Research Out of the Gate

In a deceptively unassuming computer laboratory tucked away in a quiet corner of the Schaap Science Center, a class of Hope freshmen is conducting original research that not too many years ago would have been the purview of an advanced graduate program.

Grouped in teams of five, the 20 biology students are working on sections of the genome of two bacteriophages, viruses that infect bacteria. They are annotating the phages' DNA, identifying elements of the genome and attaching biological information to the elements. At the end of the semester the information will go into an international database upon which scientists around the world are able to draw as they conduct research of their own.

It's not an exercise. It's not simply repeating something that someone else has already done. The results matter, it's groundbreaking and it's learning what science truly is: the process of discovery.

That last quality is why Hope established the year-long class in the fall of 2008 through a major, multi-year award from the Howard Hughes Medical Institute (HHMI). Hope was one of only 12 colleges and universities nationwide to be chosen to participate in the first year of HHMI's "Phage Genomics Research Initiative," through which the course was developed. Another 12 were added this past fall, and an additional dozen will begin participating next year.

Faculty and students find the answers together in the year-long phage genome course. The process is, in fact, one of the most important lessons, not only preparing students for future learning at the college but equipping them with experience in working with others in handling the sorts of open-ended questions that they will face throughout careers in the sciences. Pictured during the course's debut year last year are Angelica Willis of Lansing, Mich., and Courtney Long of Canton, Mich., with biologist Dr. Joseph Stukey.

The year-long laboratory course has been designed to provide beginning college students with a true research experience that teaches them how to approach open-ended scientific problems creatively and hopefully will solidify their interest in a career in science. It was a natural fit for Hope, where students have engaged in research collaboratively with faculty for decades and research experience had already been integrated into upper-level classes.

"Hope has a strong history of incorporating undergraduate students into active research programs of individual faculty members, and we've been using open research questions in our advanced coursework in recent years," said biologist Dr. Aaron Best, who is team-teaching the course with Dr. Joseph Stukey. "This new initiative enables us to create a dedicated research experience in the context of first-year coursework that is modeled on work we have done in advanced courses."

While the students in the spring are doing most of their work at the computer, the process began—-rather literally—in a much more down-to-earth way, with students isolating phages from soil samples they collected from the field. The phage that last year's class annotated, for example, was taken from Dr. Stukey's vegetable compost pile at home, and the two phages being studied this year were found in soil samples collected on the Hope campus.

From day one, incoming freshmen in the college's year-long HHMI-funded "Phage Genomics Research Initiative" class experience Hope's nationally recognized emphasis on teaching students by involving them in original research. They identify and investigate a previously unknown bacteriophage, ultimately contributing to a database used by scientists worldwide. Pictured earlier this year is Elizabeth Gerometta of Chesteron, Ind.

Each student begins the school year with isolating a phage of his or her own, and spends the fall semester conducting a variety of analyses of it, much of it through traditional bench-work. Based on the testing, the phage that seems most promising is sent to a national genome sequencing center to prepare phage DNA libraries and sequence the DNA over the semester break. The results form the basis of the spring semester, as the students team up to complete the painstaking, essential work of annotation.

The students appreciate the experience.

"On top of learning the different processes and procedures, it's just seeing what research is like," said freshman Howie Dobbs of Warrenville, Ill. "It's not just one straight road—it's lots of bumps along the way."

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>
> **– Caitlin Peirce '12**

Dobbs hasn't found that at all discouraging—in fact, he's planning to conduct research at Hope full-time this summer. Sophomore Anne Georges of Ramsey, Minn., who was among last year's students, and this year is helping the new group as a teaching assistant, has found herself similarly motivated.

"That's what research is, you hit unknowns all the time," she said. "To me it's a big puzzle."

She's conducting research with Dr. Leah Chase this semester, and plans to continue full-time in the summer. Last summer she became involved in a research team near home, at the University of Minnesota.

"There was a clear benefit from having the experiences in that class when I got into research last summer," she said. "Knowing I was going into it didn't scare me as much."

Also this summer, Georges traveled to HHMI's Janelia Farm facility in Chevy Chase, Md., to represent Hope at a conference featuring each of the schools that participated during 2008-09. "Drs. Best and Stukey gave me a chance to prepare the presentation. It was a great experience," she said.

Sophomore Caitlin Peirce of Portage, Mich., who was also in last year's class, finished the first semester with a bonus: it was her phage that was chosen for sequencing and spring-semester annotation. Like Georges, she was a teaching assistant for this year's class and is also already involved in a faculty research group, working with Dr. Best.

"I think the phage course encouraged all of us to think independently," she said. "We were able to see the Scientific Method in practice and it was exciting to feel like we were contributing to actual scientific knowledge. The research emphasis also forced us to problem solve and modify experiments when things didn't always work out. I think the phage course gave many of us confidence in our own judgment, which is important in further research opportunities."

Dr. Stukey is integrating the phage research into his own research program, and also anticipates seeing it find its way into upper-level classes at the college. The research could also make a difference far beyond Hope. As the results from all the participating schools are compiled, the information could ultimately help other researchers anywhere in the world with projects of their own, including, potentially, those seeking to develop cures for diseases like leprosy or tuberculosis.

"One of the reasons to look at the phage of mycobacteria is so that you understand how the mycobacteria, themselves, are working," Dr. Best said. "And mycobacteria cause major diseases worldwide."

That it is even possible for beginning undergraduates to be involved in cutting-edge genetic research reflects the dramatic pace at which technology is changing. The first complete genome of an organism was produced in 1995. While he was in graduate school in the 1980s, Dr. Stukey spent a year sequencing just one gene of less than 3,000 genomic base pairs. Now, an entire genome of more than 100 genes and 75,000 base pairs can be sequenced in less than one month.

Based on that rate of change, today's students will similarly find the particulars of science much changed a dozen years hence. The goal for their Hope mentors, then, is not only to train them in the current state of the art, which is indeed essential in the short-term, but to prepare them—even in year one—for whatever lies ahead.

"The rate of technological improvement is amazing," Dr. Best said. "It's certainly driving the way science is done. It's altered the way that biology is done forever."

"Education has to keep up with that while also equipping students to handle the changes and challenges that they will encounter," he said. "I think that this program positions Hope well in both respects."