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BIENNIAL SHEDS LIGHT ON PERENNIAL ISSUES

Education conference covers guided inquiry, early organic chemistry, undergrad research

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You could say the whole town of Bellingham, Wash., turned out for the recent 17th Biennial Conference on Chemical Education (BCCCE). At least for a while. On the second morning of the conference, a transformer malfunctioned and the power went out all over town. After five years of planning, George S. Kriz, professor of chemistry at Western Washington University, which was the conference site, and Sara Selfe, a chemistry instructor at Edmonds Community College in Lynnwood, Wash., thought they had prepared for anything. But they didn’t expect this.

The Bellingham Herald called the event the “Blackout Biennial.” But chemists—especially chemistry teachers—are a hardy bunch. Some teachers held sessions in rooms lit by flashlights or gathered on the quad for more informal sessions. As they say, the show must go on.

The lights came back on after several hours, though, and nearly 1,300 conference attendees got down to business in rooms with more of the comforts of campus. The participants hailed from 23 countries and included 94 foreign registrants. The five-day program consisted of more than 600 papers and 62 workshops and an exposition of chemistry educational materials that had 61 booths.

The American Chemical Society’s Division of Chemical Education has sponsored these conferences since 1970. The kickoff for the 2002 gathering was a plenary lecture by Columbia University chemistry professor Ronald Breslow. His address set the tone for much of the conference as participants tackled perennial problems of attracting and retaining undergraduates in chemistry—particularly during the first two years of education.

As chemistry instructors, Breslow said, “we have a wonderful opportunity to improve the reputation of chemistry in our undergraduate and high school classes. To achieve this, we must be sure that these classes are inspiring.” Too often, however, chemistry is taught “in an atmosphere where even some of the brightest students ask, ‘How could anyone find this interesting?’” he added.

VARIOUS SYMPOSIA addressed the problem of getting students engaged in chemistry. One multiday symposium dealt with the advantages of “guided inquiry” throughout the curriculum. “Imagine a coach who spends every practice demon-

strating good technique, but never lets her students hold the racket and figure out how to hit the ball,” saidAndre Straumanis of Sandia National Laboratories. Straumanis has written a book, “Guided Inquiry Organic Chemistry,” that is being published by Houghton Mifflin. He pointed out that “most people learn by doing.”

At Norwich University, Northfield, Vt., chemistry professor Roy Butler avoids using a lecture hall for just this reason. He told symposium participants that in his general chemistry class, students gather in small groups at clustered tables to discuss and argue and come to decisions about chemistry problems. He said he switched over to this system because it became clear to him over the years that a straight lecture format wasn’t working.

Butler interacts with each group of four students, sometimes sitting down for a while with a group to help get the conversation pointed in the right direction. “Not much information is given in the activity sheets that we use,” he said, “and that’s the point.

“One of the advantages to this method,” he explained, is that “you find out what student misconceptions are. And there are a lot. In addition, guided inquiry provides an opportunity to learn individual student intellectual personalities so you can customize instruction.”

In guided inquiry, the instructor’s role is to probe, encourage, and guide; to draw out critical ideas; and to avoid the “gimme”—that is, the spoon-feeding of answers to the student.

R. Daniel Libby, professor and chair of the chemistry department at Moravian College in Bethlehem, Pa., has created a lectureless introductory organic chemistry class that he has used in classes ranging in size from 17 to 110. Libby teaches class in a series of learning cycles.

A LEARNING CYCLE, Libby explains, is a “three-phase process that provides opportunities for students to explore new material.” In the first phase, “exploration,” students evaluate data, try to identify significant trends, and develop hypotheses that explain the trends. In the second phase, “concept invention,” the students and instructor work in class to evaluate hypotheses and find concepts that best explain the data. The third phase, “application,” is an out-of-class application of the concept to new situations.

Groups come up with answers and then get together to argue over them. Libby finds that this approach works well with both highly motivated students and weaker students.
The sad fact is that, for most students, general chemistry is a terminal chemistry course. “It is our last chance to show them the excitement and beauty of the field,” Breslow said, pointing out that perhaps 5% or less students in the typical general chemistry class will become chemists.

He reminded conference that organic chemistry, usually taught in the second year of undergraduate study, is populated by “survivors” who were not “weed-out” by general chemistry. “We must not pretend that all students are future chemists or future organic chemists,” Breslow said. He suggested that a way to get students excited about chemistry is to make it relevant to the subjects the students find interesting.

**SOME EDUCATORS** who gave presentations at the biennial believe that the best way to generate this excitement is to teach organic chemistry first — before general inorganic chemistry (see page 36). I. David Reingold, professor of chemistry at Juniata College, Huntingdon, Pa., believes that general chemistry should be organic chemistry. About 80% of the students in the college's general chemistry courses are biology or premed students, he said. The ideal curriculum would not start with a math-oriented, low-level physical chemistry course, as it does now. Reingold asserts that this is not what these students want or need, and not what we should be teaching them.

First, he explained, incoming freshmen have very different levels of preparation. Some have seen it all before in high school, and many are worried about the math. To Reingold, advantages of teaching organic chemistry first include that it is a more logical introduction to chemistry (going first to qualitative subjects, then to quantitative subjects). Concepts that rely on more advanced math are delayed until sophomore year. And biologically useful chemistry is covered first, which is a real plus for future biologists and medical students.

Tom T. Shave, professor of chemistry at Bucknell University, Lewisburg, Pa., noted that Bucknell implemented an organic-first sequence in 1960 to avoid higher level repetition of high school chemistry. “Redundancy is not satisfying,” he said.

A lot of general chemistry concepts can be taught using organic chemistry examples, said Shave. The curriculum at Bucknell consists of two semesters of organic chemistry in the first year followed by a semester of inorganic chemistry and a semester of analytical chemistry. The content of a traditional general chemistry course is dispersed among the first four introductory courses and presented in varied contexts. Learning is reinforced by repetition within the curriculum.

Relevance to biosciences is stressed in Shave’s classes. Drug discovery, synthesis, consequences of stereochemistry, and biochemical mechanisms are treated early in the course — not relegated to the last uncovered chapters in a standard text. “Taxol is the first organic structure that students see,” he said.

Breslow noted that “heterocyclic chemistry is usually relegated to the end of the book, and most classes never get there.” But biological and medicinal molecules are overwhelmingly heterocyclic. “Make sure there is time for them: imidazole, thiazolium, nicotine, purines, pyrimidines, and their biochemical roles. Organic phosphate esters are critical in biology,” he urged.

Some educators at the conference said they believe that early organic chemistry prepares students for undergraduate research better than general chemistry.

Plenary speaker Michael P. Doyle, a University of Arizona chemistry professor and president of Research Corporation, Tucson, Ariz., told attendees that he believes that “research is the defining endeavor of those who have pursued careers in the chemical sciences.” In his address, Doyle focused on the value of undergraduate research and touched on some of the misconceptions that exist in the minds of chemical faculty about the value of research done by undergraduates (see page 30). He told attendees that “there is abundant evidence that undergraduates can make discoveries with you to advance science.” Much of his talk dealt with Research Corporation’s groundbreaking study, “Academic Excellence: A Study on the Role of Research in the Natural Sciences at Undergraduate Institutions” (C&EN, Oct. 22, 2001, page 59).

**ATTENDEES ENJOYED** Western Washington University’s (WWU) bounty. It is blessed with a stunning campus replete with Bellingham Bay sunsets — and a chemist president. Karen W. Morse is a Ph.D. chemist who has been president of WWU since 1993. She is clearly proud of the university. In her plenary address, Morse noted that the university has “a handsome campus, good teaching, and what one national magazine called one of the best values in higher education today.”

WWU is also a center of science and in the process of building a state-of-the-art chemistry facility. It is doing this with the support of the M. J. Murdock Charitable Trust and Research Corporation, which made an award to the university’s chemistry department of nearly $750,000. The sponsors recognize the university’s emphasis on a quality liberal arts education and undergraduate research.

“This grant has sparked an evolution of Western’s chemistry department and greatly contributes to the university’s overall mission to achieve the highest level of distinction,” Morse said.

The grant, along with approximately $1.6 million in pledged funds from WWU, will be used to recruit 10 faculty and equip them with state-of-the-art instrumentation for instruction and research and to generate a culture of undergraduate research in chemistry and biochemistry.

“We expect to recruit top-notch faculty,” said Mark Wicholas, chemistry department chair. “We want to attract the most talented and capable science students by developing a chemistry department that is recognized as one of the best nationwide for its quality undergraduate curriculum.”

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