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teaching toolbox >>>

ALL THINGS GREAT AND small

By Margaret Loftus

A few universities have established programs to teach nanotechnology to children. But there's lots of controversy over how to present the incredible opportunities that nanotech offers along with the possibly serious consequences.

A Rice University program uses a series of animated molecules to teach children about nanotech.

It's sometime in the not-so-distant future. Scientific advances have made it possible to genetically engineer embryos in laboratories. Any disease can be eradicated, as can other "defects," such as a bad temper. As a result, American society has stratified: People whose genes have been tweaked to perfection are groomed for great things, like space exploration. As for those with less auspicious beginnings? Well, there's plenty of janitorial work to be done here on Earth.

The likelihood of such a future—the plot of the 1997 science fiction film "Gattaca"—is up for debate. But some scientists and educators warn the chances of science running amok are greater if today's schoolchildren aren't taught about the next potential technological revolution—nanotechnology—and its implications. Some analysts predict that nanotechonology will generate an industry worth 1 trillion dollars in the next decade in the United States alone. "The pace of nanotechnology is breathtaking," says Akhlesh Lakhtakia, a professor of engineering science and mechanics at Pennsylvania State University. As a result, Lakhtakia and others are calling for nanoscience to be integrated into high school, middle school and even grade school curricula. "I want our children and grandchildren to be able to cope with this because I don't want them to become slaves of oligarchy."

Born in the 1980s with the development of the scanning tunneling microscope that enabled scientists to work on a nanoscale—that is, one billionth of a meter—nanotechnology involves manipulating molecules and atoms to build structures with new properties. Since all materials exist at this level, the technology involves scientists of all stripes, from engineers to chemists to medical doctors. Among its much-touted, potentially wide-ranging applications is a cure for cancer, supercomputers 500-times more powerful than those today and chips capable of storing the entire content of the Library of Congress. Consequently, "nanohype" has given rise to a host of fanatics and naysayers, from those who embrace the technology as the key to transcending the human condition to others who believe that tinkering with nanoparticles is sure to open Pandora's Box. "The truth usually lies somewhere in the middle," explains Nigel Cameron, director of the Center on

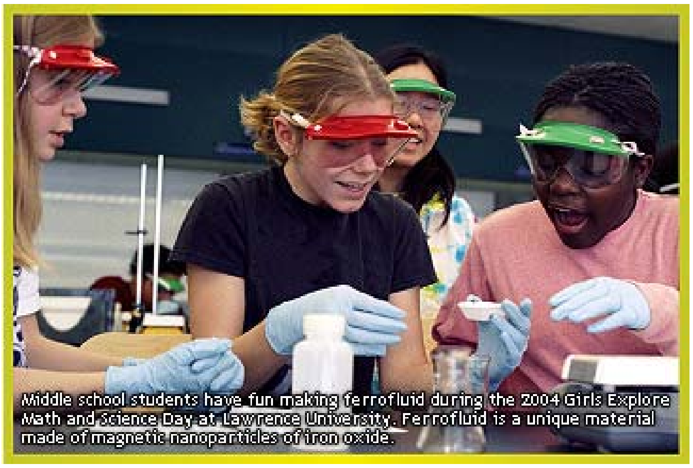
Nanotechnology and Society at the Illinois Institute of Technology in Chicago. Nonetheless, he says, "it increases to a huge degree a far greater capacity to manipulate the natural order."

Not surprisingly, other countries, such as China and Taiwan, are already teaching children about nanotechnology as part of their standard curriculums, according to Judith Light Feather, founder of the Texas-based Nanotechnology Group (www.thenanotechnologygroup.com), a foundation that promotes nanotechnology education. "You go into a grade school [in the United States] and say nanoscience, and they look at you like you're from another planet," she says. Light Feather works with universities to obtain grants to develop programs for teaching nanoscience in K-12.

In fact, 20 percent of National Science Foundation funds granted to universities for nanotechnology research is earmarked for the development of K-12 nanotechnology education. As part of a 13-university network, the Georgia Institute of Technology teaches basic nanotechnology concepts and applications to children by holding workshops at its research facilities. Elementary, middle and high school students can tour the university's labs and "clean room," a dust-free environment where nanotechnology research takes place. Elementary school students use s'mores for a larger-scale, hands-on lessons in how these tiny chips are made. Diana Palma, who heads up Georgia Tech's program, says the kids are fascinated. "I tried to find every conceivable motivational hook in the classroom as a science teacher for 20 years. This is it."


Chemistry professor Karen Nordell and Lawrence chemistry major Richard Amankawah use a scanning electron microscope to characterize samples of polymer nanoparticles.

At Lawrence University in Appleton, Wis., Karen Nordell, an associate professor of chemistry, facilitates week-long workshops in the summer for middle and high school teachers. Rather than teaching a stand-alone course in nanoscience, she looks for ways to supplement and integrate nanoscience into the teachers' curricula by using it as an example in the science courses they are already teaching. She's developed a short experiment, for instance, where kids actually synthesize gold into nanoparticles. The result looks something like grape juice, which demonstrates how properties—like color—change on a nanoscale. "There's usually a sort of 'gee whiz' factor," Nordell says. "That's a very important part of keeping students curious about science." Nordell uses the experiment as a launching point to talk about gold nanoparticles, which hold promise as a cancer therapy, and other applications of nanotechnology. "One of my goals is to get them interested in the problems that haven't been solved yet," says Nordell. She hopes nanoscience will attract kids to science the way space did for kids in the 1960s.



Middle school students have fun making ferrofluid during the 2004 Girls Explore Math and Science Day at Lawrence University. Ferrofluid is a unique material made of magnetic nanoparticles of iron oxide.

But nanotechnology education isn't just for budding scientists. Kevin Ausman, director of Rice University's Center for Biological and Environmental Nanotechnology, stresses that all kids should learn about nanoscience. "Nanotechnology is the next plastics," opines Ausman. "It's poised to explode on the market." Once that happens, it will generate workforce demands, from manufacturing lines to sales forces, and all workers will need to have an understanding of nanotech concepts. Since 2001, Rice has sponsored nanoscience training for seventh-grade physical science teachers in Houston, including weekly workshops, summer internships and sabbaticals. Another Rice program currently being tested in six states, Nanokids, uses actual anthropomorphic molecules synthesized in the laboratory—they look like stick figures—to instruct kids in the concepts of nanoscience through interactive multimedia.

Proceed Cautiously

Meanwhile, Cameron cautions that there is a fine line between education and promotion of technology. "What's the message here?" Cameron asks. "If it's that [nanotechnology] is wonderful, then that's not education." He questions the motivation of those who believe that children as young as kindergarten need to be prepared for nanaotechnology. The enormous societal and ethical issues can't be ignored, argues Cameron; "Otherwise, there's a danger of the whole thing collapsing into public relations."

Penn State's Lakhtakia agrees that nanotechnology can't be taught in a vacuum. He's developed a plan to educate children in grades six through 12 through interdisciplinary team projects. Just in Time education, as Lakhtakia calls it, would present nanotechnology in a context, warts and all. For example, he envisions eighth or ninth graders investigating water filtration systems based on carbon nanotubes. Initially, they may examine the effectiveness of nanotubes compared with charcoal water filters. Next, they could determine the system's commercial viabilty. And what about disposal of the filter cartridges? Would there be health hazards? How about neurological damage? Is it conceivable that behavior patterns would be altered? If so, how would those who were affected impact society?

At the core of Just in Time education is the synthesis of humanities and the STEM disciplines. "People who are primarily humanities-minded should have to work with people who are primarily science-minded," he insists. "Unless we do that, the change in the political landscape will be enormous." He points to the fall of the former Soviet Union as an example. While Soviet universities churned out highly skilled scientists, they were overspecialized. "They couldn't do anything else," Lakhtakia says. "I don't want to live in a world where either scientists dominate or science is exploited to dominate people."

Ultimately, he says, it's up to regular citizens to prevent such a scenario. "In a participatory democracy and technological society, it behooves everyday citizens to know how money is made. You don't have to know quantum mechanics, but you do need to know that light travels in optical fibers and can be used to communicate, for example." The public needs to be sophisticated enough about nanotechnology to be able to distinguish the applications that are dangerous from those that are not, adds Ausman; "Otherwise, you could be throwing away the cancer cure along with the hazards."

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