Science Standards Near Finish Line

After a series of delays, the National Academy of Sciences is finally getting ready to issue a report on what students should know about science and how they should be taught

In May 1991, representatives from about a dozen national scientific and educational societies gathered at the Washington Hilton for a 2-day meeting called by the National Science Teachers Association (NSTA). Educational reform was the topic du jour, and the groups were jockeying for position in a race to develop national standards for what children should know about science. Sparks flew as educators debated various approaches, until a compromise was floated: Give the job to the National Academy of Sciences (NAS)—"the one organization everyone could fall in behind," recalls one participant, John Rigden of the American Physical Society.

Not everyone was immediately convinced. Several meeting attendees pointed out that the academy was better known for its roster of distinguished researchers than for its expertise in teaching school-age children. But by summertime, most of the key players, including NSTA, had formally requested that the academy organize the project, and in September the academy agreed.

It took on a tough task: to develop a consensus vision of what children should know and be able to do in science at various grade levels. This vision would be enshrined in a document to be called the National Science Education Standards that would also be a vehicle for continued reform, a rallying cry for better tests, improved teacher training, and closer ties among educators, publishers, scientists, and the public. "We're really calling for a revolution in science education," says NAS president Bruce Alberts, who has made education reform his top priority since taking office in July 1993.

The revolution is not yet at hand, however. Three years and $6.5 million later, the community is still waiting for the academy to produce its manifesto. A draft was scheduled to be released in late 1993, but the deadline slipped to early 1994, then to the summer, then September. It's now set for sometime in November, with a final version not due out until 1995. All these delays have stretched the project's budget—supplied by the National Science Foundation (NSF), the National Aeronautics and Space Administration, the National Institutes of Health (NIH), and the Department of Education (DoE)—to the point where the academy has had to chip in some of its own money, says Alberts. And the waiting may also weaken the impact of the standards: Some states, unable to wait for the academy to finish its work, are already following other blueprints for reform.

The standards have "taken longer than we thought, proven to be more difficult than we thought, and there's less consensus than we thought," says Janice Earle, NSF's senior program officer for systemic science initiatives and one of many educators eagerly awaiting the standards. One problem has been a turnover of top staff. A few months after Alberts succeeded Frank Press as NAS president, both the chair of the standards project, James Ebert, and its staff director, Kenneth Hoffman, left the project. To replace Ebert, Alberts tapped Richard Klausner, an NIH cell biologist who had conducted a widely acclaimed review of NIH's intramural program (*Science*, 27 August 1993, p. 1120), but had no prior experience in precollege science education.

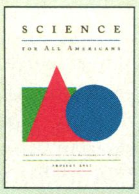
A more serious problem was that the academy's early efforts met with a mixed review. A version circulated in May as a "predraft" earned scathing comments from all sides. Educators worried that the standards demanded too much of students, while some scientists deplored a section on the philosophy of science that they felt presented a distorted and disparaging view of scientific inquiry. Those working on the draft insist they've turned the document around. But insiders say that the latest slip in the schedule—last month the release of the draft was delayed, from 29 September to sometime in November—shows how difficult it is to settle some of the key issues. "They're facing pressure from every direction," says Bill Aldridge, executive director of NSTA, who also sits on the project's advisory board. Aldridge says he's not surprised by the delay, because "anybody who tries to identify the important subject matter is going to get criticized."

Common core

In spite of the disagreements, the May predraft did reflect accord among the various players in science education on a common core of general principles. In brief, reformers believe kids need to learn fewer facts and more concepts. They think students will better understand the process of science through inquiry-oriented classes filled with hands-on activities rather than through lectures. And in a key departure from 1960s-era reforms, the new efforts are aimed at all students—not just those planning to become scientists. These ideas are not unique to the standards: They can also be found in such reform efforts as Project 2061, sponsored by the American Association

1989

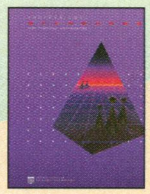
February
A summary of what all high school graduates should know about science is published by Project 2061.



September
Governors and President Bush establish six national education goals that will lead to standards.

1991

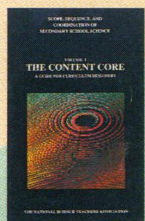
March
Teaching standards in mathematics are published by NCTM.



September
National Research Council agrees to direct standards project.

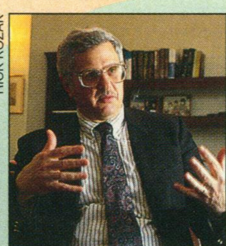
1992

March
National Science Teachers Association releases *The Content Core*, a summary of topics to be covered in various grades.



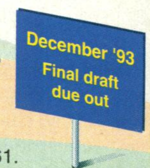
1993

July
Bruce Alberts becomes president of the National Academy of Sciences.

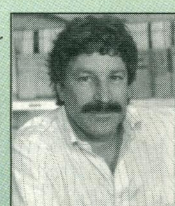


RICK KOZAK

October
Benchmarks for Science Literacy, which sets out content guidelines for various grade levels, is published by Project 2061.



November
Richard Klausner takes over as director of standards project.



for the Advancement of Science (which also publishes *Science*), which last fall issued a report called *Benchmarks for Science Literacy*.

But while many projects focus on subject matter, the national standards will go further, also addressing teaching, assessment, science programs, and school systems as a whole. The message, says Klausner, is that all parts of the system, not just curricula, need to be improved. The standards for teacher training, for example, will stress that teachers themselves must learn—and continue to learn—science through active investigations. That would require major structural changes in the way teachers are trained.

The recommendations on assessment and teaching that the academy outlined in May received relatively high marks from teams of educators and scientists. However, they gave lower scores to the section many consider to be the meat of the standards—what children are supposed to learn in the biological, physical, and earth sciences. The problem is one of balance: Which scientific concepts are essential and which can be left out?

Some reviewers say the document avoided making hard choices by cramming too much content into the proposed standards. Must all students know the meaning of the words lithosphere and hydrosphere, or prokaryote and eukaryote? The predraft said yes, including those concepts as "fundamental understandings." But some educators think no. "The devil still lies in the details," says educator Mark St. John, president of Inverness (California) Research Associates and a member of a working group that helped write the assessment standards. "And it may not be a resolvable issue."

Klausner says the final draft of the standards will forgo the details of relativity theory and biochemistry found in the May version. The earth science standards for high school students, for example, might eschew detailed discussions of radiant energy in favor of a simple explanation of climate. "The content is much less threatening," says the Carnegie Institution's Robert Hazen, a science-literacy expert who helped write parts of the latest version. "I'm very excited about what I've seen, and I wasn't very excited about the original draft."

Indeed, the issue of cramming too much into the curriculum is not unique to science. The NAS project is one of eight in which educators are developing national standards in their disciplines as mandated by the federal Goals 2000 legislation passed earlier this year. And each discipline would like to fill the entire school day, says Eve Bither, director of DoE's Office of Educational Research and Improvement, which provided almost half of the academy's funding and supports several of the other standards projects.

"One of the watchwords of reform is 'Less is more,'" says Bither. "But what we really have now is 'More is more.' The next challenge for everybody will be to integrate across all these standards projects. It's not possible to teach all of this to everyone."

While educators fretted over the amount of subject matter presented in the May predraft, some scientists were up in arms over the description of the philosophy of science. Instead of saying that researchers make discoveries, the document described science as a "social activity" of "constructing knowledge," and emphasized the "tentative nature of scientific knowledge." Physicist James Trefil of George Mason University in Fairfax, Virginia, says the early version conveyed "the really bizarre postmodern notion that somehow science is just a matter of social convention, rather than analysis of data." Harvard University physicist Eric Mazur, a pioneer in undergraduate teaching, was so dismayed by this section that he resigned from the project immediately after reading it. "Science is much more discovery-based than they seem to think," he says.

But Trefil and other scientists give Klausner high marks for his response. Klausner insists the academy never intended to weaken the rigorous underpinnings of the profession, and he says all hints of the offending philosophy will be excised from the final draft.

Dogged by delay

While the standards move slowly toward completion, some other reform projects intended to march in tandem with the standards have been put on hold or are proceeding on their own. "The absence of science standards has really made our execution of the reform agenda very difficult. The standards are very, very much needed," says Luther Williams, assistant NSF director for education and human resources. His agency will spend about $225 million on various precollege programs this year and already requires that the projects it funds be consistent with the emerging standards.

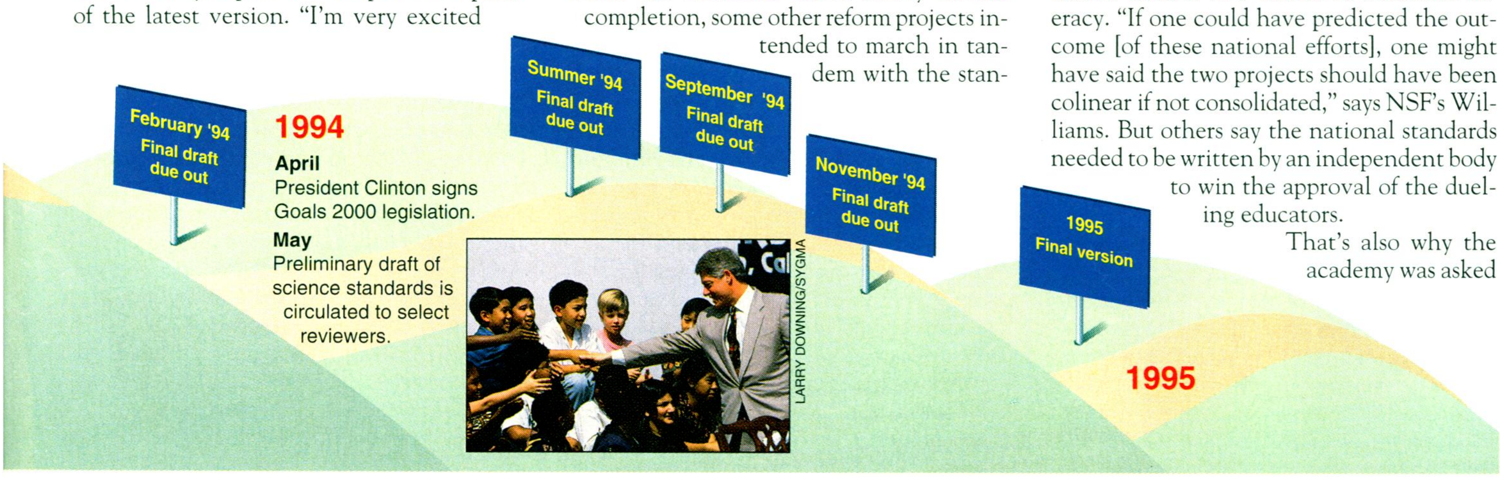
Standards or no, the wheels of reform have been churning at other national and state projects. Sixteen states and the District of Columbia have received DoE grants to revise their approach to science, and several others are going ahead without grants. Ideally, such work would have been guided by the standards. Now, the window of opportunity for influencing reform is closing, educators say.

"The delays put states in a very difficult situation," says Shirley Malcom, director of education and human resources at AAAS and chair of a national committee that last year reviewed the standards projects in all disciplines. "They can't just hold up on the work they're called upon to do. The standards then become a check against work already done, as opposed to the foundation for that work."

For example, North Carolina recently revised its state science framework, cutting half the factual content of the old curriculum and instead emphasizing major concepts developed through scientific inquiry. But if the final standards document ends up including a few more facts, North Carolina isn't likely to immediately stuff items back into its curriculum, says William Spooner of the North Carolina Department of Public Instruction, who also sits on the chair's advisory board to the standards. To flesh out the details of their curricula, North Carolina and 17 other states have relied on AAAS' *Benchmarks* report, which sets out what students should know at various grade levels and, therefore, fulfils part of the mission of the standards.

In hindsight, some wonder whether the nation needed two visions of scientific literacy. "If one could have predicted the outcome [of these national efforts], one might have said the two projects should have been colinear if not consolidated," says NSF's Williams. But others say the national standards needed to be written by an independent body to win the approval of the dueling educators.

That's also why the academy was asked



to arrive at a national consensus. Early excerpts of the standards were sent to hundreds of organizations, although not all saw the May predraft. And Klausner says all these groups are being invited to prepare formal reviews of the upcoming draft.

F. James Rutherford, director of AAAS' Project 2061, points out that his group involves hundreds of scientists and educators and worked with the same societies now reviewing the standards. But he agrees that his project's goal was not to codify the national consensus, but to present a new vision of science education.

"The key thing about the national standards was the national critique and consensus process," says Arizona's Mike Lang, chair of the council of state science supervisors. "We have a very diverse science education community in this country, and everyone wants to be part of everything."

Making peace among those diverse players has proven difficult even for an institution known for tackling difficult subjects. "There are so many different stakeholders in science education, with such different views, that I think it was actually quite a brave decision to have them come together to achieve some consensus," says Klausner. In any event, the release of the national standards should accomplish what Klausner says is one of his major goals—"to initiate discussion" on what it means to be scientifically literate. And that's a dialogue that every educator and scientist believes is important.

–**Elizabeth Culotta**

TOXICOLOGY

Dioxin Report Faces Scientific Gauntlet

In 1991, when the Environmental Protection Agency (EPA) agreed to review the health risks of dioxin, officials wanted to know whether it was a carcinogen at low doses. This week, in a long-awaited draft of its report, EPA falls short of resolving that question, but argues that other, noncancer effects of the chemical may be a more urgent threat to humans. And that finding is sure to ignite a scientific controversy. "This is going to be one of the most important public debates on environmental chemistry ever," says Michael Gallo, a toxicologist at the Robert Wood Johnson Medical Center at Rutgers University in New Brunswick, New Jersey. At stake, says Gallo, is the scientific credibility of EPA's regulatory decisions.

The EPA report concludes that dioxin—a byproduct of paper bleaching, incineration, and other industrial processes—is more dangerous than the agency concluded a decade ago and should retain its current status as a "probable" human carcinogen at levels found in the environment. As evidence, the agency cites animal studies and epidemiological data that tentatively link some forms of cancer to people exposed to large amounts of dioxin. Because it had no direct evidence that environmental levels cause cancer, however, EPA decided against elevating dioxin to a "known" human carcinogen.

But the report does suggest a link between minute quantities of dioxin and noncancer effects in humans. Fueled mainly by studies that have appeared in the last decade, the report asserts that dioxin—in levels found in the food supply—may trigger problems such as endometriosis in women and decreased sperm counts in men. The noncancer effects "bolster our resolve to continue to take action to reduce exposure to dioxin," says Lynn Goldman, EPA's assistant administrator for prevention, pesticides, and toxics.

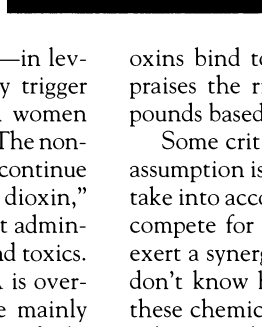
But some scientists believe EPA is overinterpreting the data, which come mainly from animal studies and observations of subclinical perturbations in humans. One outside scientist who has seen the risk-characterization chapter written by EPA scientists complains that it contains "sky-is-falling statements that don't belong in a scientific document." Adds Oregon State University immunologist Nancy Kerkvliet, "I just don't think people have been exposed to enough dioxin to see effects, especially on the immune system." Kerkvliet authored the review chapter on dioxin's immunotoxic effects, which focused on animal studies and found "no clear pattern of immunotoxicity" in humans.

In its indictment of dioxin, however, EPA is including many similar compounds,

"I think we need to say we might be seeing these effects in the general population."

—Lynn Goldman

EPA



which agency scientists believe exert similar effects. The underlying assumption is that the dioxin of utmost concern—2,3,7,8 TCDD—exerts its harmful effects by binding to the aryl hydrocarbon (Ah) receptor on the cell surface. Because some PCBs, furans, and other dioxins bind to the same receptor, EPA appraises the risk of exposure to these compounds based on their binding affinities.

Some critics of the report argue that this assumption is unwarranted because it fails to take into account how such chemicals might compete for binding sites in some cases or exert a synergistic effect in others. "We just don't know how to add up [the effects of] these chemicals," says John Gierthy, a toxicologist at the New York State Department of Health's Wadsworth Center in Albany. Gierthy, who is serving on a panel supported by the Chemical Manufacturers Association (CMA) to review the report, says EPA should use in vitro assays of relevant target organs to determine the activity of dioxin-like chemical mixtures.

Even assuming that dioxin and its chemical relatives are as risky as EPA believes, a third area of controversy remains: Just how much of these substances are Americans exposed to? EPA estimates total exposure to dioxin and dioxinlike compounds at 40 to 60 picograms per gram of body fat. But when a draft of the EPA report was circulated to other federal agencies for review last spring, the Food and Drug Administration and the U.S. Department of Agriculture blasted EPA for heightening fears about the safety of the U.S. food supply on the basis of dioxin exposure data gathered mainly in Europe rather than in the United States (*Science*, 20 May, p. 1071).

EPA scientists, while defending the study, acknowledge the difficulty of writing a balanced summary of dioxin's health risks. "Even within EPA, scientists have a range of opinions," says Goldman. "I don't think each individual agrees with every statement in the report."

But Goldman says the agency will take a firm stand on dioxin's alleged noncancer effects. "From the public health perspective, I think we need to say we might be seeing these effects in the general population," she says. And while the lack of U.S. exposure data on dioxin is "a valid concern," she says, "it's probably reasonable to assume that we're looking at a phenomenon in industrialized countries." She adds that EPA has toned down the risk characterization to emphasize that the benefits of a balanced diet outweigh the "theoretical" risks of dioxin exposure.

The public, which includes at least four high-powered panels sponsored by industry and environmental groups, has 120 days to comment on the report before it heads to EPA's Science Advisory Board for review. Early next year, says Goldman, "we'll pull in the traps and see what we've got."

–**Richard Stone**