HANDS ON

Models of Excitement

Teachers use rapid prototyping to build protein structures.

Discoveries normally take years to trickle down from the lab to the classroom. But a team of high school science teachers in Wisconsin has dramatically reduced the wait, while helping scientists see their work in new ways.

The teachers spent last summer creating sophisticated three-dimensional molecular models of the ribosome—the cell's protein-making factory—based on atomic structures published less than a year before. Seeing, touching and manipulating the three-dimensional models "makes the molecular world real," says Michael Patrick of the University of Wisconsin–Madison, who runs a summer enrichment program for science teachers in collaboration with the Center for BioMolecular Modeling at the Milwaukee School of Engineering. "It deepens understanding for the teachers, their students and even for researchers who know the molecules inside and out."

Thomas A. Steitz, an HHMI researcher at Yale University who published the structure of the 50S ribosomal subunit (*Science*, August 2000), says he was amazed when he received the teachers' version of his discovery. "I immediately showed it around the lab. We noticed a number of things we hadn't appreciated about the molecule. For instance, it's absolutely flat on the bottom. That fits with the fact that it sits on the [cell] membrane."

"Every student I show them to gets very excited about the models," Steitz adds. "Everybody wants to have one."

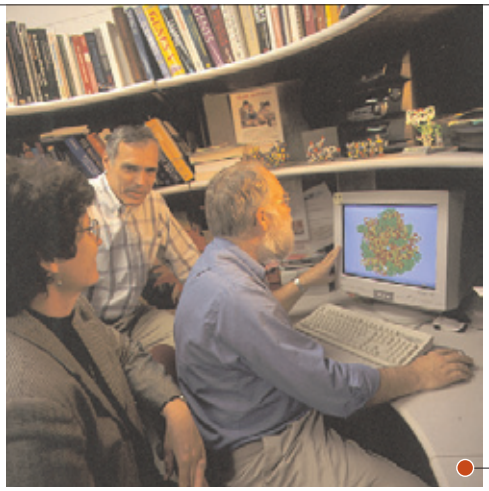
The models are a product of *Genes, Schemes and Molecular Machines*, a teacher-development program partially supported by a grant from HHMI. Six Milwaukee-area teachers, who call themselves the 3D Translation Team, used the biomolecular modeling center's rapid prototyping technology to produce several ribosomal subunits and complete ribosome models. Center director Tim Herman explains that recent software advances make it possible to use rapid prototyping—which is commonly used for simulating auto parts and ships' keels—to fabricate intricate molecular structures out of polymers, powder, ink and glue within a day.

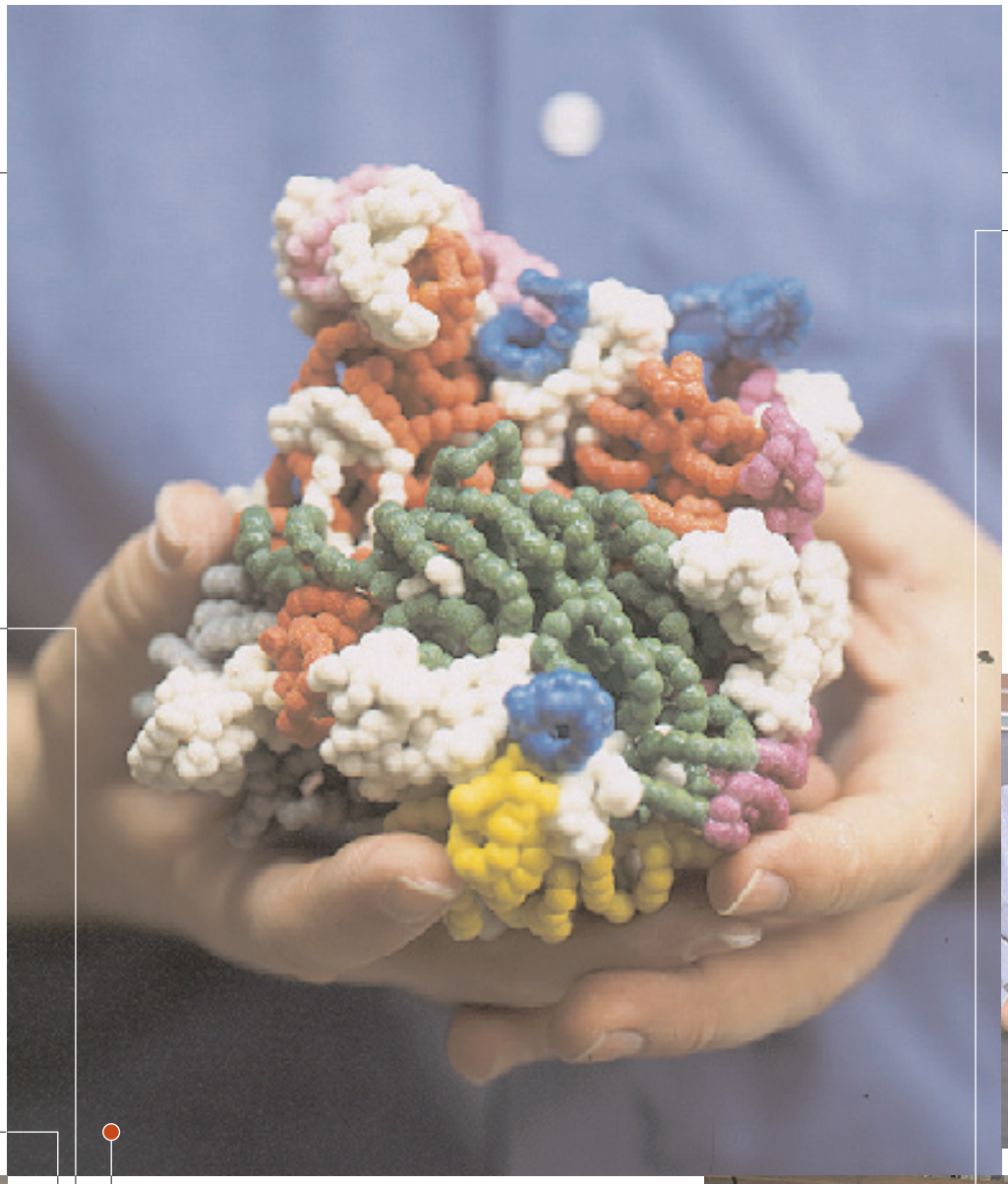
The teachers first learned to use the prototyping equipment and then set themselves an ambitious goal: develop a complete protein synthesis kit, with models to demonstrate each step of the process in their classrooms.

The team's first models were highly intricate. The teachers now feel that giving these to high school students is "like putting student drivers in a Porsche," says Jon Knopp, who recently retired from Milwaukee's Rufus King High School. The protein synthesis kit they plan to finish by fall 2002 will use simpler, more streamlined models. "The biggest stumbling block was discovering what we can do, then determining what level of sophistication is right for our students," says Pete Nielsen of Kettle Moraine High School.

New teams of students and teachers have formed to build models. One team is modeling three proteins responsible for the toxicity of anthrax. Another is building a model of the p53 tumor suppressor protein, inactiva-ted by the carcinogens in tobacco smoke, to use in an anti-smoking lesson.

Despite a steep learning curve at the start, the teachers have enjoyed immersing themselves in science. The original three-week program turned to six, and still the teachers kept returning to improve their models. Says Kettle Moraine's Karen DeBoer,"What keeps us coming back is that we're working on something cutting-edge and important." **—TONI SHEARS**





■ Pete Nielson uses models of the 30S and 50S ribosomal subunits to demonstrate the details of protein synthesis to advanced placement biology students Stacy Weber, Eric Poweleit, Joe Yatzeck, Jacob Schmidt and Tasha Shallow at Kettle Moraine High School in Wisconsin.

■ HHMI investigator Thomas A. Steitz (center) examines models of the 50S ribosomal subunit built by a team that included high school teachers Jon Knopp and Pete Nielson. Steitz's lab at Yale University determined the atomic structure of the 50S ribosomal subunit.

■ Wisconsin high school teachers built this three-dimensional model of the 50S subunit of the ribosome, which works as a protein-building factory.

■ The first step in molecular model-building is to download a computer file of the molecule's structure from the Protein Data Bank and create a design file that rapid prototyping equipment can use to fabricate the model. Wisconsin high school biology teachers Donna LaFlamme and Jon Knopp watch Tim Herman, director of the Center for BioMolecular Modeling at the Milwaukee School of Engineering, manipulate a computer image of the anthrax protective antigen protein.

■ High school teacher Karen DeBoer removes a finished model from a specialized color printer, one of five rapid prototyping technologies used to produce three-dimensional molecular models.

■ Donna LaFlamme, Jon Knopp, Tim Herman and Karen DeBoer put the finishing touches on their models to teach protein structure and function to high school students.

JAMES SCHNEPF (5), MICHAEL KIENITZ (STEITZ, ABOVE)