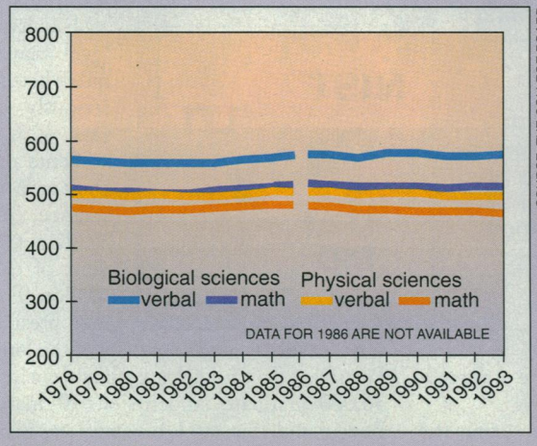
Coping With the Underprepared Undergraduate

Freshmen at the Massachusetts Institute of Technology (MIT), arguably the world's most prestigious institution of scientific and technological learning, routinely score well into the 700s on the mathematics portion of the Scholastic Aptitude Test (SAT) and on math and science achievement tests. So why, with so much talent on board, have school officials lengthened a traditional introductory physics course by a few weeks to slow its pace?

The answer, according to MIT faculty, is that the last decade has witnessed a significant shift in the profiles of entering students. Although MIT rejects 40% of the class valedictorians who apply, incoming freshmen seem to have a broader range of abilities than did their predecessors but less depth and preparation in math and science. So in 1991 MIT decided to test this hypothesis by administering a diagnostic exam. "The results shocked us," says physicist June Matthews. "Many students were deficient in algebra, plane geometry, trigonometry, and logs and exponentials—the stuff of standard high school math!"

MIT wasn't alone. In the post-Sputnik era of the 1960s, when many of the current generation of senior scientists were in high school, students wanting to be scientists had a certain single-mindedness about them. They progressed from regular to honors math and science courses and spent their free time tinkering with radios, cars, or chemistry sets. But after interviewing scores of professors across the United States—in big schools and small ones, in elite schools and in the second- and third-tier institutions—*Science* has learned that that type of student is now rare. Some no longer have the opportunity—many high schools have dropped their honors and advanced-placement courses—while others want to show college admissions officers that they can excel at sports, music, or student government as well as at traditional academic subjects. "Students are stretching themselves in ways they didn't do before," says William Fitzsimmons, dean of admissions at Harvard. Sounds delightful, except that, as a result, high schools are graduating fewer students steeped in traditional course work in math and science.



SOURCE: THE COLLEGE BOARD

Artifacts? SAT scores have held steady, but today's freshmen need remediation. What's going on here?

From MIT to the University of Oregon, faculty members say that while the best science and math students are as good as ever, the majority are in serious trouble. "There's a general lack of preparedness," says Jeremy Burdett, chair of the chemistry department at the University of Chicago. "It is surprising and worrying." He cites a freshman who didn't know that white light was made of different colors and a "very bright" graduate student who didn't know copper sulfate was blue.

More troubling, however, are the apparent deficiencies in how students think, reason, and extract information. "Students don't seem to have the self-discipline to use what they have," says Joseph Ackerman, chair of the chemistry department at Washington University in St. Louis. "It's as if they come with a backpack of tools but don't know how to use them." Adds John Postlethwait, a geneticist at the Institute of Molecular Biology at the University of Oregon, "Students have trouble distinguishing between evidence and opinion."

There are some hard data to confirm these impressions. Alexander Astin, director of UCLA's Higher Education Research Institute, has spent 28 years monitoring U.S. college freshmen expressing an interest in majoring in science. A recent analysis showed that 29% of these students need remedial or tutoring help in math, and 12% in the sciences.

Testing organizations have found that students are taking fewer of the key courses that assure success in college, including 4 years of English and three or more years of math, social studies, and natural sciences, than they did in the past. Says Richard L. Ferguson, president of the American College Testing (ACT) Bureau in Iowa City, Iowa, "We continue to graduate nearly half our college-bound seniors without the course work they ought to have." Even those who plan to major in science often do not take 3 years of science and math in high school.

Given those gaps, what's a school to do? Some, like MIT, are reacting by slowing down their introductory courses. At the University of Chicago, an introductory chemistry course was started last year that proceeds at a pace described as "less frenzied than usual." In both cases, faculty members stress students soon catch up with their peers. "These students do just as well by the time they are seniors," says Robert Birgeneau, MIT's dean of sciences.

Another strategy for helping the poorly prepared is to break up demanding courses. At St. Olaf College in Northfield, Minnesota, for example, labs and lecture courses can be separated to give students more time. The division also gives faculty a better chance to update their notes, adds Anthony Mahowald, a professor of molecular genetics and cell biology at the University of Chicago.

However, some faculty members believe that more than tinkering is required. They suggest that radical changes in pedagogy are needed to mesh with the current crop of college students. "This is a different generation," says Arthur Ellis, a chemist at the University of Wisconsin. "They are experienced users of computers and are visually oriented." Carnegie Mellon University chemist Rick McCullough agrees, noting that many students have grown up with MTV and take state-of-the-art graphics for granted. "I think we have to include the 'wow' factor in what we teach," he says.

Both professors admit to trying to dazzle their students with real-world examples of how chemistry is used. Problems of synthesis are looked at, for example, by studying the design of new drugs and polymers. The dazzle factor can be used in the design of labs, too. In Ellis's course, for example, students study atomic structure by examining the diffraction patterns of different materials. "It gives them something they can see and touch," says Ellis.

Another useful strategy is to encourage teamwork. Ellis has done this by abandoning the grading curve, allowing students to help others without jeopardizing their own grades. Group learning is also a central feature of several science programs at San Diego State University and at the University of California, San Diego, that are designed for minority students lacking adequate science training in high school. "The important message to send to these students," says Ellis, "is that we want them to succeed."

–Anne Simon Moffat