SMART in More Ways than One

HIGH SCHOOL SOPHOMORES LEARN ABOUT SCIENCE THROUGH STRUCTURE.

PROTEIN REACTIONS ARE INTERESTING. BUT MAKE THEM GLOW IN the dark, and wow! That's what Max Horlbeck remembers thinking as a high school student in fall 2004, as he stared at the glimmering contents of a Petri dish in Fred Hughson's biology laboratory at Princeton University.

That luminescence, Horlbeck and his classmates were told, happens when the marine bacteria in the dish communicate with each other. As sophomores, these visiting students might not have had the opportunity to spend months exploring the structure of just one protein involved in that reaction. But Horlbeck and his classmates from the nearby Pingry School, in Martinsville, New Jersey, were in luck.

They were members of Pingry School's SMART (Students Modeling a Research Topic) team. Working with the team was a winner for Hughson, a professor of molecular biology, as well. In exchange for a few hours of mentoring, spread out over several months, the students built him a sophisticated three-dimensional model of the protein, known as LuxP.

Hughson got his model, and Horlbeck and his classmates got an introduction to how high-level science works. "Knowing how to manipulate protein structure is a valuable skill," says Horlbeck, now a junior studying biochemistry and computer science at Columbia University. "What I learned during that experience has been beneficial in nearly every lab I've worked in since."

Sustained by positive feedback, the SMART team program has grown considerably since its launch in 2001 at the Milwaukee School of Engineering (MSOE). It started with 10 teams based at 7 schools. Today the program runs more than 50 teams throughout the country, 18 of them funded by a precollege science education grant from HHMI. The National Institutes of Health funds the rest. Eighty percent of the SMART teams are in public schools.

"Our main goal is to introduce kids to professional science by allowing them to play a significant but peripheral role in research," says SMART developer Tim Herman, a biochemist and molecular biologist at MSOE's Center for BioMolecular Modeling. "When you engage students in building protein models, you grab their

Maxwell Loren Holyoke-Hirsch

attention and focus it in a magical way. They begin to wonder, and then ask questions, about how a protein's function and structure depend on each other."

The SMART team experience typically begins with high school teacher training at MSOE. Over two weeks in the summer, teachers learn how to design proteins using molecular visualization software. They take those skills back to their classrooms, where they teach students how to design protein models, which are then physically created at MSOE with automated, rapid-prototyping equipment.

"We use a modified inkjet printing technology that builds them up layer by layer," Herman explains. "We just replace ink in the printheads with pigmented glue, and then glue together successive layers of plaster powder to build up the final physical model." Two models are made; university mentors keep one, the students keep the other.

"The models make incredible tools," says Ann Stock, an HHMI investigator and biochemist at University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School. "We use them for explanatory purposes and also to explore how different domains in a family of proteins can be arranged." Stock mentored one of Pingry School's SMART teams during the 2008–2009 school year (see Perspective, page 34). She lauds what she says is the program's "backwards" approach to education. Instead of working forward from genes to proteins, she explains, the students backtrack from a protein to its genetic origins, which dictate structure. "These models help to make that whole process real and understandable," she says.

Deirdre O'Mara, a biology teacher at Pingry School, says the SMART team program provides professors a way to give something back. "They tend to be thrilled that the students get so interested," she says. "Soon they're having fantastic conversations about theory, structure, and why a particular protein residue is important. You get this high-level conversation that goes on as the relationship develops."

More than 90 percent of students who participate in SMART report a positive impact on career choices, Herman says. And 85 percent of teachers involved in the SMART program return year after year.

Meanwhile Horlbeck—like many of the 1,300 students who have gone through the SMART team program so far—is eyeing a career in research. And he credits the SMART team experience for teaching him how to make sense of biological structures. "When you first look at a protein, it's hard to see why it performs its specific function," he says. "But through this experience, we learned how to connect structure and function, which makes proteins much more meaningful." ■ –CHARLES SCHMIDT

2009 HOLIDAY LECTURES ON SCIENCE

EXPLORING BIODIVERSITY: THE SEARCH FOR NEW MEDICINES

Glow-in-the-dark bacteria and poisonous sea snails took center stage at the 2009 Holiday Lectures. HHMI investigator Bonnie Bassler (bottom left) and HHMI professor Baldomero Olivera (top right) introduced 180 D.C.-area high school students to the creatures through lectures and hands-on projects that explained how the organisms are helping identify potential medicines. The two researchers were joined in a panel discussion about biodiversity by (top left, l–r) HHMI President Robert Tjian, biologist E.O. Wilson, and physician-environmentalist Eric Chivian.

Paul Fetters