The phage course is a relatively simple concept based on work by HHMI professor Graham Hatfull at the University of Pittsburgh. Students isolate novel viruses that infect bacteria, called bacteriophages or phages, from soil, and then purify them, isolate their genomic DNA, and send it away for DNA sequencing. When the sequence comes back, the students employ bioinformatics tools to annotate and characterize their new-found phages.

From start to finish, there are no guarantees of success or right answers. Students endure the pitfalls of true research, such as contaminated bacterial plates and inscrutable results, along with the thrill of discovery and eureka moments small and large. “Just because something is effective, doesn’t mean that it’s always a comfortable experience to go through,” says Grant Hartzog, a professor at the University of California, Santa Cruz. “These [students] are getting pushed to think hard in ways that they aren’t used to.”

And the phage course is effective. As the first initiative of HHMI’s Science Education Alliance (SEA), which now encompasses 67 schools, participants have been documenting their experiences: students participating are more likely to continue in science courses and perform significantly better in lecture courses than peers in traditional laboratories, says Tuajuanda Jordan, former director of SEA who was instrumental in getting the program off the ground. Jordan notes, “We are born naturally curious and the SEA course engages that curiosity and really helps students develop higher thinking skills.”

The quality of those thinking skills and the significance of the science produced was on full display in the January 27, 2011, issue of the peer-reviewed journal PLoS One where 192 coauthors composed of students from the first cohort of SEA schools and from the University of Pittsburgh identified and characterized 18 previously unknown phages. At the time, their work represented a fifth of all bacteriophage genomes characterized.

The ability to adapt the course to best fit the students and curricula of an individual school is part of what makes it so effective at institutions ranging from elite universities to regional colleges, according to Jordan.

While the course has been built around phages that infect Mycobacterium smegmatis, a cousin of the bacterium that causes tuberculosis, some schools are switching to different organisms because they are less expensive or easier to work with or represent “uncharted” territory. For example, the University of Mary Washington, in Fredericksburg, Virginia, through a collaboration with the Naval Surface Warfare Center at Dahlgren, will look for phages that infect spore-forming bacillus bacteria—common and easily maintained organisms that could inform the Navy’s work on anthrax bacteria.

At the College of William & Mary in Williamsburg, Virginia, the biology department will institute a Helicobacter pylori genomics lab course and the environmental science and neuroscience departments will explore the effect of mercury on embryonic development in frogs.

One of the most exciting ways the phage course is evolving takes the effort to upper classmen. The first cohort of schools faced a “problem” when students were eager to continue pursuing questions arising from the phage course work and the schools had nothing to offer them. “Once you’ve sequenced and annotated a phage genome, this is just the beginning of discovery,” says associate professor Aaron Best of Hope College in Holland, Michigan. The annotation process sheds light on new avenues of exploration that truly engaged students want to pursue. “We had a student at the end of the course throw up her hands and ask if this was IT?” laughs William & Mary biology professor Margaret Saha. Like most of the first cohort of schools, Hope and William & Mary are developing courses for upperclassmen designed to explore gene expression patterns in the phages they’ve annotated.

“People always ask how we afford to offer this experience,” Saha says. “It’s really not that expensive when you consider what it gives the students and the institution. It’s mostly time and it just works so well.” -Lisa Chiu

2011 Holiday Lectures on Science

Bones, Stones, and Genes: The Origin of Modern Humans

Some 150 years after Charles Darwin proposed that we have a common ancestor with great apes, human evolution remains one of the most debated topics in all of science. In HHMI’s 2011 Holiday Lectures on Science, three world experts will delve into millions of years of evidence that scientists use to study human evolution and the fact and fiction of this important topic. John J. Shea of Stony Brook University will explain how ancient stone tools provide evidence of problem solving. Sarah Tishkoff of the University of Pennsylvania will examine the genetic heritage of modern humans and human evolution. And Timothy D. White of the University of California, Berkeley, will describe the fossil evidence that links modern humans to our earliest relatives. This year’s lecture series—Bones, Stones, and Genes: The Origin of Modern Humans—will take place in front of an audience of high school students October 6–7 at HHMI’s headquarters in Chevy Chase, Maryland. Sign up now for the live webcast at www.hhmi.org/biointeractive.