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## Twelve Schools Chosen To Expand HHMI's Innovative Science Education Program

One year ago, 12 colleges and universities took a leap of faith by joining the Howard Hughes Medical Institute's Science Education Alliance in an education experiment with an ambitious agenda—teach science to students by involving them in scientific discovery on a national scale.

After one term of the course, many faculty who have been teaching the Alliance's innovative genomics research course to freshmen are now realizing they may never again teach science courses the same way. Now 12 additional colleges and universities have been chosen to join the Science Education Alliance (SEA).

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"When you visit these schools, you can see that institutional transformation is occurring," says Tuajuanda Jordan, director of the SEA program at HHMI. "We have given these educators ammunition to show their colleagues that research courses are a viable way to engage students and possibly retain them in the sciences."

HHMI created the Science Education Alliance in 2007 in the hope that it would become a resource for science educators from across the nation. It allows faculty to work together to deliver innovative science education programs and bring the excitement of the doing of science directly to students in a novel, collaborative way. The Institute has committed \$4 million over four years to the Alliance.

The SEA's first project is the National Genomics Research Initiative, a two-part, year-long research course offered by colleges and universities selected through a national competition. The course is aimed exclusively at beginning college students, who make real discoveries by doing research on bacterial viruses, called phage. In the first term, the students isolate colonies of phage from locally collected soil samples. Given the diversity of phage, each one is almost certain to be unique, so the students get to name their newly identified life form. They then spend the rest of the term purifying and characterizing their phage and extracting its DNA.

Between terms, the purified DNA is sent to the Joint Genome Institute-Los Alamos National Laboratory in New Mexico, where it is sequenced. In the second term, the students receive files containing their phage's DNA sequence. The students then use bioinformatics tools to analyze and annotate the DNA from their phage.

The 12 new SEA colleges and universities were chosen from among 33 applicants. The schools, ranging from small private colleges to large research universities, will start offering the course in Fall 2009. HHMI provides research and laboratory materials and the support from Jordan and a dedicated HHMI staff. Another four colleges will join the Alliance as associate members. They will attend training sessions that will allow them to implement this research experience in laboratory classes on their campuses. Eventually, HHMI will select at least 36 schools to participate in the genomics research initiative as full members.

The first 12 schools, chosen in 2007, began offering the course in Fall 2008. Already the professors teaching the courses see major differences in their teaching and their students. "I don't know if I'll ever be able to go back to teaching a standard lab after working with this class," says Kit Pogliano, a biology professor at the University of California, San Diego, who says the experience teaching 24 freshmen has changed how she looks at teaching science. "The students don't know what the outcome will be, they don't know whether the experiments will work—and indeed, the first time most did not. The students really did have to work things out. And that was fantastic."

Professors teaching the SEA course, like Pogliano, say the freshmen students were hooked by the classes: they worked many extra hours and bonded with their fellow students, even faculty members. They loved learning science by planning and guiding their own long-term research projects rather than by plodding through cookbook labs or enduring rote memorization.

"It is clear that these schools are bringing discovery to their beginning students, which is just what we hoped would happen," says Peter Bruns, HHMI's vice president for grants and special programs. Their enthusiasm was also shown in the students' commitment: the faculty teaching the phage course report that it has higher than average retention numbers, Bruns says.

As freshmen, most of the students participating in the first term of the SEA course had never done research before. The course provides facts about phage and lab work, and, more importantly, it requires these beginning

students to think like scientists and deal with the ups and downs of research projects that have uncertain outcomes. Ann Findley, a biology professor at the University of Louisiana at Monroe, says her freshman students have already presented the work at two scientific meetings. “We took some kids and basically built their confidence. They really think they can do this,” Findley says. And the word has spread: Findley’s class is almost full for Fall 2009.

The students told professors teaching the SEA course that the most exciting moment came when they saw a picture of their phage for the first time. Phage are so tiny they can’t be seen using a standard microscope. But the SEA ensured that every student got a picture of their phage using an electron microscope, either at their home institution or through an agreement with another institution. As the image of the phage emerged on the computer screen, many students pointed and jumped up and down. One student from Hope College in Michigan called her mom from lab when she saw her phage for the first time. In Findley’s class, the students later had the equivalent of a phage fashion show, and they “oohed” and “aahed” over the phage with the longest tail or darkest head.

The students’ excitement and creativity was also reflected in the names they gave their viruses. The quirky names aren’t the normal staid acronyms often seen in the scientific literature. For example, some students named their phage after the Comedy Central duo of “Colbert” and “Jon Stewart.” Other groups chose “Peaches” and “LRRHood” for Little Red Riding Hood. A student at Spelman College named her phage “Hope” the day after Barack Obama was elected President of the United States.

The DNA from those phage is being sequenced over the winter holiday break. In January, most of the same students who identified the phage will return to class to take a detailed look at the DNA. Using standard research software modified for the course, they will identify genes and try to determine their function. It is highly likely that the students will discover brand new genes whose functions are totally unknown.

Many professors teaching the SEA course say that the network of science educators has made it possible for them to bring real research to students in ways they could not have done on their own. The HHMI staff support much of the setup and operation of the labs, and the SEA faculty at other schools are a useful resource to solve technical or teaching problems or to find ways to present the work to other faculty or administrators. Tips and other helpful ideas and guides are shared online via SEA’s online Wiki.

Edwin Vazquez, who will be teaching the course at the University of Puerto Rico in Cayey in Fall 2009, is most excited about being part of a network of educators who can share ideas about how to teach science more effectively. “It helps me and other professors who believe that students should be exposed to research as early as possible, and we want to infuse this across the curriculum,” Vazquez says. “I think it is part of a movement across the United States of reforming science education and the realization that science

can only be understood by doing it. There is no other way.”

Faculty inside and outside the schools’ biology departments are asking questions and watching to see whether real research can be done inside classes. SEA intends to prove the answer is yes. “This is a really unique new way of teaching,” says Manny Ares, who is currently teaching the course at the University of California, Santa Cruz. “I think people should be watching how this experiment turns out.”

The new participants in the National Genome Research Initiative are