Student/Faculty Research Models in Computational Biology

Review of the workshop organized by:
Suzy Renn, Albyn Jones, Jim Fix (Reed College),
Andre Cavalcanti, Jo Hardin (Pomona College), &
Brian Tjaden (Wellesley College)
June 18 - 20th, 2008

It is our goal to increase undergraduate student engagement in computational biology at the research level. As a step towards that goal we conducted a three-day workshop to explore different models for student/faculty research collaborations in computational biology that are currently in place at liberal arts colleges. Twelve faculty members from, math, computer science, and biology departments, representing eight liberal arts colleges, convened on the Reed College campus June 18^{th} - 20^{th} of 2008. Beyond the simple description of different academic models, included in our agenda was the aim to learn how different institutions might adopt a successful strategy without having to "reinvent the wheel." Discussions addressed the degree to which significant and minor changes would be required of the academic infrastructure.

The following review summarizes the topics, discussions, and, when possible, conclusions as expressed by the attendees. Despite the common goal for the workshop, the background, experience, and agenda of each attendee contributed a different perspective on the problems and solutions. This diversity was critical to the success of the workshop.

The highly interactive nature of the workshop allowed us to identify current rifts between math and biology that might hinder collaborative research particularly at the undergraduate level. Through the exchange of ideas and experiences, we identified different changes that could/should be made at an institutional level and what our own roles would be to enact those changes. The workshop was a positive experience for all involved. The intimate workshop venue was a critical mechanism by which to outline and achieve our goals. Below, we provide a summary of our conclusions and discussions.

There is a Need to Integrate Math and Biology.
We are seeing the culture of science changing. Journals are requiring more sophisticated analyses. Students will need to understand computer programming in order to publish in top journals. Therefore, one cannot consider computer science and math as separate from a rigorous training in biology.

There are Hurdles to Integrating Math and Biology Students.
Due to the varied backgrounds of the attendees, we were able to identify difficulties in communication amongst ourselves, explore how these difficulties would affect students and discuss possible solutions to bridge the gaps. Several of the attendees commented on the rift of knowledge that separates biology and math students at the early undergraduate level. While this rift may decrease as a student progresses toward graduation, it often

presents an obstacle to fruitful collaboration at an early stage. There is some sentiment that this early stage is critical in order to spark the interest of students. Therefore we discussed ideas regarding means to work around or remove this obstacle.

Part of the Problem is Perception:

While Computer Science is seen as tool building, Biology is seen as problem solving. Each field can be perceived by the other as having components with a certain monotony and drudgery, for example, experimental design and execution in biology, and programming and debugging time in front of a computer in computer science. These preconceptions are propagated throughout the culture, and within education, long before students arrive at our liberal arts colleges. Promoting the creativity and ingenuity of each field, especially in research that spans these disciplines, can change these perceptions.

Bridging the approaches of each field could promote change, also. One idea suggested was to teach a multi-step lab protocol as if it were an algorithm. This could provide a means to teach biology students a new rule based approach to a familiar topic, and might provide a means to introduce a new biology topic to a math/CS student using familiar language.

Part of the Problem is Approach to Research:

There is a different approach to research in the two fields that might contribute to the current rift between faculty members and thereby trickle down to affect student research. While biology research is often conducted as a "team" over a prolonged period of time, math/computational work tends to be approached by individuals in a project-based manner. These differences might cause students who are used to one approach to be reluctant to engage in the other.

Part of the Solution is Approach to Research:

At a liberal arts college, we know our students, and can identify their strengths. In math, perhaps more than biology, it is common to identify a student's strengths and develop a research program tailored to that student. In biology, perhaps due to grant durations and the need to show progress on proposed work, especially work that requires an established lab infrastructure, the research tradition is not as student-tailored. Perhaps a compromise of short, focused team-based projects would be appropriate for computational biology collaborations involving students.

Part of the Solution is Curriculum:

Several biology programs are attempting to infuse bioinformatics throughout the program so that biology students are repeatedly exposed to manageable sized problems in computation. However, it was questioned by some as to whether this is the most appropriate approach. Should biology curriculum be infused with computation, or should computational biology be taught as a subset of biology?

There was repeated and enthusiastic interest in team taught courses. Biologists wanted to be able to combine rigorous algorithm work beyond the simple application of tools, and computational faculty expressed interest in infusing cutting edge biology and experimental application and evaluation of tools beyond a theoretical approach. While only a few of the attendees had direct experience with team-taught courses, we discussed successful programs at similar colleges.

At some of the institutions represented, many of the students in introductory biology courses are non-majors fulfilling a science requirement. However, math and computer science students are often underrepresented among these non-majors due to encouragement (or even a requirement) to take physics. At other institutions, a year of chemistry is required as a prerequisite for introductory biology, substantially decreasing the number of math and computer science majors in the course. Changing these requirements requires institutional changes but would foster interaction between math and biology at a more elementary level.

Part of the Solution Could be Seminars:

Another approach suggested was to aim faculty seminars at intro level students, not just upperclassmen. There is no reason why such seminars couldn't (for a short seminar series) target an interdisciplinary audience of biology and math students. This solution would also foster exchange of ideas and possibly collaborations between faculty members from the different fields.

What is the role of curriculum in training for student/faculty research?

While curriculum development was not the focus of this workshop, the topic is central to training students for research and thus it came up on several occasions in addition to the panel discussion on this topic.

While not all courses, nor by any means all students, constitute a direct channel to student/faculty collaborations, a few of the attendees suggested that approaching curriculum development with research in mind could actually drive the change that we are after. If the curriculum entices students toward computational biology research, the students will demand more. Since the demands of students, in addition to the desires of faculty, can be a catalyst for institutional change, curriculum may be a means to increase interest in and commitment to this kind of student/faculty research. However, a view was also expressed that research is so focused that the curriculum cannot be viewed as contributing to the needed training.

One attendee had experience teaching a computer programming class aimed specifically at biology students. Similarly, a Perl programming class for DNA analysis is taught at Wheaton College. This focused approach allows students to reach an intellectual level of questioning sufficient to spark their interest and explore computer science and math beyond the biology department.

Who is required for fruitful collaborations?

While at the graduate level, collaborations may be instigated by two students in different fields, it was generally agreed that student collaboration at the undergraduate level requires the cross-disciplinary involvement of two faculty members. Except in special cases, the students aren't quite ready to negotiate the collaboration and overcome obstacles without the support of an expert from each field.

The importance of good relations with IT (Information Technology) support cannot be underestimated both for curriculum development and student research.

Is it "harder because we are small" and don't have the wealth of research interests to draw from that a larger school might have? Or, is it "easier, because we are small" and we do talk to each other? Unlike larger institutions, where conversations occur primarily with people doing exactly the same type of work, liberal arts colleges foster cross-disciplinary conversations among students and faculty members.

In response to those questions, it was suggested that we look beyond our own institutions for collaborators. The ease and economy of Skype makes interstate or international collaborations feasible for undergraduates. Here, however the difficulty lies in identifying the collaborator and building the social ties that may be critical for a successful collaboration. Workshops such as ours provide a critical opportunity to identify collaborators.

While each liberal arts college is small, the network established through workshops such as this one extends the community to include a wealth of researchers and expertise. Therefore, we should consider this larger network between schools when a larger community is needed.

This social aspect of collaboration is important (as it is for many other aspects of successful academic environments) and should not be overlooked. As small liberal arts colleges, we should be able to capitalize upon the tight community.

What sort of funding is required to establish successful student/faculty research collaborations?

Despite past funding through HHMI, and NSF, many of the colleges represented at this workshop had recently lost substantial funding that is critical to summer student research experience.

The models for summer research experience that were presented differed on extent to which they are "programs" vs. "research projects". At some institutions, the faculty/student collaboration was dramatically emphasized such that students were individually selected for a specific project by the faculty advisor. At other institutions several students were selected for a summer research program that involved a lot of social interaction and events. While the unity of these groups is appreciated, the added effort of organization requires additional staff commitment, and likely funding through outside sources.

It was suggested that sources for post-baccalaureate funding could be especially fruitful in computational biology because the students are required to master both biology and computer science. The extra year as a research assistant allows them to fully develop a research project. However, most NIH and NSF funding aimed at undergraduates, specifically excludes post-baccalaureate funding so private or alternate sources would be required.

Career Impact:

Despite enthusiastic suggestions for radical curricular changes, the attendees also considered the practical aspects and career impact of initiating a program in computational biology. Not only the junior faculty, but the senior faculty as well, expressed frustration at the evaluation and advancement process.

Points of concern included:

Though all attendees disagreed with such an evaluation, it was feared that publication with undergraduates might be viewed by some (particularly in the humanities) as having less rigorous scholarship. While the research work may be slower, the final publication result is held to the field's standards.

While student/faculty collaborations are highly time consuming, not all institutions acknowledge, evaluate, or reward faculty members according to the level of commitment to these activities.

As computational biology is often outside of the primary research field for both the biologist and the computer/math collaborators, these publications may not count toward scholarly publication when it comes to career advancement that is highly focused on contributions to the individual's research field.

Institutional Changes might be needed in order to encourage the initiation of computational biology research.

Throughout our discussions, the need for institutional changes was repeatedly mentioned, and we were encouraged by reports from each other's colleges and plans to enact such change.

A simple step towards increased math/biology collaboration would be to cross list courses. This may have implications for teaching load.

In order to encourage integration of students at an earlier stage, it was suggested that course requirements be reduced, or made to be alternate requirements, (e.g. either an upper level math or an upper level biology plus introductory level in the other field rather than upper level requirements in both fields). This solution would obviously increase the integration of students, which is the goal, but would come at the expense of difficulty in teaching the course. Team-taught courses would be an obvious remedy but would require changes in departmental and likely institutional policy regarding teaching load.

A more dramatic change (for some colleges) would be to offer interdisciplinary degrees or double majors between math and biology.

Colleges could also give more value to research time with students. The funding that supports a few summer students could be used to hire a more qualified part-time research assistant which would advance research. Therefore, working with students should be evaluated as a portion of the teaching duties and rewarded as such.

There was a strong realization by all attendees that things can change with effort, and all showed willingness to put in that effort. We felt that workshops, such as this one, are a valuable experience to increase our exposure to alternate models and generate enthusiasm for the required efforts as it allows us to appreciate the success at other institutions.

Our Findings, with Future Suggestions for Similar Workshops

During the workshop it became clear that the problem of integrating undergraduates into a computational biology research program is a complicated one, with many facets and subtleties. Being a multidisciplinary field, research in Computational Biology often requires more than a single faculty member and the ideal approach in one institution might not work at all in another.

This problem is aggravated in small liberal arts colleges as the restricted size of the faculty makes it difficult to find a specialist in the other area that has similar research interests as yours. One way to overcome this is by maintaining interactions with faculty from other colleges. Workshops like this are fundamental to foster such interactions.

The highly interactive atmosphere at this workshop was fostered by presentations by every attendee. This provided a glimpse into many areas of research demonstrating the breadth as well as overlap in computational biology. However, the need to consider your audience was evident, even at our workshop, where there was greater need for explanation of terms, and avoiding jargon. This experience underscored the difficulties we face in integrating math and biology for students.

It was suggested that future gatherings could benefit by small focused groups that actually pursue a research idea. In that same spirit, it was suggested that groups spend time to brainstorm ideas/outlines for grant applications to fund either curriculum development or student/faculty research.

Workshop attendees:
top row: Brett Pellock, Brian Tjaden, Andre Cavalcanti, Albyn Jones, Ralph Morelli, David Matthes, Wi-Jen Chang.
front row: Bryan Head, Dan Bernstein, Jim Fix, Jo Hardin, Peter Dolan, Suzy Renn, Peter Otto.
not pictured: James Bernhard