostly to math or math-biology double majors). We formed a working group and invented a quarter-credit course *Exploring BioMath* to be taught in a two-hour time slot one evening per week. The goal of this low-stakes class was to introduce students to the idea that there is indeed a valuable overlap through a series of examples. Seven to eight faculty members sign up each spring to present something of interest to them in one or two sessions involving background reading and most importantly, hands-on computation. Most students report having a wonderful time as their talents and new ways to use them are revealed. This class has become a fixture and a great place for biologists and mathematicians to explore the interface of our disciplines—an opportunity to teach something fun in a different context showing the value of working across disciplines

We hired an "official" mathematical biologist in the Mathematics Department and she organized us by applying for college funds to support a summer workshop to write modules for courses—ecology, physiology, calculus, linear algebra and, especially *Exploring BioMath*. The ones for ecology courses definitely "stuck" and are still in place today. We argued over computer languages and statistical programs – the biologists adapted STATA at the request of our statistics faculty who later abandoned it for "R". Could we use EXCEL? Our Texas Instruments programmable calculators?

We also hired a bioinformatics specialist in biology, then lost him, then hired someone new. This little chapter resulted in pulling one of our senior computer scientists into the biological world and two Bioinformatics courses one offered in biology and the other in computer science taught in alternate years with both professors serving as guest lecturers for the other.

Another setback: we had to replace our biomathematician! Our new biomathematics professor was keen, and willing despite being early in her career, to take some leadership. Indeed her post-doc had trained her to think about how to move incrementally and effectively. Her dream was to add a laboratory component to our existing mathematics of biology course and our collective dream was a concentration (an interdisciplinary minor) in mathematical biology. And we did both.

With the help of funds to support two summer research students we developed lab projects that were doable by novices, generated real data sets. The students wrote and tested the computational analyses as

well and these efforts resulted in what is now the only math course with a wet lab (Sanft and Walter, 2014). A little grant from the college allowed us to train another biologist to teach the labs and turn our handouts into an actual manual with lab protocols, notes/guidelines for using "R" and case studies. Although we lost our second official biomathematician (to the classic two-body problem) we've taught this course three times now, once with a visiting biomathematician and the fourth time is on the schedule with yet another new one. Both of our visiting faculty members were very keen to take on a team-taught lab-based course and have already contributed new ideas. *The Mathematics of Biology* has a linear algebra prerequisite allowing the math to be challenging: fortunately the culture of the biology department has evolved to advise students to continue their math as far as they can so we have a larger population of biology students prepared to take this class. This year, we applied for and were granted a "general education" attribute for this class so that mathematics students may use it for one of their lab sciences thus achieving our goal of a true interdisciplinary experience.

In parallel, we initiated our Mathematical Biology Concentration three years ago with existing courses and a capstone project: students are amazing us with their work. Other faculty members are making opportunities like the upcoming 3rd annual microbiology-computer science course project to identify a microbe "pet" using biochemical and genomic tools. We added a "doing the math" component to a Summer Bridge science course for incoming TRiO students, again linking lab projects to data analysis and a little computation.

Although we have an extremely long list of things we want to do, a look back tells us that baby steps and persistence have taken us from nothing to something—something tangible and robust enough to stick and yet still new enough to evolve and grow. We have a concentration, two courses with "math" and "bio" in the title and multiple instances of courses using modules or referencing the opposite discipline, and a new course on computational neuroscience percolating while *Bioinformatics* is appeals widely. We have a depth of commitment and leadership in the faculty that we will continue to take steps.

My steps this year include learning to use MATLAB and its resources to shake up my Animal Physiology course, an area rich with possible problems to solve. Finding computational tools that don't get in the way of understanding the computation or the biology is essential if we are to succeed in getting more computation into our courses.

Sanft, R. and A. Walter. 2015. *Experimenting with Mathematical Biology*. Primus 26(1):83-103. DOI: 10.1080/10511970.2015.1064050