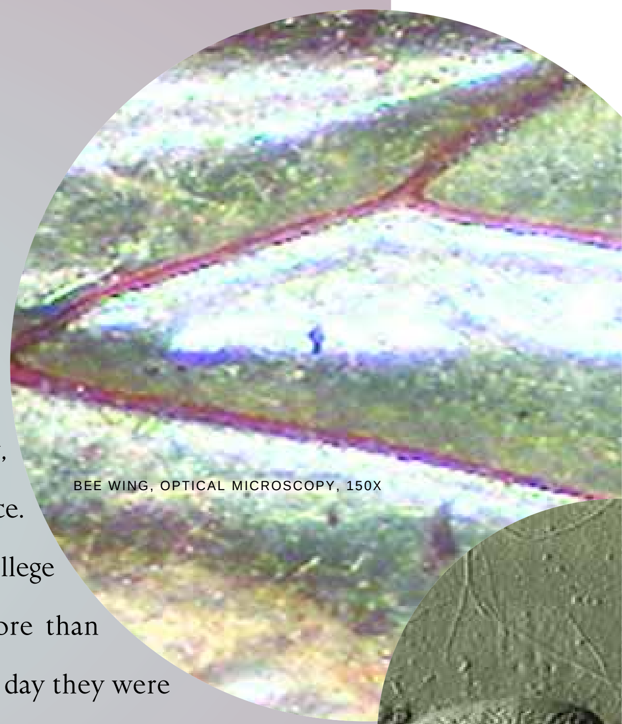
ASU's IN-VSEE program is developing "a laboratory without walls."

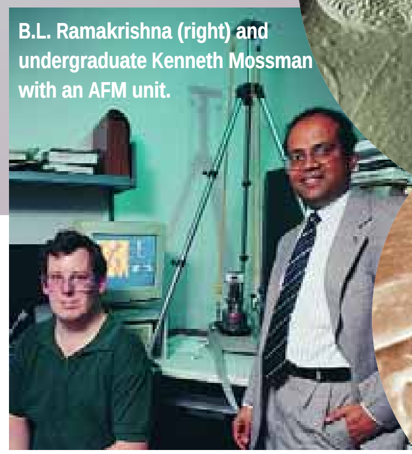
www.science to go

by Sarah Auffret



BEE WING, OPTICAL MICROSCOPY, 150X

TEACHING SCIENCE today can be like keeping up with the strides of a giant, trying to match his spaced-out footprints by hanging on to his pantlegs. ➪ Or at least it should be. ➪ Breakthrough follows discovery, one after the other, with technology proceeding at a breathtaking pace. Cloning. Mars exploration. Nanotechnology. ➪ But for many community college and high school students, learning science continues to be nothing more than reading about a bunch of dead people in textbooks that were outdated the day they were published. For the MTV generation, it's a killer. ➪ How can a public school keep up with the costs of constantly updating texts? Don't even mention the cost of new equipment. ➪ ASU is merging cutting-edge science and technology with state-of-the-art telecommunications to bring both equipment and teaching to public schools.



B.L. Ramakrishna (right) and undergraduate Kenneth Mossman with an AFM unit.

Students from community colleges and high schools around the world can watch live scientific experiments being conducted at ASU, using one of the most powerful research tools available, a scanning probe microscope (SPM). Because ASU researchers have developed software for operating the microscope remotely over the World Wide Web, the students could be in Minneapolis, the scientist in Madrid.

Even more astounding, students can design their own experiments, manipulating a Nobel Prize winning microscope that is not yet available to most laboratories in the country. They can direct the SPM with the click of a mouse; the images pop right up on their computer screens.

"Students are fascinated by this. They can actually see atoms," says Bill Glaunsinger, an ASU professor of chemistry and biochemistry. "We've made a giant leap in grade level, putting equipment that's generally available only to doctoral students in the hands of high schoolers and undergraduates.

"They are getting involved in significant science at an early age," he says. "It's captivating. This project should have a big impact on scientific accomplishment and productivity of students."

Why extend such a sophisticated research tool to people who are not yet out of their teens? The idea is to grab a student's interest at key transition points, when they're making decisions about college majors and careers, according to B.L. Ramakrishna, director of the project.

Inviting 16- through 19-year-olds into the laboratories of a major Research I university blends science and education in a most compelling way. It brings home key concepts they're learning in the classroom, while wooing their participation in real world research. It tears down both spatial and temporal walls of the "ivory tower" to reveal human scientists whose work can benefit society.

A medical school student in Puerto Rico has sent mutant yeast cells to ASU, so the SPM might show him how the cell walls change, and how certain drugs may affect human cells. A marine geologist in South Carolina hopes to see what the very powerful microscope can tell him about samples of microfossils from different depths in the Mediterranean.

Here's the trade-off: In return for using the microscope, the researchers must allow students to participate in their projects.

The SPM has a very fine probe at the end, like the tip of a finger. It allows scientists to move molecules, studying the properties of materials and even building tiny functional structures less than 100 nanometers in size (a nanometer is one-billionth of a meter).

Invented only 16 years ago, the SPM has quickly merged with the industrial trend toward miniaturization, providing an important visualization tool to create even smaller structures. Engineers build these structures one layer of atoms at a time.

Vincent Pizziconi is keen on the possibilities of manufacturing at a nanoscale. The ASU bioengineering professor foresees the day when "nanobots" will perform medical procedures within the human body itself. He envisions elegant micromachines that don't wear out. They will assist space technology, provide better communications tools, and boost energy sources for transportation.

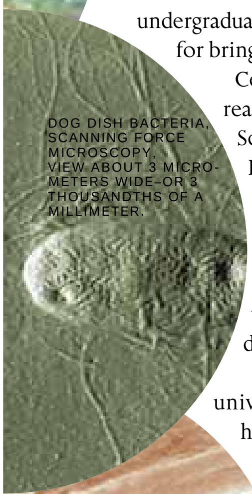
For students, images viewed over the microscope are way beyond cool. They might see the surface of a compact disc, its parallel dots and dashes the code for a rock band's opus; the eerie craters of a yeast bud; or "ASU" spelled out in atoms, the letters so small that an encyclopedia could be written on a pinhead.

They also might compare the carbon atoms in graphite with those in diamond, for example, and in the process learn about the properties and structures of different materials in a most intimate way.

The pictures are so arresting that the Arizona Science Center has developed an exhibit around the SPM, with a computer monitor that connects via the Internet into ASU's microscope and the image bank. Just like schoolchildren around the globe, museum visitors will be able to "drop in" on experiments in progress, via the Web.

"It's such a breakthrough to get images at this magnification," says Laura Martin, director of education and research for the center. "People find them exciting and intriguing. These kinds of visualization tools will be more in demand in the medical profession, so it's a nice thing to bring them to the public so they can become comfortable with them."

All the forces for the innovative project came together in January 1996, when four ASU scientists—who had begun teaching the world's first undergraduate SPM course at ASU two years ago—realized its potential for bringing the excitement of science into children's classrooms.



DOG DISH BACTERIA, SCANNING FORCE MICROSCOPY, VIEW ABOUT 3 MICROMETERS WIDE–OR 3 THOUSANDTHS OF A MILLIMETER.

Certain they could meld research and education with outreach, they applied for and received funds from the National Science Foundation to develop the project, called Interactive Nano-Visualization in Science and Engineering Education (IN-VSEE).

ASU is strong in microscopy, already home to one of the nation's few high resolution electron microscopy centers. The potential for bringing such an intense visual learning experience to public school children has drawn unprecedented support from across campus.

IN-VSEE is a collaboration of an ASU-led consortium of university and industry scientists, community college and high school science faculty, and museum educators.

KLEENEX, ELECTRON MICROSCOPY, IMAGE ABOUT 400 NANOMETERS WIDE

The ASU colleges of Liberal Arts and Sciences, Engineering and Applied Sciences, and Education provided supplementary funds, staffing, and space. Glaunsinger and Ramakrishna are from liberal arts; Pizziconi and Tony Garcia are from engineering. Anshuman Razdan, technical director of the PRISM project, developed the software *(See page 22)*.

The Arizona Science Center also is a partner, along with microscope manufacturer TopoMetrix, and Motorola, which has several SPMs and is eager to have more students trained to use them. Other educational partners include the University of Arizona, Chandler-Gilbert Community College, and Chandler High School.

"The power is not in the tool itself, but in the community that has been brought together and the creation of a collective vision," Ramakrishna says. "Our vision has been to create an interactive Web site with a whole new educational thrust."

One class of community college students already has tested the remote technology. Several high school teachers provide input on curriculum, and three top high school students tested and helped refine the multimedia educational materials that make the microscope a teaching tool.

"Until now, distance learning has been passive," says Pizziconi, who is in charge of developing the lesson modules. "Look at what you're competing with in education—Nintendo™ and the Super Mario Brothers©. This is a chance to teach key science concepts in an intense, visual, interactive way. We get students engaged in something that's real versus something in a textbook," he says.

"This is a grand experiment. If we can get students engrossed and excited to the point that they will propose their own experiments, we'll inspire some of them to become tomorrow's scientists and engineers," Pizziconi adds. "There is power in bringing students to this level of research so quickly."

IN-VSEE is supported by the National Science Foundation, Motorola, TopoMetrix, and many educational institutions. For more information, contact B. L. Ramakrishna, Ph.D., Director of Scanning Probe Microscopy, 480.965.6560. Send e-mail to bramakrishna@asu.edu

Shrinking Out of Sight

Think small. Real small. A grain of sand, for instance, is about 1 millimeter in diameter. A human hair is about one-twentieth as big. Now think teeny-tiny. Think about some of the smallest things on in nature, the individual building blocks of a cell. How tiny are they? Consider that one human is made up of about 10 trillion cells. Inside those cells are building blocks just one billionth of a meter–a nanometer–in size.

Welcome to the nanoworld, where the real action of the universe takes place. Scientists working in nanotechnology say the field has promise for allowing engineers to manipulate and assemble individual molecules to create almost any material.

Others talk about the practical uses of building micromachines with tiny gears the size of cells. Medical robots might patrol the bloodstream, scraping out arterial blockages, killing cancers and viruses. Tiny machines that perform better and don't wear out might operate indefinitely in space.

Powering these hopes has been the development of the scanning probe microscope (SPM), which has a tiny tip that drags across the surface of an object. The tip "feels" individual atoms, its motion sensed by a computer, and can move them around with great accuracy.

The SPM magnifies on par with an electron microscope, but costs much less and is simpler to operate, according to B.L. Ramakrishna, director of ASU's IN-VSEE project. The instrument also has advantages for research. It requires no vacuum and can be operate in liquid.

In 1989, scientists were able to use the SPM to arrange 35 xenon atoms on a nickel surface to form the letters of their employer, IBM. Since then, other teams have used SPMs to build a tiny nanoscale guitar and an abacus with beads consisting of individual carbon molecules. Using a process called nanolithography, an entire encyclopedia could be written on a pinhead.

Ramakrishna says that miniaturization is driving the most recent industrial revolution. But work is tapering off because scientists are reaching a limit for making things smaller from the top down.

Nanotechnology is the answer to that challenge. The processes involved allow scientists and engineers to start ultra-small and build up, one layer of atoms at a time. Real-world applications for students are found in biotechnology and the semiconductor industry, where companies want people trained to study and make small structures.

ASU scientists believe that the ultimate value of bringing this research into classrooms across the world may be in the number of young people who are attracted to the exciting possibilities of nanotechnology. A new revolution is in progress. –SARAH AUFFRET

Ed Ong and the Scanning Probe Microscope.