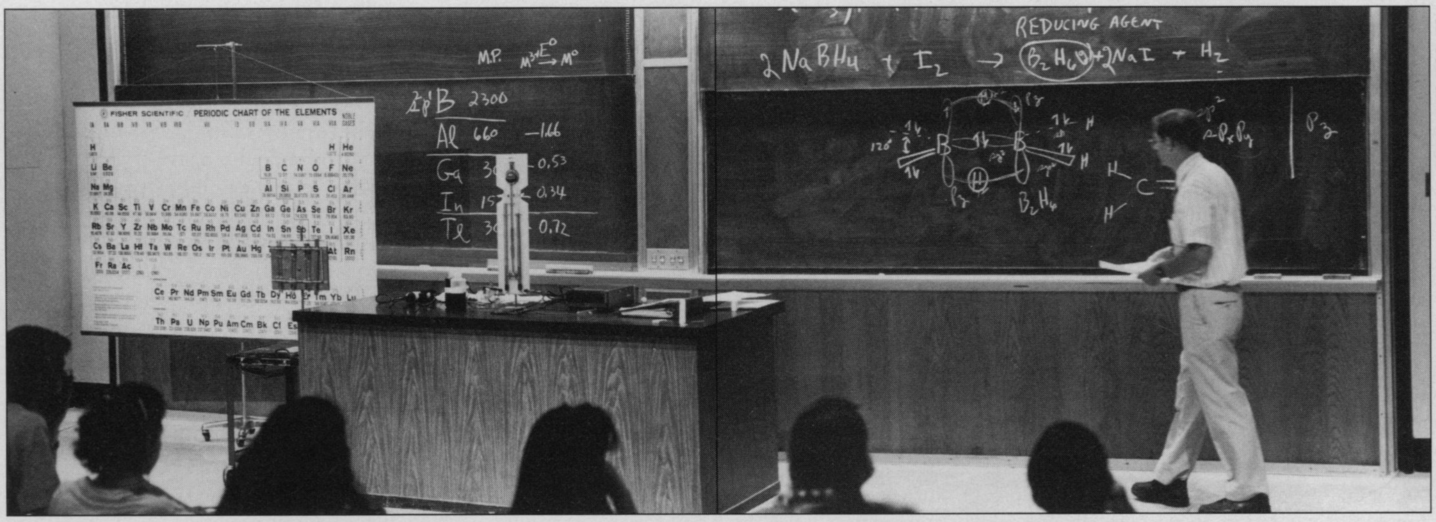


DARROW MONTGOMERY

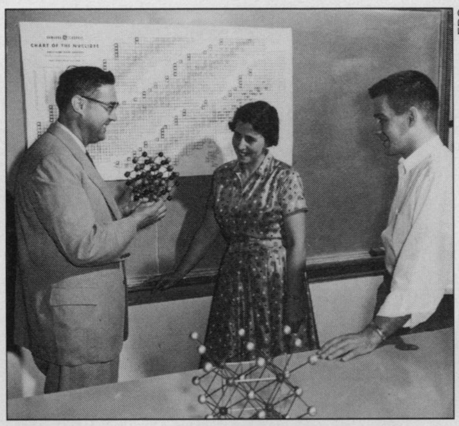
SCIENCE EDUCATION

Chemistry Curricula Edge Toward a New World

What's the best way to turn college freshmen off chemistry? Put them through Chemistry 101. The students know it. The professors know it. The American Chemical Society (ACS) knows it: Introductory chemistry courses have lost touch with the excitement of the field and become a trial for students and often an embarrassment for professors. "It's a terrible, terrible mess," says Fred Wood of the University of California, Davis, chairman of the 12th biannual conference on chemical education, held last week at Davis. And it's a mess that the chemistry community can ignore only at its peril, agree both chemists and outside observers.

"There has been a steep decline in chemistry majors [in the last decade]," says Sheila Tobias, a social scientist whose books and articles on science education reform have urged (or goaded, some would say) many college science teachers to take a critical look at their courses and teaching methods. In the 1984-1985 academic year, for example, 9679 students earned B.S. degrees in chemistry programs approved by the ACS. In 1988-1989, the number was 8122. And over the same period, scads of reports have warned that such trends harbor hard times for American industry and competitiveness.

Help may, finally, be on the way for future generations of students. After years of bemoaning the situation, the chemists are mobilizing. Reform-minded chemists and educators around the country are trying out innovative curricula and courses in an effort to ensure a supply of future chemists, or at least to increase chemical literacy by attracting and educating more students. And the



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Time warp? Many chemists think too little has changed in the teaching of their subject over the 40 years separating these two classroom scenes.

ACS has set up a Task Force on the General Chemistry Curriculum that aims to bring some coherence to this reform movement by offering professors guidelines and materials to help throttle up the pace of change in introductory chemistry courses.

All these efforts face plenty of inertia, of course, from faculty who have been teaching chemistry the same way for decades. To change "requires political struggle [in departments] and fighting for resources," says Tobias. But Michael Abraham, an education researcher and chemistry teacher at the University of Oklahoma, thinks "the critical mass for change has finally come about."

The challenge facing Abraham, Wood, and like-minded colleagues isn't unique to chemistry. Like other college science, chemistry suffers from overfilled classrooms and students with weak high school training in math and science. But chemistry has problems of its own because the curriculum hasn't kept pace with change in the field, says Harry Gray of the California Institute of Technology. "The courses and classes are 30 years behind the times," he says. Textbooks are a case in point: As chemistry has expanded in scope and radiated into new subfields over the past few decades, publishers have responded by including more and more without subtracting much of anything or rethinking how the material is presented, laments James Spencer, a chemistry professor at Franklin and Marshall College and head of the ACS task force.

Add the fact that "teachers teach what they were taught and what is in textbooks," Spencer says, and you've got a formula for a grim pedagogical cycle. Professors concentrate on principles and formulas, giving the students little feel for the many arenas of science and technology where chemistry now has an impact—among them molecular biology, materials science, and environmental science. Students "get no picture of why chemistry is important to the economy, health, the environment, or their lives," says University of Michigan chemist Seyhan Ege. You might think that arid approach would be on hold for the one morning or afternoon each week when the students don safety goggles and gloves and do chemistry themselves. But no—the experiments tend to be recipe-style exercises with known outcomes that are supposed to reinforce principles presented in lectures, says Wood. No wonder just 7% to 8% of all the freshman chemistry students end up choosing chemistry as a major, and nearly one-third of them don't even get out of the course with a passing grade.

The ACS Task Force hopes to change all that. Over the next few years, it will be developing and field testing less dense and compendious texts, lab manuals, and other teaching materials for a new "Core Modular Curriculum." Spencer says the aim is to encourage professors to teach fewer, more fundamental concepts while making their presentation more lively, relevant, and exciting by hitching each course module to a hot topic like the ozone hole or drug design.

Instead of waiting for the ACS to recommend reforms, trend-setters such as Ege at the University of Michigan are bringing about reform in their own backyards. In place of the stream of facts and principles in standard introductory chemistry courses, Ege centers her introductory course, called Structure and Reactivity, on what she refers to as molecular thinking: trying to predict how a given molecule will behave in a real-world role—when it is close to a receptor in a cell membrane, say, or an ozone molecule in the stratosphere. The conceptual ingredients come from Ege's own text, which teaches a handful of far-reaching concepts such as atomic and molecular structure, electronic orbitals, stereoisomerism, and acidity and basicity. The teacher then helps students connect these fundamentals to problems in drug design, materials science, and environmental research. "They very soon get the idea that all of this [molecular thinking] is related to what is real and interesting out there," Ege says. It seems to be working. Since 1989, when Structure and Reactivity was first offered to students, who had to pass an entrance exam, the number of declared chemistry majors at the university has leaped from three or four students a year to 15 to 18.

Abraham, at the University of Oklahoma, takes a different approach. For nearly 20 years, he has been pushing what he calls inquiry- or laboratory-centered instruction. Instead of presenting abstract principles and their difficult mathematical incarnations in lectures and then having students verify the lecture's main points in recipe-style lab procedures, Abraham does the reverse. "I use the laboratory to introduce the concepts," he says. Students get a sensory, gut-level feel for the chemical and physical phenomena and then discover in the lectures how formal mathematical principles emerge from their observations.

Although most of the reform efforts have focused on introductory chemistry courses, many schools have been trying to bring more advanced parts of the college curriculum into step with the diversity of the field as well. Many colleges now offer ACS-approved options—specialized chemistry programs—in biochemistry, polymer chemistry, and chemical education. ACS guidelines for options in materials chemistry and chemical physics are in the works as well, says Barbara Gallagher, secretary to the Committee on Professional Training at ACS's headquarters in Washington, D.C.

With a reform movement gaining momentum on so many fronts, many chemistry educators feel their curricula are revitalizing. "I think the word 'crisis' now is a bit of an exaggeration," says Gray. But it will be some years before the innovations now sprouting sparsely around the country will spread out and cover the academic landscape. Next semester Chemistry 101 at many schools will again be a grim reaper nipping undergraduate chemical ambition in the bud.

–Ivan Amato

NATIONAL SCIENCE FOUNDATION

NSF Holds Plan Close to Its Vest

What should drive the agenda of the National Science Foundation (NSF)—the federal agency whose main mission has traditionally been the support of basic research? Budget concerns? Scientific need? Or the technological demands of the nation's economy? Those are some of the questions swirling around a strategic plan for the agency that may be unveiled soon. The foundation's governing board derailed an early version of the plan—which had been scheduled to be made public in June —because those core issues had not been fully addressed. And now Congress has gotten into the act, insisting that NSF should play a more direct role in supplying the scientific needs of American industry.

Walter Massey

For the moment, NSF is keeping the plan's specifics under wraps, making the numerous scientific associations and university government affairs offices in Washington more than a little nervous. NSF officials insist the strategic planning process has not been secretive. According to NSF spokesman Michael Fluharty, NSF director Walter Massey has met with scores of university presidents, industry CEOs and engineering deans to describe the plan to them and seek their input. But in the typically leaky Washington environment, where draft documents tend to circulate like pollen in hay-fever season, the strategic plan remains closely held.

Not that there haven't been hints. The framework for the plan emerged at a presentation to the Coalition for National Science Funding on 16 June, when Massey identified the issues the plan will address: interdisciplinary research, human resources, educational responsibilities of researchers, and increased coordination with other federal agencies. The agency is also examining the way it conducts its own internal business. Specifically, Massey has said that NSF lacks the personnel resources to manage its large portfolio of small grants. Although he insists that individual investigators will continue to receive the lion's share of NSF's funds, the agency is considering new mechanisms for distributing that money, perhaps by awarding large grants to institutions or centers that would then administer the smaller grants.

NSF had originally intended to make the plan public after the National Science Board—its governing body—met in June. But some board members insisted that more work was needed before the plan could go forward. Board members contacted by *Science* were reluctant to discuss their specific objections, but several suggested that the underlying concern was what forces should shape the agency's mission. "The major issue that is on the table," says Phillip Griffiths, director of the Institute for Advanced Study in Princeton, "is should NSF's course change because of science reasons or funding reasons."

The board will take another look at NSF's plan when it meets this week. But if NSF officials are able to allay the board's concerns, they may still have trouble satisfying Congress. Last month the Senate Appropriations Committee provided its own vision of NSF's future role: "This role should include: opening up applied research programs to greater participation by nonacademic personnel; making education programs better prepare future scientists and engineers for the needs of industry; and building day-to-day working relationships with other federal agencies whose missions require cutting-edge technology." According to Griffiths, if all these concepts are included in NSF's strategic plan, the agency would no longer be driven by scientific priorities. He adds that such a shift may not be intrinsically bad, since it may serve some higher national priorities—but it is a fundamental change in course that deserves a full public airing before it is adopted.

And of all the groups that NSF must satisfy, the scientific community may prove to be the most difficult. Consider what happened to the National Institutes of Health. NIH was poised to release its strategic plan last February, but faced a firestorm of protest from scientists who felt they had been excluded from the planning process. After 6 months of soliciting input from its constituents, NIH's plan is finally approaching its final form. NSF should be so lucky.

–Joseph Palca