REENGINEERING THE UNDERGRAD LAB

ACS MEETING NEWS: Thymine polymer project at Simmons College helps integrate lab instruction and research

STEPHEN K. RITTER, C&EN WASHINGTON

UNDERGRADUATE students at Boston-based Simmons College are part of an education experiment that has thrown out the standard approach of cookbook lab instruction and instead thrusts students immediately into integrated lab training and undergraduate research. Organic chemist Rich Gurney and his colleagues admit their concept is a gamble, but they say it seems to better prepare students to enter the chemical workforce.

At the American Chemical Society national meeting in Denver late last month, Gurney and some of his students made presentations in Division of Chemical Education symposia in which they laid out the details of their program, including progress on one research project involving thymine-based copolymers.

With the help of a grant from the W. M. Keck Foundation, the Simmons science faculty is creating an undergraduate experience in which students in chemistry, physics, and biology study different aspects of ongoing faculty research projects, Gurney explained.

"With the traditional approach, students don't even need to bring their brains to the lab, because all the materials have been prepared and all the thinking has been done for them in advance," Gurney told C&EN. "We can't afford to do that at Simmons."

Although Simmons is a private all-women's college, it isn't as well-known or well-endowed as other private colleges in Massachusetts, Gurney noted. Many Simmons students are the first in their families to go to college, and when they graduate they tend to have substantial debt, he said. Rather than go to graduate school, Simmons graduates are more likely to go to work.

"Our students need to be trained to enter the workforce immediately," Gurney said, "and to do that in chemistry they need to know how to do research when they graduate."

From their first semester at Simmons, students jump in and begin learning the fundamentals of research. In chemistry, they learn lab safety, synthesis techniques, and how to use analytical instrumentation. They also help design experiments and prepare the needed reagents.

COURTESY OF KATRINA THISTLE

WORKING VACATION Thistle (left) and McLaughlin pose during a break at their summer lab home in Argentina.

"More learning takes place when the students experience the ins and outs of an experiment and have to work through or around problems that arise," Gurney said.

As students progress from one semester to the next, they learn more advanced skills and begin to mentor newer students. Some of the students evolve into teaching assistants or instrumentation technicians for the introductory lab courses. "Peer mentoring fosters a greater sense of community, the benefits of which cannot be overstated," Gurney said. The Simmons experience for chemistry majors culminates with a senior-year research project and thesis.

One thrust of Gurney's research, which has been integrated into the organic chemistry lab, involves preparing functionalized vinylbenzyl thymine (VBT) copolymers. For example, Gurney's group couples VBT with vinylbenzyl triethylammonium (VBA) to prepare nontoxic, water-soluble, ultraviolet-curable copolymers that can be cast as long-lasting coatings on any type of surface without using organic solvents.

ONE POTENTIAL application of VBT-VBA copolymers is to take advantage of their antimicrobial properties to protect ship hulls from fouling by microbes and by barnacles that feed on the microbes. The films' antimicrobial effect stems from the trialkylammonium groups, which interact with and rupture microbial cell walls. The films are potentially greener alternatives to antifoulant chemicals added to paint.

"At Simmons, they have a very cool thing going," John C. Warner, president and chief technology officer of the Warner Babcock Institute for Green Chemistry, located nearby in Wilmington, Mass., told C&EN. In the early 1990s, while working at Polaroid, Warner invented chemistry based on thymine that allows polymer properties to be manipulated through hydrogen bonding and π-stacking interactions. When Warner went into academia in 1996 at the University of Massachusetts, Boston, he created a series of experiments based on his thymine chemistry for undergraduate labs.

"The thymine experiments are a good way to illustrate the universality of chemistry—how it pertains to biology, physics, engineering, and other disciplines," Warner said. "I think what Rich is doing is a wonderful extension of that."

One of Gurney's research challenges has been to synthesize VBT in the highest yield and by the greenest method possible, he said. To that end, first-year students taking organic chemistry this past spring began helping to fine-tune the synthesis, which included learning recrystallization techniques and ^{13}C nuclear magnetic resonance spectroscopy. They also developed a thin-layer chromatography method to follow the course of the reaction and optimize the reaction time. During the experiments, they generated enough VBT, which is not commercially available, to supply Gurney's research lab.

This fall, these students are taking the

second semester of organic chemistry and picking up the thymine project where they left off, Gurney said. They will be implementing and testing the new procedures and begin working out how a known impurity forms and how to avoid it.

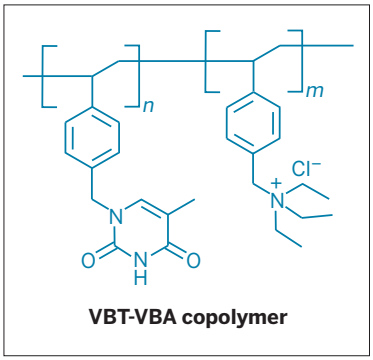
THE RESULTS of Simmons' lab-research integration are revealing, Gurney said. In 2003, Simmons had eight graduates in chemistry-related majors, he noted. This year, after fully adopting the integrated curriculum, the college had 28 graduates in chemistry-related majors and 11 chemistry minors—most of the graduates started out with other majors, but switched because of the integrated learning.

But the real value of the program is reflected in the testimonials of the students. In Denver, Amanda L. McLaughlin and Katrina M. Thistle, two effervescent members of Gurney's group, presented a poster on their research to develop VBA analogs and characterize VBT-VBA copolymer films.

"Our friends at larger universities can't believe what we are doing," McLaughlin said. "They wish they could come here once we tell them what they are missing."

McLaughlin, who has been focusing on characterization work, is looking forward to leading students in the advanced instrumental analysis course to develop a mass spectrometry method to study the copolymers. "It's really interesting to watch how greening the monomer synthesis is leading to other aspects of the project," she observed.

"It is rewarding to see our work implemented in the teaching labs," Thistle added. "With the underclasswomen performing experiments, we are able to accomplish a lot more. The research integration creates a great learning experience for them and an enhanced research experience for us."



VBT-VBA copolymer

McLaughlin and Thistle further enhanced their research by scoring a summer vacation of sorts in Argentina. Gurney used funding from the National Science Foundation and from Simmons to pay for a 12-week research trip for himself and four students. They were hosted by Débora M. Martino at the National University of the Littoral, in Santa Fe, Argentina, who was a postdoc in Warner's group at UMass Boston.

Gurney had been sending VBT samples synthesized at Simmons to Martino, Thistle said. Thistle and McLaughlin went to Argentina to show Martino and her collaborators how to make the monomer themselves. "In return, we were taught thin-film fabrication techniques, including coating and surface-analysis methods," she said.

Besides antifouling coatings, the Simmons chemists are thinking about possibilities for using the copolymers for drug delivery and as photoresists for electronics. "It's unbelievable to think that one day our chemistry could be used for something practical," McLaughlin said. ■