online environment," Mayadas says. "The labs are difficult."

Members of the consortium are trying to solve that problem. Electrical engineer John Bourne of Olin College in Needham, Massachusetts, who is principal investigator for the group, says one idea is to have students log on to remotely controlled instruments that allow them to build a circuit, say, or mix a solvent. This kind of chemical engineering course is already under development at Illinois. At the University of Washington, Seattle, Robert Franza, director of the Cell Systems Initiative, leads an information technology team that hopes to produce a wireless tablet PC. It will be somewhat like a personal digital assistant, on which students can build digital proteins, jot down notes in class lectures, or brainstorm with others —anytime, anywhere. "Most people think of 'online' as tethering people to a box and a seat," Franza says. "We think the future looks different."

No matter how the future unfolds, tech-savvy students are likely to insist on being plugged into the Internet. After Raineri added virtual labs to her molecular biology course 3 years ago, her scores on student course evaluations skyrocketed. "They want more of this, and in the years to come, they may demand it," she says. For Sears and other Internet pioneers, that means feeding a grassroots movement until it spreads like the Internet itself.

–KATHRYN BROWN

NEWS

Are We Having Fun Yet? Joys and Sorrows of Learning Online

Web classes offer students and instructors great flexibility and a chance for more focused interaction. But cyberspace can also be a lonely place

WASHINGTON, D.C.—Wrist deep in ground-up spinach leaves and rubbing alcohol, I'm wondering if some of my fellow online students have ignored the instructions not to directly mix vinegar and bleach. The hands-on lab—and the potential for disaster—enlivens an otherwise lonely and at times frustrating online introductory biology course. I'm learning on the Web, but I'm not loving it.

In May, my editors asked me to write a first-person account of taking an online undergraduate science course with a lab component. Finding one isn't as easy as it sounds (see sidebar on p. 1620). But eventually I settled on one offered by the University of California, Berkeley, Extension program.

Within minutes, I had charged the $475 tuition and $50 "fee" on my credit card and enrolled in the four-credit semester-long X19 Introductory Biology with Lab. A link to an online bookstore soon made me the electronic owner of a textbook, two CD-ROM virtual laboratories, and a lab kit —and drained me of another $236. That's about par for costs per unit for an in-state Berkeley undergrad, but substantially less than for a nonresident. Just 3 days later the book and CDs arrived, although the lab kit was on back order.

Eager to get started, I went to the course Web site. There I was greeted by a written introduction to the class and the friendly (virtual) face of my Harvard-trained instructor, Monica Ranes-Goldberg. She was available via e-mail, as well as through a message board and chat room where we could post assignments and communicate with our peers. (Although the course was billed as cooperative and interactive, I would end up communicating much more frequently with my instructor than with other students. Indeed, I spent 3 days diligently checking the chat room without hearing from a single classmate.)

With 6 months to complete the one-semester course, I set to work. My first "assignment" was to post an autobiography. Although I hid my true intentions for taking the class, others spoke freely of their motives. A Wyoming high school student felt ready for college material. A premed student needed one more lab class. An investor wanted the scientific dope on biotech stocks. And a surface warfare officer in the U.S. Navy had decided to cram biology into a busy schedule.

CREDIT: A. STONEBRAKER

Hands-on at home. Virtual learning gets real with use of lab kits.

The course was divided into 14 units emphasizing biology at the cellular level: basic biochemistry, cell structure, metabolism, genetics, cell division, and molecular biology. Assignments for each unit included posting a brief review or summary of a Web site related to the topic at hand; "wet" and virtual labs, reports of which I would e-mail to the instructor; and quizzes and problem sets. The core knowledge for each unit was contained in the textbook and lecture notes written by the instructor. Chapter quizzes written by the textbook publisher offered a convenient way to test my progress—after a week's worth of calls to get a Web site password that should have come with the book.

CD-ROM activities brought alive the concepts presented in the textbook and notes. Some of the exercises were informative, such as changing the size and shape of a virtual cell to learn about surface area and volume or studying the effect of changing adenosine triphosphate concentration and food supply on a computer model and animation of cellular respiration. But one lab was an exercise in dull repetition: Using a virtual spectrophotometer and a selection of five indicator dyes, I was supposed to test more than 10 compounds. And each of the more than 50 trials subjected me to animation that lasted several seconds.

Boredom wasn't the only challenge. The spectrophotometer lab produced reams of data that resisted export for analysis. Other exercises didn't allow me to manipulate parameters necessary to answer the questions, and the instructions for the simulations were overly vague. Subtle flaws in the resources became incredibly frustrating: One CD-ROM listed questions in such a way that you couldn't read them while doing the "experiment" and you couldn't cut and paste them into a word processing document to answer them.

But learning on the Web does have its advantages. I could set my own pace, delving into harder or more interesting topics and

Online Science Offerings Are Hard to Reel In

It's lonely out there in undergraduate cyberscience. Online education may be booming, but my search for a Web-based natural sciences course with a lab component revealed that the world's premier universities offer meager scientific content in their online fare.

For starters, most online classes are not listed in a university's general course catalog but instead reside in units typically labeled as extension, distance learning, or continuing education programs. And the science choices are not bountiful. Harvard University offers a computational biology class, but most of its classes are in computer science. Stanford offers a selection of professional development courses for engineers and computer scientists, but no basic science courses. Yale hopes to enter the Web learning game later this year as part of a consortium. Across the pond, Oxford offered only three classes, including one on local history.

That left private ventures, often in partnership with universities. The completely virtual Cardean University (found at UNext.com) emphasizes business, and OnlineLearning.net (www.onlinelearning.net), a consortium between Houghton Mifflin and several education institutions in California, offers only a handful of courses in introductory mathematics and physics in contrast to a hearty fare of business, computer, and education classes. Fathom.com, a consortium founded by Columbia University that includes both U.K. and U.S. institutions, has a flashy Web site and a fair number of biology offerings. But most courses are in the applied sciences—soil chemistry, biotech and agriculture, and dietary supplements. The Global Education Network (www.gen.com), a Web-based company founded by professor Mark Taylor of Williams College in Williamstown, Massachusetts, and investment banker (and Williams alumnus) Herbert Allen, offers liberal arts courses taught by professors around the country, but none are in the core sciences.

The Electronic Campus of the Southern Regional Education Board (www.electroniccampus.org) looked more promising, with a healthy selection of science classes at institutions throughout the southern United States. After eliminating those tied to the normal academic term—a nonstarter for me—I found a candidate that fit my tight schedule: a geology class with a lab offered through the University of Georgia, Athens. Visits to other university sites revealed two other possibilities: an oceanography class through the University of Washington, Seattle, and a marine biology class from the University of California (UC), Berkeley. However, the UC class appeared to require a visit to the UC campus, and the oceanography class was already full.

That left geology. After failing to navigate the board's registration protocol, I turned to the University of Georgia's Web site, where I learned that the class was actually being offered by Georgia Southern University. Two weeks after registering, however, I received a phone call telling me that I could enroll in the lecture portion but that the lab portion was still a work in progress. When I asked for alternatives, a "student representative" helpfully suggested turf grass management.

Things looked bleak. But a week later, a serendipitous search on the UC Berkeley Web site turned up an introductory biology class, complete with lab (see main text). Touted as the equivalent of a semester-long, lower division biology class, the university extension class included "wet labs" to be done at home.

Success at last. But my education had already begun. Even before starting the course, I was already much more savvy about how to seek undergraduate cyberenlightenment.

–R.J.D.

skating over material that I, with a Ph.D. in chemistry, already understood. That freedom also requires online students to be self-motivated. (Speaking of which, honesty compels me to disclose that, although I did well on the quizzes and labs I completed, job responsibilities forced me to drop out before the final.)

Eager to escape from learning biology on a computer monitor, I jumped at the chance to do some "real" science in my kitchen. But halfway through Unit 3, and already one lab behind, I realized that my lab kit was still on back order. Phone calls to the bookstore yielded daily assurances that the $32 kit would be in stock "today or tomorrow." Fortunately, the lab manual revealed that the kit contained only four items—pH test paper, test tubes, medicine droppers, and dialysis tubing. A visit to the Georgetown University chemistry stockroom provided me with most of what I needed for only $18, and after a return trip to "borrow" some yellowing dialysis tubing I was all set.

The labs were simple, consisting of pH measurements of bleach and vinegar solutions, popping beet cells with pH, and extracting plant pigments from spinach using rubbing alcohol and separating them on coffee filters using nail polish remover. But the concepts were well illustrated, and doing experiments in my own kitchen reminded me of how science is integrated into everyday life. It also let me get my hands dirty—the whole point of doing science, to my thinking.

Family matters. Teaching an online course lets Monica Ranes-Goldberg spend more time at home with her children.

CREDIT: JEFF GEISSLER/GETTY IMAGES

Besides the obvious appeal to students whose lives don't allow for an on-campus experience, online classes also provide alternatives for instructors. Ranes-Goldberg says it helps her to juggle a career and a family. "Sometimes I grade quizzes in the middle of the night if I'm having trouble sleeping," she says. And having self-paced students relieves the burden of having to grade 30 versions of the same lab report or quiz at the same time. The rewards are also different. "I find I have more personal contact" with each student than in a traditional classroom, she says. Still, "I wouldn't want to give up traditional teaching. There is a certain excitement that goes along with being in a classroom."

I agree. My passion for science stems from the infectious enthusiasm of a professor in my introductory chemistry class. I don't think he could have conveyed that same level of excitement in silico. But on the other hand, how else could I have done paper chromatography in a Snapple bottle on my kitchen counter? **–R. JOHN DAVENPORT**

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