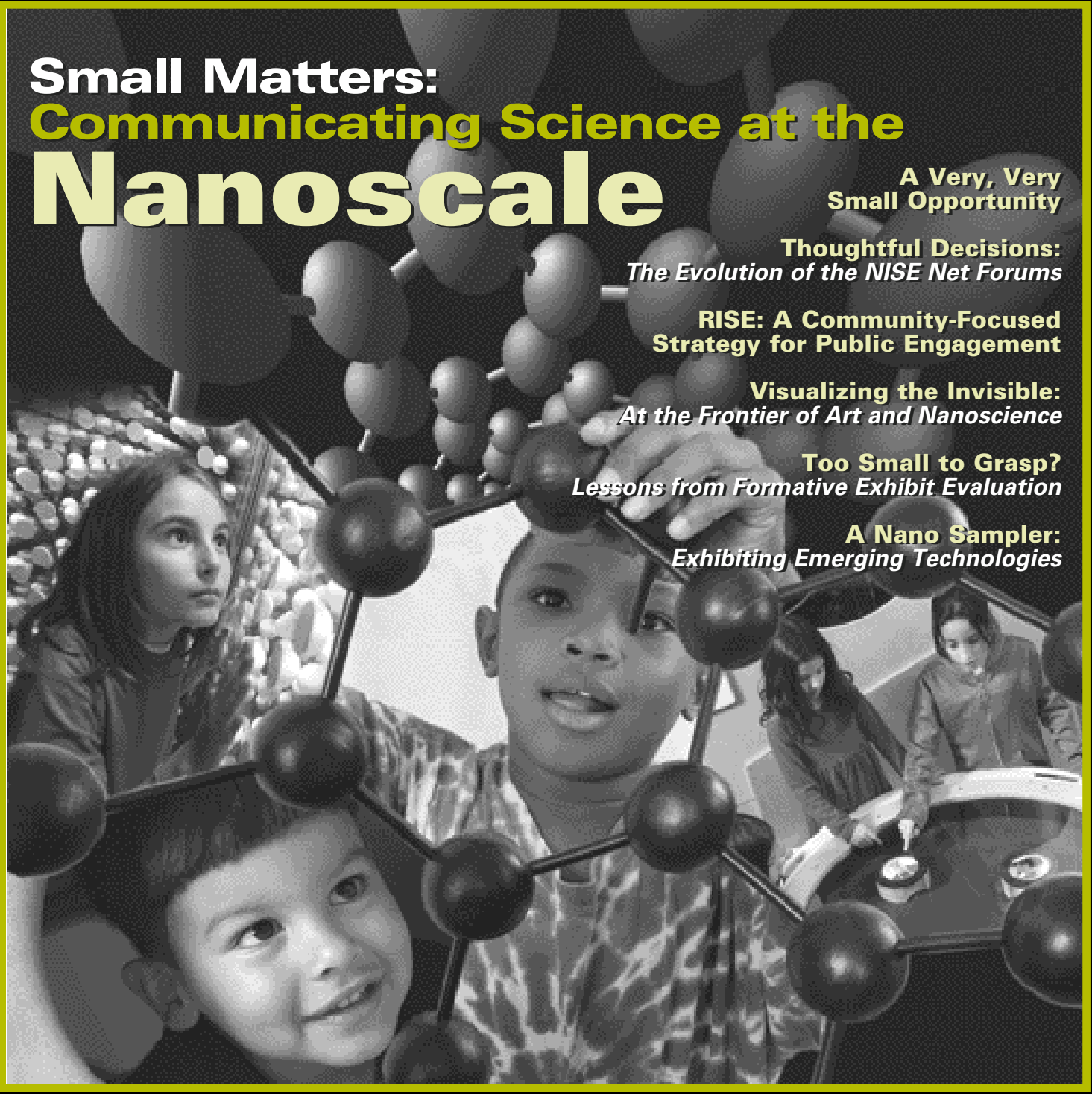
ASTC Dimensions

Bimonthly News Journal of the Association of Science-Technology Centers

January/February 2008

Small Matters: Communicating Science at the Nanoscale



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IN THIS ISSUE

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Much of this issue is devoted to the Nanoscale Informal Science Education Network (NISE Net), a National Science Foundation–funded initiative intended to foster an informed U.S. citizenry and a competitive workforce in the emerging field of nanotechnology. Articles from the Museum of Science, Boston (lead institution), Science Museum of Minnesota, Exploratorium, and others describe network members' progress in creating new public programs, exhibitions, media, online resources, and professional development opportunities based on the latest in nanoscience and nanotechnology. Of course, NISE Net was not the first to tackle the nano challenge. Here, too, are stories of pioneering exhibitions about science at the nanoscale and a preview of projects now in development.

Features

Departments

Cover: Few scientific discoveries have as much potential as those emerging from research in physics, chemistry, and biology at the nanoscale. Communicating those discoveries is an exciting task for science centers. *Clockwise from top:* Carbon nanotube diagram/*V.H. Crespi, Penn State University, http://opencontent.org;* Dust Pinball exhibit *(It's a Nano World)/©Frank DiMeo, courtesy Sciencenter;* nanotube model building *(Too Small to See)/©Garry Hodges, www.jonreis.com, courtesy Sciencenter;* young boy at play/*©Marilyn Nieves, courtesy NISE Net;* Infinity Crystal *(Too Small to See)/© Garry Hodges, www.jonreis.com, courtesy Sciencenter*

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A Very, Very Small Opportunity

By David Rejeski

Over the last few decades, scientists have developed tools that allow them to see and manipulate matter at an atomic scale, down to a nanometer (that's around 1/80,000th the width of a human hair). Nano is an invisible technology with big impacts that almost nobody is talking about; bring manufacturing down to a nanoscale and you have the makings of the next industrial revolution.

Government and industry are betting that nanotechnology will allow us to create new properties from old matter, making materials stronger and lighter, for instance, and even create whole new forms of matter. If you talk with investors, they will tell you that nano is the next big thing. By 2014, nanotechnology is expected to account for over $1.4 trillion of global economic production. Like most technological revolutions, this one will have some downsides. Animal studies have shown that nanoparticles can enter the bloodstream, cross the blood-brain barrier, and damage tissue and DNA—reasons for concern, and for more research.

Given the size of the global investment, possible risks, and what's at stake for our lives, our economy, and the environment, you might ask: "Shouldn't we be having a conversation about this technology?" Yet recent U.S. surveys have shown that 70 to 80 percent of Americans have heard "nothing" or "very little" about nanotech, despite its potentially transformative effects on medicine, agriculture, computation, defense, and energy production.

This is nothing new. When was the last time the government asked you how to spend your taxes on science? That didn't happen with nuclear power, genetics, or agricultural biotechnology. For people who lived through the biotech revolution, nanotech is a flashback: the collision of rapidly advancing technology with lagging public understanding, which could scuttle billions of dollars in public and private sector investment in nanotech and jeopardize some real breakthroughs, like better treatments for cancer and far cheaper solar energy.

It doesn't have to be this way. In nanotechnology we find an unprecedented opportunity to do things differently, to develop a social contract between the public and the scientific community that is built on openness and trust. And that begins with a conversation.

For the past several years, a number of surveys and focus groups have been conducted around public attitudes toward nanotechnology (see below). When given some balanced background material on nanotechnology and its potential benefits and risks, few people in the United States want to shut down scientific progress. But most do not trust industry to self-regulate. They want effective oversight, more disclosure and transparency, premarket testing, and testing by independent, third parties—all rational expectations for a new science with some inherent risks. These are expectations that could form the foundation for a new social contract between society and science that helps define mechanisms for oversight, industry disclosure, better risk research, and public consultation.

Movement in this direction is starting at a community level. Berkeley, California, recently passed the world's first nanotechnology ordinance, requiring nanotech firms within city limits to detail what they are producing and what they know about its risks; Cambridge, Massachusetts, may do the same. NGOs are asking valid questions about the risks and benefits of nanotechnology, and media coverage is finally expanding beyond the science journals. If we are on the cusp of the next industrial revolution, we need a public conversation about our goals. Nano may be the small technology that creates that large opportunity. ■

Carbon nanotuebe by V.H. Crespi, Penn State University, http://opencontent.org

David Rejeski is the director of the Project on Emerging Nanotechnologies (www.nanotechproject.org) *at the Woodrow Wilson International Center for Scholars, Washington, D.C. This article originally appeared in the July/August 2007 issue of* Orion (www.orionmagazine.org).

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• Project on Emerging Nanotechnologies. *Awareness of and Attitudes toward Nanotechnology and Federal Regulatory Agencies.* Washington, D.C.: Peter D. Hart Research Associates, September 25, 2007. Accessed 20 November 2007 at *www.nanotechproject.org/135/.* A 2006 Hart study on the same topic, useful for comparison, is at *www.nanotechproject.org/78/.*

Introducing NISE Net...

By Larry Bell

The Nanoscale Informal Science Education Network (NISE Net) is a nationwide community of U.S. researchers and informal science educators dedicated to fostering public awareness and understanding of, and engagement with, nanoscale science, engineering, and technology in both the near and the long term.

Launched in 2005, NISE Net is funded by the National Science Foundation (NSF) in a five-year cooperative agreement with the Museum of Science, Boston, and core partners the Science Museum of Minnesota, St. Paul, and the Exploratorium, San Francisco.

In its first two years, NISE Net focused on developing and evaluating a range of exhibits, programs, media, forums, visualizations, and other materials and activities that could be useful in achieving its public engagement goals. Participants developed new relationships and built both individual and institutional capacities to develop and present nano educational opportunities to the public.

In NISE Net's third year, the focus is shifting toward activities that will disseminate knowledge, materials, programs, and exhibits to new sites across the United States. To that end, network members are working on three connected and mutually supportive mechanisms for delivering nano educational experiences to the public:

- a network of 100 informal science education (ISE) partner institutions that can present nano educational experiences to the public on an ongoing basis;
- sustainable collaborations between nano research centers and ISE partners to support ongoing work; and
- NanoDays, an annual event that can serve as a focal point for ISE and research partner activities. In 2008, NanoDays will be held March 29–April 6.

Simultaneously, two key resources are being developed to support this work:

- an open-source catalog of high-quality tools, exhibits, programs, and media, and
- a web site, *www.nisenet.org*, that can help support the needs of the partners, build the NISE Net community, and provide a window for the public into NISE Net activities.

To make these resources widely known and to broaden participation in NISE Net activities, members are organizing a variety of outreach and professional development activities among informal science educators, researchers, and organizations that serve diverse audiences. ■

Larry Bell is senior vice president for exhibits and programs at the Museum of Science, Boston, and principal investigator for the NISE Net project.

Thoughtful Decisions: *The Evolution of the NISE*

By Larry Bell and Troy Livingston

Though scientific research may at times appear removed from the daily concerns of life, the development of new technologies based on that research inevitably has societal implications. Decisions about technological development, therefore, require input beyond scientific knowledge, as the authors of *Science for All Americans,* a 1989 report from the American Association for the Advancement of Science (AAAS), pointed out when they wrote that "engineering decisions, whether in designing an airplane bolt or an irrigation system, inevitably involve social and personal values as well as scientific judgments."[1] *Technically Speaking,* a 2002 report from the National Academy of Engineering (NAE), suggested a role for the public in decisions about technology: "In a democratic society, people must be involved in the technological decisions that affect them . . . ."[2]

Committed to public participation

What does this call for civic engagement with new technologies mean for informal science educators? At the Museum of Science, Boston, it was not until 2002 that we began to take education in technology and engineering as seriously as we do education in science. At the AAAS conference in Boston that year, several of us heard professors from North Carolina State University talk about their experiments with Citizen Consensus Conferences. These public events were modeled on forums conducted by the Danish government to get ordinary citizens' advice on matters of technology policy.

After the AAAS conference, we asked ourselves if we could develop a similar model, a program that would address technological literacy goals cited by the NAE while incorporating the social and personal values called for by AAAS. One influence on our decision was an article by Jon Turney of University College London, in which he argued that "a host of experiments with consensus conferences, citizens' juries, (and) deliberative polls . . . all show that people involved in such discussions quickly become adept at quizzing experts, mastering a brief, asking questions, and unmasking political assumptions masquerading as scientific conclusions."[3] Not only do participants become scientifically literate, Turney concluded, but they do so "under conditions in which they decide what they need to know."

To several of us, this sounded like an interesting parallel to our museums' interactive exhibits, which allow visitors to explore scientific phenomena and practice inquiry skills. In our new model, it would be interactive *programs* that would explore the societal implications of new technologies and offer participants the chance to practice decision-making skills. And so we set out to offer museum visitors a means to engage in dialogue and deliberation around emerging technologies.

The NISE Net platform

We soon had an exciting opportunity to experiment with programs that feature dialogue and deliberation. In January 2005, the National Science

1. AAAS, Science for All Americans, *1989, p. 40.*
2. National Academy Press, Technically Speaking, *2002, p. 36.*
3. The Guardian, "How Greenfield Got It Wrong," April 17, 2003, www.guardian.co.uk/life/opinion/story/0,12981,937901,00.html.

Net Forums

Foundation solicited proposals for a science center collaborative that would focus on informal science education approaches to the new field of nanotechnology. The solicitation cited the economic, environmental, social, and ethical dimensions and issues associated with nanotechnology; advanced the need for an informed citizenry; and encouraged the creation of science cafés and other forums that would address its implications and potential consequences.

In partnership *(continued on page 6)*

Participants in a June 2007 NISE Net forum at the Museum of Science, Boston, ponder the medical applications of nanotechnology. *Photo courtesy Museum of Science*

Taking NISE Net Forum Programs on the Road

By Marilyn Johnson

At the Oregon Museum of Science and Industry (OMSI), in Portland, we decided to experiment with holding NISE Net forum programs for adult audiences in a variety of settings. The question we posed for each location was, "Would new and diverse audiences be interested in forum programs on nanotechnology?" The answer, in most cases, was "yes."

Forums held in the cities of Portland (August 2006, local brewpub) and Eugene (March 2007, university; June 2007, local pub/restaurant) drew standing-room-only crowds and received highly favorable reviews on evaluation forms.

In Portland, where OMSI's monthly "Science Pubs" now draw 150 to 180 persons, we used tools like Craigslist to draw 65 participants to our first forum. But in Eugene, home to the University of Oregon, we encountered a logistical challenge. The university would provide nanotechnology experts for the forum, but because this town of 142,000 is 110 miles south of Portland, we had to rely on local support for marketing, room arrangements, registration, and facilitation. OMSI staff shared marketing templates and registration protocols with organizers, held a facilitators' training, served as emcees for the events, and worked with graduate students and professionals from local companies to frame the forum and facilitate table discussions. Attendance at the March and June forums was 96 and 150, respectively.

A different kind of challenge arose when the model was tested at rural libraries in eastern Oregon. At the public library in La Grande, 30 participants contributed to lively discussions in a September 2007 forum. OMSI emceed the event, provided speakers, and facilitated the forum, and logistics were handled locally. The tone of this rural discussion, however, was unlike that of the urban forums.

Participants raised deeper concerns about the societal implications of emerging nanotechnologies and expressed a sense of disconnect from nanotechnology applications and the decision-making process. Their conversation emphasized a perceived lack of access to knowledge. All of the surveys returned by participants indicated that a key reason they attended was "to learn about nanotechnology," and a number of respondents indicated that they wished there had been more time for information and discussions.

For a second planned rural forum, in Prineville, the local library was unable to recruit participants at all. Initial analysis suggests a need for increased support, similar to the types of support OMSI provided for the Eugene forum. NISE Net has taken note.

Our final setting was the 2007 conference of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), held in Kansas City, Missouri, last October. Our evening event drew 55 participants, mostly adults aged 18 to 34. As revealed by on-site registration, our audience was 67 percent Latino, 19 percent Asian-American, 13 percent white/not of Hispanic origin, 8 percent African American, and 5 percent American Indian.

Respondents had attended for a variety of reasons, especially "to learn about nanotechnology," "to hear others' perspectives," and for "professional networking." Between 89 percent and 100 percent agreed or strongly agreed that they enjoyed the experience, it raised their curiosity, they felt more informed about nanotechnology, the presentations were easy to understand, the scenarios were easy to follow, and they had weighed the pros and cons of medical nanotechnologies during the discussion. Eighty-two percent reported that they felt comfortable voicing their opinions, and 22 attendees gave their contact information and offered to participate in and support future NISE Net forum programs in their region. ■

Marilyn Johnson is director of research and development at the Oregon Museum of Science and Industry (OMSI), Portland, Oregon.

(continued from page 5) the Science Museum of Minnesota (SMM) and the Exploratorium, the Museum of Science, Boston, submitted the winning proposal and became lead institution for the new Nanoscale Informal Science Education Network.

NISE Net launched in the fall of 2005. Soon after, we put together a group of five museums to experiment collaboratively with the public forums format. Joining the three original partners in this effort were the Oregon Museum of Science and Industry (OMSI), in Portland, and the Museum of Life and Science (MLS), in Durham, North Carolina.

MLS is located in North Carolina's Research Triangle Park region, a hotspot for empty nesters and retirees seeking meaningful learning opportunities. Staff at the museum were already looking for new ways to attract adult audiences to the science center. At their suggestion, the group decided to develop a series of nanoscale science and technology forums that would target adults and encourage them to become more involved with science topics.

NISE Net forum programs focus on a hot current science topic and typically begin with a question or problem that participants will grapple with during the event. Because a central goal from the start was that participants would engage in dialogue not only on the science itself, but also on its societal and ethical implications, organizers regularly invite social scientists, ethicists, and regulation experts from local universities, as well as nanoscale science and engineering researchers, to join the discussion.

After hearing from both kinds of experts, audience members engage panelists and one another in small-group discussions on questions like "Who should decide how much risk is acceptable?" and "What role should the public play in shaping discourse on regulation?" Afterwards, each group reports out on the decisions that were reached.

Programs like these are easy to conduct and relatively inexpensive, and they connect scientists with the public and participants with one another in enjoyable, meaningful ways. Over the past two years, we have formally evaluated 20 forum events developed by our five museums. The majority of participants in all locations reported that they enjoyed the experience, felt more informed as a result, and felt comfortable expressing their opinions.

Forum attendees also routinely report that they value the small-group discussions as much as the expert presentations. These are gratifying results for a program designed to reach adults and get them more involved in issues of science policy. ■

Larry Bell is senior vice president for exhibits and programs at the Museum of Science, Boston, and principal investigator for the NSF-funded Nanoscale Informal Science Education Network. Troy Livingston is vice president for innovation and learning at the Museum of Life and Science, Durham, North Carolina.

Between Parents and Children

By Sabrina Sutliff-Gross

Are NISE Net forum programs strictly for adults? Or could science centers adapt the format to make it compelling for new and varied audiences?

At the Science Museum of Minnesota, we considered this question while planning a forum around a discussion of nanotechnology's benefits and risks for the environment. In pursuit of answers, we decided to invite 9- to 12-year-old participants (along with their parents) from a weeklong SMM summer science camp, *Nanotechnology, What's It All About?,* to attend a special family forum. The two-hour event combined a presentation from a nanotechnology expert, a performance of a nano theater piece, and small-group discussions about nanotechnology.

This was our first experience with creating forum programming for a child-and-parent audience. The most intriguing outcomes to us were the pathways the discussion took and who led those pathways. Interestingly enough, the small-group discussions were not entirely led by the adults. In fact, several parents confessed that they were somewhat intimidated by their child's knowledge of nanotechnology, and it was the children's insights that fueled the thought-provoking discussion.

In general, the young people felt they had a better understanding of nanotechnology than the adult participants did, and they were extremely comfortable discussing—and even disagreeing with the adults about—the complex ethical issues surrounding nanotechnology research and the environment. "I learned a lot about nanotechnology—like about how it harms and helps things," commented one 10-year-old participant.

Challenges we encountered included convincing different families to sit together for more varied small-group discussions, presenting background information that was interesting to both youth and adults, discussing with the adults their role for the evening, and, finally, creating provocative questions that resonated with both adults and youth.

"Having kids and adults, family units together, and trying to create a way for them to access the issues—it's a challenge," commented one Science Museum staff member. "This was more challenging than any of the others we have done.... But we also felt it was one of the most insightful and rewarding dialogues of our nano forums to date." ■

Sabrina Sutliff-Gross is education programs coordinator at the Science Museum of Minnesota, St. Paul.

RISE: A Community-Focused Strategy for Public Engagement

By Carol Lynn Alpert

Fostering effective nanoscale Research Center–Informal Science Education (RISE) partnerships is a key strategic focus for NISE Net over the next three years. The goal is to build capacity for the continued development and dissemination of nano-scale ISE resources beyond the term of direct NSF support.

The RISE strategy is based on the notion that both the educational outreach efforts of university-based research centers and the current-science-and-technology interpretive efforts of science museums will be more effective if they are pursued collaboratively, leveraging the strengths of the respective organizations. The strategy is also community-focused, enhancing public engagement through cross-cutting professional relationships and joint activities and strengthening local connections among researchers, educators, and museum staff. Best of all, the strategy doesn't depend on volunteer efforts; instead it offers significant incentives for research centers and funders to provide support for educational outreach.

To illustrate these points, here's what happened when the Museum of Science, Boston, entered into partnership with a local nanoscale research center.

Building an institutional partnership

Six years ago, as chief developer and manager of the museum's newly minted Current Science & Technology Center (CS&T), I got a call from Harvard physics professor Bob Westervelt. He and colleague Bert Halperin wanted to come by to discuss a proposal they were making to NSF to launch a Nanoscale Science and Engineering Center. (For their take on the story, see "Nano-

Harvard graduate student Tina Shih discusses nanoscience with a CS&T visitor. *Photo courtesy Museum of Science, Boston*

science and the Public," page 8.) The two had seen our CS&T setup and thought it might make a good venue for pursuing their public outreach goals. Since ours was essentially a development and delivery infrastructure, ready to be filled with engaging content, I was happy to meet with them.

The Harvard scientists were not only committed to bringing the work of nanoscale researchers to public attention; they also wanted to respond effectively to NSF's "broader impact" criterion. This is one of two primary criteria ("intellectual merit" is the other) used by the foundation since 1997 to evaluate the strength of research proposals. One broader impact recognized by NSF is enhancement of science and technology understanding among students, teachers, and the general public.

A partnership with the Museum of Science, Bob and Bert thought, would provide a platform for sharing their research with the public and access to the museum's already well-developed student and public audiences. The NSEC could send researchers over to give talks on the CS&T stage, right in the middle of the exhibit halls.

I welcomed this idea and also shared my concern that few researchers have the experience and skills to engage general museum audiences in this kind of forum. Our "free-choice" audiences expect entertainment, interaction, and relevance; they tend to shy away from lectures of the type that researchers are schooled to give to students and professional colleagues.

The museum had enjoyed previous educational outreach partnerships with research centers. In fact, our 2000 Science Education Partnership Award (SEPA) grant from the National Institutes of Health had connected us with seven Boston-area health science research institutions and provided funding for full-time museum education associates. We found then that if we hired people with terrific science communication skills plus graduate-level backgrounds in health-science-related areas, we could provide quick turnaround exhibits and programs. Our new staffers kept CS&T up to date by developing presentations, exhibits, media, and guest researcher events on current health science research and "hooked" audiences by linking to related news headlines.

I asked Bob and Bert to consider adding to their proposal support for a full-time senior education associate at the Museum of Science, as well as tools for media and small-exhibit production. As part of the job, the education associate could also curate effective interactions with guest researchers.

Not only did Bob and Bert write the museum into their grant application;

they underlined their NSEC's commitment to educational outreach by making us a full partner in the project, along with M.I.T. and the University of California–Santa Barbara. Not long after, the proposal was funded.

Results of the collaboration

Since Harvard launched its NSEC, each annual NSF site-visiting committee has awarded high marks for its educational outreach activities. The center was recently renewed by NSF for an additional five years. Our efforts were joined three years ago by another NSEC, the Center for High-rate Nanomanufacturing (CHN) at Northeastern University and the University of Massachusetts–Lowell. Led by Ahmed Busnaina, CHN also included the Museum of Science in its NSF proposal, allowing us to expand our program to include two full-time nanoscale education associates and professional development activities.

As of October 2007, 38,000 people had attended 985 live Museum of Science staff presentations on nanotech research and 33 guest researcher events. The 44 nano "SciTech Today" segments we produced for New England Cable News had each been viewed by 9,000 to 19,000 households; our 25 nano podcasts had each been downloaded by 5,000 to 7,000 people; and a total of 240 teachers had attended our yearly Nanotech Symposium for Educators. Partners at both NSECs leave the selection of topics and stories to museum staff; we "cover" the spectrum of nanoscale research as we see fit.

The experience we gained by working with these two nanoscale research centers helped build our confidence—when the opportunity arose—that the Museum of Science could play a key role in developing a national infrastructure for nanoscale informal science education. Input from our NSEC partners helped convince NSF that a nationwide NISE Network could foster similar partnerships elsewhere—hence the inclusion of RISE as an integral part of the NISE Net strategy.

Looking ahead

The model described here is just one of many possible types of research center–science museum partnerships. Such collaborations have already produced major nano traveling exhibitions, community forums, and planetarium shows. While RISE focuses on funding professional ISE work through institutional partnerships, NISE Net is also working with ASTC, the Materials Research Society, and the IMLS-funded Volunteers TryScience (VolTS) initiative to encourage individual involvement of nano and materials science researchers with museums on a volunteer basis (see *ASTC Dimensions,* September/October 2007).

Upcoming RISE efforts will include a campaign to raise awareness among stakeholders through journal articles and presentations at professional meetings, as well as match-making/consulting services and guides for planning collaborative activities. Though our current focus is on nanoscale informal science education, our long-term objective is to foster an ongoing culture of partnership that can effectively engage public audiences in any and all future domains of research. ■

Carol Lynn Alpert is director of strategic projects at the Museum of Science, Boston, and a co-PI for NISE Net. For details on RISE, write to her at calpert@mos.org.

Scientists Speak about Nano . . .

Nanoscience and the Public

By Bob Westervelt

When the National Science Foundation's National Nanoscale Initiative (NNI) was authorized in 2001, researchers were pleased. At last Congress recognized how important it was to understand how things work on the nanoscale, the level at which we can see the quantum nature of objects and understand the inner workings of biological systems.

As my colleague Bert Halperin and I began work on a proposal for an NSF-funded Nanoscale Science and Engineering Center (NSEC) at Harvard, it was clear that we must actively engage the public. Many academic researchers would like to inform the public about nanoscience, but don't know how to do it. Science museums, on the other hand, are keen to get people's attention, show them what is happening, and invite them to think about the big ideas. A collaboration with a science museum would be an excellent way to involve the public with our research work.

Bert and I visited Carol Lynn Alpert at the Museum of Science, Boston, to discuss how to proceed. At the time, the museum was developing its Current Science & Technology (CS&T) program. Presentations about new discoveries were made by talented staffers, backed by an impressive array of video displays, on a suspended stage in an exhibit hall. CS&T also held public forums on important topics. We decided to make the museum a central partner in our proposal.

After our NSEC, officially titled "Science of Nanoscale Systems and Their Device Applications," was funded, I talked with Joel Rosenberg, the Museum of Science educator hired to work with our project, about the goals of the center and introduced him to NSEC researchers. Joel also attended lectures in which faculty presented their work. The entertaining, well-informed shows on nanoscience and nanotechnology that he developed for the CS&T stage generated a lot of interest and questions from visitors. His work has subsequently been ably carried on by CS&T staffers Daniel Davis and Tim Miller, and researchers have also presented shows at the museum.

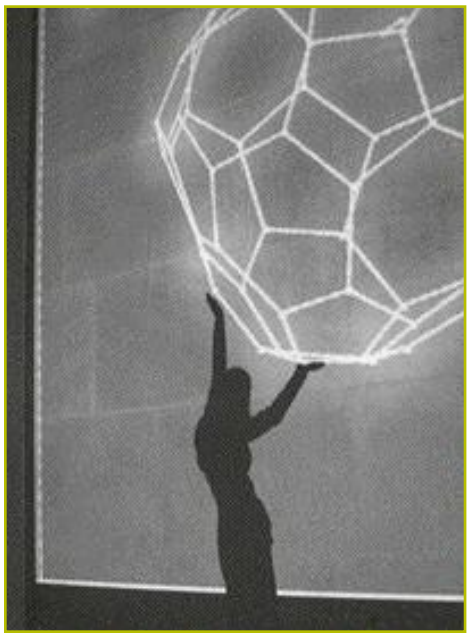
The collaboration continues to benefit all parties. Graduate students who work at the museum connect with the public at an early stage and learn how to integrate their plans and careers with issues of public importance. Museum visitors are drawn into engagement with advances that excite researchers, such as carbon nanotubes and bucky balls, and with larger questions, such as "good" vs. "bad" science. They can see why academic scientists find nanoscience so involving—and can raise any concerns they may have about the new technologies.

This model is now being extended to research centers and science museums across the United States. Headed by the Museum of Science, the NSF-funded NISE Network offers the experience and skill to build collaborations and help scientists bring their ideas to the public.

NISE Net advisor Bob Westervelt is Mallinckrodt Professor of Applied Physics and Physics at Harvard University and director of Harvard's Nanoscale Science and Engineering Center.

Visualizing the Invisible:
At the Frontier of Art and Nanoscience

By Tom Rockwell



In the immersive digital interactive *Zero@Wavefunction,* bucky-ball projections are manipulated by the viewer's shadow. The IDI was created by artist Victoria Vesna and software designer Josh Nimoy in 2003, in collaboration with nanoscientist James Gimzewski. *Photo by Pete Conolly*

Except for those who spend their time in laboratories, constrained by empirical experience, comprehending science at the nanoscale takes an extreme act of the imagination. It requires conjuring up an utterly foreign world—a remote world populated by atoms and molecules, a place our bodies can't go and our minds are ill equipped to grasp.

As museum educators, we need to remind ourselves just how cognitively difficult this is. Astronomy is far easier on the mind. Travel and acceleration are everyday experiences: Just extrapolate from car travel to warp speed, and you've wrapped your head around intergalactic distances. There is no similar experiential basis for shrinking to the size of DNA. Likewise, the mental time travel of paleontology is simpler to imagine than nanoscale science. Imagining distant eras is far more natural than picturing a world of detail inside a grain of sand. (And giant reptiles make it so much more engaging.)

Stories about miniature worlds, found in many cultures, reveal only that people hope for shrunken realms more familiar than they really are. If the nanoscale turned out to be populated with fairies or Lilliputians, we would have a much easier time talking about it. But it is not, and we are left probing, picturing, and trying to explain a world that is hard to get to and contains little that is familiar.

Which brings us to the need for art. Artists could be described as professional explorers of perception and imagination, people whose life's work is to specialize in the edges of cognition and help others to see and feel new things. Unlike scientific illustrators, who typically avoid ambiguity for the sake of educational clarity, artists revel in the murky territory where aesthetics, emotions, and cultural meaning come together. Who better, then, to make the invisible not just visible, but also compelling and relevant?

Finding the art in nanoscience

It was with this affective and cultural content in mind that, in 2006, the Exploratorium began to survey artistic investigations of nanoscale science. This effort was part of several directions pursued by NISE Net's Visualization Laboratory team.

We took stock of the relevant literature. We held weeklong, exploratory residencies with artists who had either worked directly with nanoscale science or demonstrated a style that seemed appropriate for it. We commissioned exploratory artworks and displayed previously produced works in a gallery on the museum floor. We worked with *Leonardo,* the journal of the International Society for the Arts, Sciences and Technology, to solicit a selection of papers on art and nanoscale science and technology. And we collaborated with the Magic Theater in San Francisco as they, with support from the Sloan Foundation, commissioned short plays about nanotechnology. Reflections on this survey, along with the artists' works, can be found at *www.nisenet.org/artnano.*

What the process revealed is a territory that is still young, diverse, and incomplete—a kind of frontier town full of exploration and start-up businesses. Its denizens include artists like Victoria Vesna, Zack Booth Simpson, and Santiago Ortiz—all of whom have been working on nanoscale science for some time, exploring the same issues of scale and digital modeling that nanoscale educators grapple with. Present, too, are scientists like Eric Heller and Don Eigler, who manipulate visualization-based experimental data or computational simulations in ways that resemble art, as well as artists like Stephanie Maxwell and Scott Snibbe, who are new to nanoscale science but bring an interesting sensibility to the table. Each is responding to and participating in an open-ended cultural exploration of a new topic—a broad, diverse, interdisciplinary topic that is well funded but still very much in flux.

What we learned

Space does not permit a full account of our survey of nanoscale science and art, but I can share, in the form of personal observations, some lessons learned in the process.

The shapes and images of the nanoscale, once they are manipulated, can have a strong abstract appeal. Colorized

micrographs, geometric arrangements of atoms, and computer simulations of electron paths are visually engaging, although they require considerable interpretation to explain. One could envision a show of the "abstract world of the nanoscale" at art museums or research centers. The educational value of these images in the typical informal science setting, alongside interactive exhibits, is still being debated.

Works like Vesna's *Sand Mandala* and Snibbe's *Three Drops* show that scale-travel is an intriguing formal and conceptual problem. Although there have been previous educational "zooms," starting with the Eames's *Powers of Ten,* it seems that this form could benefit from having different artists explore how imagery and cultural resonances shift when the same object or situation is viewed at different scales.

Art, drama, and literature have already engaged emerging technologies like genetic engineering. Science fiction, utopic or dystopic, remains one of the most engaging entry points for nanoscale science and engineering. "What if" scenarios about new materials and technologies have carried the first wave of public interest in nanotechnology. I would like to see a new generation of artists, playwrights, and sci-fi writers engage this discourse and explore these futures scenarios in terms of human values, hopes, and fears.

Finding relevance

These observations point to areas for ongoing investigation in a still young arena of research and artistic exploration. But before museums devote more time and capital to the effort, we must address a final lesson of the Exploratorium's survey—the "Big Why." That is, who cares? What does it matter to *me?* How many artists, educators, and audiences would care about nano if it weren't so well funded?

It is not enough just to present nanoscale science and engineering as the technological flavor of the decade. Though the epistemological issues of seeing the invisible are intriguing, they haven't yet risen to the level of essential cultural topic, and probably won't. If there is relevance to be found in this work, I personally think it centers around the fact that it is at the nanoscale where physics and chemistry become the world as we know it—and where, most importantly, matter becomes life. The emerging human power to sculpt the molecular foundation of all we know is remarkable, frightening, and increasingly possible. It may be easier to imagine far-away galaxies or the time of the dinosaurs, but it is at the nanoscale that we will learn about the scientific underpinnings of the material world. All our debates about new materials, genetic engineering, and the nature and origin of life must take this scale into account.

As NISE Net helps different communities build collaborations between informal science education and the research community, we hope new partners will turn to artists to continue the exploration of aesthetic, affective, and cultural territory that has been surveyed in the network's first years. ■

Tom Rockwell is the associate director for programs at the Exploratorium, San Francisco, and a co-PI of NISE Net.

Scientists Speak about Nano . . .

Capturing the Public Imagination with Nanoscale Science

By Krishna Madhavan

I was part of NISE Net from the original proposal-writing days until shortly after I changed positions in October 2006. My research area (cyber-tools and cyber-environments for engineering education) provides me with a unique vantage point. Cyberinfrastructure is the vertical integration of computational power, networks, data, and software to provide seamless scientific or non-scientific user experiences. This includes a wide range of users and tools, from large supercomputers to cell phones and iPods.

What motivated someone interested in cyberinfrastructure to collaborate in NISE Net? Advances in information technology are driven today by knowledge and control of nanoscale phenomena. Just think about the fast processors in our current PCs! The development of powerful computers has, in turn, resulted in increased use of simulations as a primary method for doing nanoscale engineering and science. So when I first contacted the NISE Net team, my primary motivation was to explore this interesting and exciting link.

The initial stage of the project was a learning experience, to say the least. For me, this was not so much about the technical aspects of NISE Net as it was about the social and cultural aspects. I began to understand that the project represents a new experience in collaboration, even within the informal science education world. The immense effort involved in building the network and the significant investments by NSF trigger the important question: "Why?"

The answer, in my opinion, goes beyond the obvious one: "The taxpayers fund this research, so they have a right to know." This is absolutely true. However, it is more important to understand that nanoscale engineering and science is ushering in a new era of scientific insights that will impact our daily lives in numerous ways. This impact will be so fundamental that we need an informed public able to evaluate the choices provided to us.

For the first time, nanoscale science is unifying diverse disciplines that have co-existed for years, often at odds with each other. Nanoscale science offers insights into the very essence of what constitutes the world as we know it. How can the general public be left out of this incredible journey? Placing nanoscale science within the larger dimension of human experience is what I see as the basic added value of NISE Net. In recognizing nanoscale engineering and science as a venue for unifying multiple scientific domains, I see a real opportunity for engaging and exciting the public about cyberinfrastructure and making it a key domain in future scientific endeavors. ■

Krishna Madhavan, a NISE Net working partner, is an assistant professor at Clemson University in South Carolina, with joint appointments in the Department of Engineering and Science Education and the School of Computing. He was previously director of education and educational technology for the NSF-funded Network for Computational Nanotechnology (www.nanohub.org).

Too Small to Grasp?

Lessons from Formative Exhibit Evaluation

By Kirsten Ellenbogen

As Larry Bell explains in his description of the NISE Network (see page 4), one of the core products of the project is an open-source catalog of high-quality tools, exhibits, programs, and media. This article focuses on the evaluation of prototype exhibits of nanoscale science, engineering, and technology, a highly productive and visible component of the first two years of the collaboration.

Front-end studies conducted by Barbara Flagg for NISE Net (see Resources, page 18) brought together valuable data drawn from previous projects dealing with nanoscience and nanotechnology. The Science Museum of Minnesota (SMM), which leads the exhibit work of NISE Net, made a commitment to visitor testing of all products that will be included in the final catalog. As of November 2007, more than 30 iterations of exhibits had been formatively tested with more than 1,000 visitors.

These evaluations have included cued testing with visitors during multi-day formative workshops at SMM, as well as on-site testing at the institutions that developed the prototypes. Besides SMM, these include the Children's Museum of Houston; the Exploratorium; the Fort Worth Museum of Science and History; the Museum of Science, Boston; the Museum of Life and Science; the New York Hall of Science; OMSI; the Sciencenter; and the University of Wisconsin–Madison. Formative evaluation has also included professional critiques by NISE Net partners and advisors, and marketing surveys at some of the 100 informal science education institutions (ISEs) that will soon join the project.

NISE Net exhibit content and visitor experiences are driven by six main messages:

1. *Nano is in many realms and is both everyday and cutting-edge.* Potential nano products range from the here-and-now (tougher floor coatings, dental repair materials) to truly innovative applications (scavenger cells, space elevator).
2. *Where will nano go?* No one is sure which paths will become reality or how nano and society will interact in the future. Reviewing historical examples of the evolution of scientific and technological innovations may help.
3. *Nano means working at super-small scales to manipulate materials.* Nano technologies are driven by the behaviors of small collections of atoms and use new tools to take advantage of special properties at the nanoscale.
4. *It's different down there.* Scale matters. At the nanoscale, gravity becomes less important, while electrostatics, friction, increased surface area, and molecular motion become very important.
5. *Nano is a people story.* Many different people (scientists, engineers, technicians, and students) work in interdisciplinary teams to investigate nano and make nano products. Artists, philosophers, policy analysts, and social scientists are also involved.
6. *How will nano affect you?* Nanotechnology has social and political implications; issues to explore include job shift, health ethics, toxicity, privacy, security, the human/machine interface, environmental safety, and environmental cleanup.

The NSF-funded National Center for Learning and Teaching (NCLT) in Nanoscale Science and Engineering (see Resources, page 18) has also been working on a set of "big ideas" that are informing the design of NISE Net learning experiences. Together, these main messages set a high bar for creating experiences that engage visitors in complex nanoscale science.

In the first years of the project, exhibit development has focused primarily on creating experiences that communicate key concepts—a challenge, given the new content of nanoscale science—and secondarily on enjoyment and innovation, an aspect of the project that is well within the extensive experience of the partners.

Promising directions

NISE Net prototypes were evaluated along several key dimensions: enjoyment, interest, clarity, ease of use, and perceived relevance. We also wanted to find out how well visitors understood our main messages and key concepts, such as scale.

What we found was that the simplest hands-on experiences—such as a classic feel-what-you-cannot-see exhibit—are often rated as most enjoyable. At the same time, these prototypes have tended to be the weakest in terms of conveying nano-related content.

More promising are prototypes about medicine. Visitors have typically rated these as not only enjoyable, but also most interesting, easiest to use, and least confusing. Medicine-related prototypes also are the most successful in conveying the main messages and engaging visitors in nanoscience content.

Museum staff seem to agree. In a marketing study of museums and other potential network partners, almost all staff (94 percent) who responded rated this topic as most interesting.

NISE Net exhibit developers have

Scientists Speak about Nano . . .

Nanoscale Science and the Science Curriculum

By M. Gail Jones

In a rural county of North Carolina, middle and high school students use an Atomic Force Microscope remotely from their schools to conduct experiments with viruses. Not only can the students manipulate viruses at the nanoscale; they can also "feel" them with a special computer joystick that provides tactile feedback. Such investigations are educating young North Carolinians about the properties and unique challenges of working at the nanoscale.

In communities across the globe, students like these have new opportunities to explore nanotechnology though activities like examining the stainproofing on nano-treated fabrics, experimenting with the properties of memory wire, and investigating how the lotus effect works to repel soiling in both natural and engineered materials. Nanoscale science is slowly making its way into the school science curriculum.

Teachers at the secondary level are increasingly educating students about the small extremes of science-introducing concepts like powers of 10 or the size of a nanometer. In biology, teachers integrate nano concepts, such as surface-area-to-volume ratios as limits to size, into the existing curriculum. In physics, teachers educate their students about the sticky, shaky, and bumpy world that comprises materials at this tiny scale. Chemistry teachers introduce students to new nanomaterials that are literally built atom by atom. And applications of nanotechnology for cleaning water and air are discussed in environmental science courses.

All of these efforts to bring nanoscale science and engineering to precollege students are in their infancy, but there is a groundswell of interest and enthusiasm for integrating these concepts into existing

curricula. "Integration" is the critical term, because the overstuffed, current K-12 science curriculum, tightly tied as it is to high-stakes testing, makes it difficult to add new concepts and processes. The challenge for both scientists and educators is to use nanoscale science as a way to bridge the different domains of science in an exciting and coherent framework that glues them together. If science teachers can position nanoscale science as the foundation for the science domains, the outcome may prove to be more connected and relevant curricula.

Each year more teachers attend workshops and read about new discoveries and technologies related to nanotechnology. A recent special issue (December 2006) of the National Science Teachers Association's journal, *The Science Teacher*, focused exclusively on strategies for teaching nanoscale concepts. For science teachers, the challenges of adding new concepts to the curriculum are great, but the unique nature of nanoscale science opens new doors for making science instruction interdisciplinary, coherent, and absolutely fascinating. ■

NISE Net advisor M. Gail Jones is professor of science education and director of the Nanoscale Science Education Research Group at North Carolina State University, Raleigh.

been able to focus prototypes successfully on the fundamentals of nanoscience. Museum visitors thought that an exhibit designed to introduce fundamental nanoscale science was clear, easy to use, best at communicating the concept of nano, and almost as enjoyable and relevant as the prototypes about more applied topics. In general, visitors have more consistently understood applications of nanoscience to technology and other fields than they have the fundamentals of nanoscience itself. Evaluation also tells us that most visitors tend to walk away with the notion that nanoscience is improving technology.

Another area where NISE Net prototypes have been successful is scale. Some prototype evaluations show that visitors are able to understand that size affects properties and that things at the nano scale are really, really, small. However, visitors are not leaving with a clear understanding of the size of a nanometer.

The exhibit prototypes that have been most successful at getting visitors to use the word "nano" are those that use the term consistently in labels and videos rather than those that focus solely on fundamental nanoscience concepts. Prototypes that focus on fundamental nanoscale science and prototypes that focus on the application of nanoscience to technology have both been successful in getting visitors to use the term.

Evaluation also compared visitor experiences at stand-alone exhibits vs. clusters of exhibits. Not surprisingly, visitors who engaged with more than one NISE Net prototype tended to comprehend more of the main messages. Recruitment and marketing efforts will probe whether this will encourage the 100 ISEs slated to join the project in 2008 to display more than one nano exhibit.

Challenges to be addressed

A critical area of work for the coming year is improving relevance. None of the NISE Net exhibit prototypes to date has been perceived by visitors as

"highly relevant," and prototypes have tended to be rated as "relevant" by 50 percent of visitors or fewer. Some of those perceived as least relevant may have suffered from poor execution in early versions. Relevance of topics has been addressed more aggressively in the round of exhibits that will be tested this year.

When prototypes have been confusing, the confusion has tended to be related to usage, rather than concepts. The most challenging exhibits for visitors, in terms of enjoyment, clarity, and the conveying of main messages, have been innovative experiences like the immersive digital interactives (IDIs).

For example, when asked about ease of use of an IDI that explores the properties of water at three scales, 25 percent of visitors rated the experience at the lowest level. For another IDI, in which water molecules form a crystal when a visitor's hand creates a nucleation point, about 80 percent of visitors said there was something confusing or frustrating about the experience. Most of this frustration was related to usage and installation issues. The creation of successful and innovative nano experiences is a critical focus of upcoming work.

Finally, we lack comparative information about the impact of different contexts. Comparative tests of the same content in different contexts (e.g., hands-on exhibits, media, IDIs, text, programs, forums) will allow us to better understand cost benefits and the best combinations of contexts for the complex, multidisciplinary nature of nanoscale science. ■

Kirsten Ellenbogen is director of evaluation and research in learning at the Science Museum of Minnesota, St. Paul. This article reports on evaluation conducted by Ellenbogen, Amy Grack Nelson, Saroeun Earm, Katonya Gillard, Amy Gramsey, Beth Janetski, Stephanie Nelson, Dave Ordos, Murphy Pizza, Stacie Redemacher, and Patrick Smith. It also draws on the expertise of lead NISE Net exhibits staff, particularly Sue Koch and Paul Martin.

Scientists Speak about Nano . . .

Nanotechnology as a Catalyst for Change

By Ainissa G. Ramirez

Being asked to reflect on nanotechnology gives me pause—mostly because this field is still in its genesis, and there isn't a consensus yet on what it is. Nevertheless, I believe nanotechnology holds many opportunities, both conventional and unconventional.

Given the confusion over what it is, I'll share a definition I use: Nanotechnology is "the study of the small and curious." By "small," I mean things as small as 1/80,000th to 1/100,00th the thickness of your hair. By "curious," I mean that materials act differently and have different properties at the nanoscale than they do at our scale.

This definition alone provides learning opportunities. With nanotechnology, we can teach scale. That covers the "small" part of the definition. The second part of the definition—the "curious" part—requires a bit more imagination. One way to explain it is to imagine a machine that can shrink things. If a hamburger is placed inside, it will continue to become smaller and smaller. But as we reach a nano-burger, suddenly it turns into a hot dog—the properties have completely changed.

This power of nanotechnology at work is evidenced by gold. At our scale, gold is harmless and can be used as jewelry and tooth fillings. But gold nanoparticles are reactive and can be used as catalysts to remove pollution. Old things act in a new way when made very, very small.

Interestingly, nanotechnology could be used to build trust between the public and scientists. If researchers are willing to be vulnerable, we can use nanotechnology to demonstrate the business of science. More specifically, we could admit that sometimes we build a tool but don't yet know its capabilities and applications, both positive and negative.

Although some applications, like stain-resistant products, are already in the market, and others, like nanomedicine and water filtration, are still on the horizon, we continue to develop all of them. By letting our guard down and

showing the unknowns and how we discover things, researchers may create a new science narrative, generate more public confidence, and demystify science by adding a human element to it.

The science of the very, very small can lead to other big opportunities as well. In particular, it can enable a paradigm shift in how we teach science. Throughout history, broad changes in science education have been catalyzed by political thrusts: World War II and Sputnik ushered in the golden age of physics; *Brown v. Board of Education* ushered in equality in the classroom.

Lacking these political imperatives, which can limit creativity, nanotechnology offers a platform to try new methods for engaging audiences and improving science literacy. We can experiment and diversify our portfolio for getting the word out—especially to groups like non-experts, girls, and underrepresented communities—by adopting tools like YouTube, television, video games, and hip-hop, and by frequenting malls, churches, and science salons. Nanotechnology can be a catalyst for innovation in science and science education alike. It can change not only how we think about materials but also how we engage audiences along the way. ■

An associate professor of mechanical engineering at Yale University, NISE Net advisor Ainissa G. Ramirez (ainissa @mit.edu) recently spent a semester as a visiting professor at the Massachusetts Institute of Technology.

A Nano Sampler:
Exhibiting Emerging Technologies

Before NISE Net was funded, science centers worldwide were finding ways to share with visitors the significance of recent discoveries at the nanoscale. In the following article, three ASTC member museums share their experiences in communicating through exhibitions the potential of this cross-disciplinary field.

***Nanotechnology: Small Science, Big Deal* made extensive use of objects, with in-depth information provided on touch-screen computer terminals.** *Photo courtesy Science Museum*

Fifteen Years of Nano

By Natasha Waterson

Nanotechnology at the Science Museum, London, began in 1993 with *How Small Can We Go?*, the first European exhibition to explore the development, applications, and potential of nanoscale science. Its aims were to alert visitors to the existence of nanotechnology and convey the excitement of work in the field.

Evaluation showed that by far the most popular part of *How Small Can We Go?* was a working atomic force microscope, which was demonstrated daily and served to show the instrument's value as a research tool. Less successful was an exhibit in which an artist in residence translated his own and visitors' imaginings about nanotechnology onto a huge canvas. Visitors simply did not understand this as part of the exhibition.

A 1998 exhibition, *Buckyballs and Beyond,* explored the discovery, in 1985, of buckminsterfullerene and its impact on science. The exhibition presented fullerenes and nanotubes as newly discovered forms of carbon, with structures and properties that opened promising avenues of research for scientists. On display were original items relating to Sir Harry Kroto's Nobel prize-winning discovery, loaned by the researcher himself, as well as models and interactives.

The exhibition also featured one of our first experiments with visitor feedback. We asked, "What do you think nanotube carbon could be used for in the future?" Over three months we got only 23 comments. The lesson we took away? People have to care before they will invest time in answering a question.

Seven years passed before our next nanotechnology exhibition—seven years in which the science moved on dramatically. In 2005 we opened *Nanotechnology: Small Science, Big Deal,* an exhibition timed to coincide with U.K. government response to a July 2004 report, *Nanoscience and Nanotechnologies: Opportunities and Uncertainties,* produced by the Royal Society and the Royal Academy of Engineering (*www.nanotec.org.uk/finalReport.htm*). As its title suggests, this report focused not only on the cross-disciplinary work of nanoscience, but also on what it might hold for the future—its drawbacks and risks, as well as benefits. Nanotechnology was beginning to become controversial, at least in the United Kingdom, and news coverage reflected that.

In this context, we were especially interested to know what our visitors thought about nanotechnology. Front-end evaluation showed that two-thirds had now heard of the word, and half could offer a sensible definition. We asked what visitors thought was most interesting about nanotechnology. Front runners were the science of nanotechnology (i.e., how do they do it?), its benefits, and its medical applications. Visitors were least interested in the risks, applications in computing, and who was paying for it.

Nanotechnology: Small Science, Big Deal took note of some, but not all, of these findings. The exhibition examined the science of nanotechnology and its applications (and risks) in medicine, the environment, leisure and the home, security, and computing. It made extensive use of objects—including many products already on the market, which often served as talking points for family groups—with in-depth information provided on touch-screen computer terminals. We also ran live events in the gallery and adults-only events at the Science Museum's Dana Centre.

Visitor feedback terminals were now well received. Visitors were asked about the uses of high-tech nanotechnology versus low-tech science, about what

should be created with nanotechnology, and about technology and privacy. By the end of the six-month run, we had logged over 12,000 comments.

Evaluation showed that people liked being involved in a controversial scientific subject. They found it interesting and important; they enjoyed reading what others had to say; and, perhaps paradoxically, they said that visitor comments lent the exhibition credibility and made it more trustworthy—it was obvious the museum wasn't trying to push any particular point of view.

The exhibition web site *(www.sciencemuseum.org.uk/antenna/nano/)* got high marks and still draws online visitors. Staff continue to produce small nanotechnology news exhibits, events, and web content for the museum's *Antenna* news area. The number of visitors recorded online show that this remains a popular subject.

Natasha Waterson is Contemporary Science project leader at the Science Museum, London, U.K.

Putting 'People First'

By Darrell Porcello

Nanotechnology is a multidisciplinary field that stands on the shoulders of complex findings in physics, chemistry, and biology. Museum educators who attempt to present the science behind nanotechnology are finding that a straightforward approach can be a tough sell, even to the most engaged of science center visitors. To create a comfortable and enticing entry point for the public, especially young children, exhibit developers at the University of California–Berkeley's Lawrence Hall of Science (LHS) focused on nanotechnology scientists as "people first" in our 2002 mixed-media exhibition *nanoZone.*

More than just a catchy slogan, "people first" represented the exhibition's goal of presenting researchers as a diverse set of real people—male and female, from different ethnic backgrounds—who share a common curiosity about the natural world. We wanted our audience to identify with the scientists associated with the exhibition. We knew from front-end evaluation that museum visitors are fascinated by the lives of scientists. But we also knew that our primary audience would be young children with their parents, or elementary school and middle school groups. It is not surprising that kids in this age range want to relate to other kids and learn more about activities they see other kids doing. We therefore decided to showcase the connections between what nanotechnology scientists study today and what they experienced as children to provide an entree into the rich scientific content of the exhibition.

Given the limited time our featured scientists had to be interviewed for the project, we strategically bundled in-depth biographical questions with specific content queries in each hour-long interview. Many times, the biographical questions served as effective icebreakers before more complex subjects were discussed. We relished all the youthful adventures and awkward adolescent moments we could charm out of our subjects with a relatively modest set of questions focusing on favorite childhood toys, inspiring role models, and early impressions of science.

The raw interviews with nanotechnology scientists served as source material for short, animated biographical vignettes that stretched from childhood to the present day. Although each animation concluded with cutting-edge science, such as ubiquitous computing, nanocrystal-infused solar cells, and nanowire-building viruses, all began with typical stories of kids falling off bicycles, taking apart telephones, and looking up to their parents. Using the art of storytelling, we tried to capture the essence of becoming a scientist, while showing kids that curiosity is a trait all people share.

The graphics and subject matter in the life stories were highlighted throughout the exhibition. This built-in redundancy helped the audience to connect abstract nanotechnology content back to specific scientists. With a stronger connection to real people, the content became more alive and exciting. Derivative exhibit components included robust interactive games, an artificial-intelligence question engine, quiz challenges, and baseball-like scientist "stat cards." Evaluation showed that the life stories were among the exhibition's most popular opportunities for engagement and learning. Today, the lessons learned from "people first" in *nanoZone* have been adapted in the creation of comics for public outreach at research centers and further LHS nanotechnology education projects.

Darrell Porcello is creative director of the Center of Technology Innovation at the Lawrence Hall of Science, University of California, Berkeley. To learn more about nanoZone, visit www.nanozone.org *or* www.exhibitfiles.org.

Nano for Children?

By Catherine McCarthy

Imagine trying to develop fun, interactive exhibits about a technology that is much too small to see and so complex that most adults don't understand it. Now, imagine doing it for kindergarteners.

That's the challenge we faced when the Sciencenter, Cornell University researchers, and the design firm Painted Universe Inc. undertook development of two National Science Foundation–funded traveling exhibitions on nanotechnology. The final products—*It's a Nano World: Smaller than a Spot on a Ladybug* and *Too Small to See: Zoom into Nanotechnology*—would provide visitors with an interactive, age-appropriate introduction to this complex topic. Both exhibitions debuted at Epcot in Florida, before going on national tour.

Designed for 5- to 8-year-olds and their families, the 3,000-square-foot *It's a Nano World* began traveling in 2003. Age-appropriate learning goals developed and tested for this exhibition included the ideas that amazing things happen

More nano exhibits . . .

The following is a sampling of design projects, ranging from activity carts to full exhibitions, that have opened since 2006 or are now in production. Together with the projects described elsewhere in this issue, they present a snapshot of current museum exhibits about nanoscience and nanotechnology.

The **Children's Museum of Houston** in Texas, with help from the mechanical engineering department at the University of Houston, has developed the *Matter Factory,* a new permanent exhibition about materials science. Its Super Small Matter Lab, a component developed with Rice University's Center for Biological and Environmental Nanotechnology (CBEN), will introduce visitors to what nano means, what is special about nano properties, and how scientists work with materials at the nanoscale. A prototype of *Matter Factory* is open; the final version is planned for March 2009.

La Cité des Sciences et de l'Industrie, Paris, recently hosted the first French traveling exhibition on nanotechnology. *Expo Nano* was co-produced by la Cité with the CCSTI Grenoble La Casemate and Cap Sciences, Bordeaux. Components include a "zoom"; hands-on exhibits on atomic bonds, Brownian motion, and hydrophobic lotus leaves; and the multimedia show *NanoJourney*. Potential risks to society and the ethics of use and misuse of nanotechnology are also presented. The exhibition will travel until 2011.

With funding from the Community Foundation of Northern Illinois and the Institute of Museum and Library Services, **Discovery Center Museum,** Rockford, Illinois, is developing kiosks on nanoscale science for local public library branches. Called "Feeling Your Way Through the Nano World," each kiosk will feature a 3-D model of a nanoscale image for visitors to identify, as well as books, pamphlets, and take-home activities. Partners include the Rockford Public Library, the University of Wisconsin–Madison, and Rockford-based Eigerlab. Installation of kiosks is scheduled for April 2008.

The **Franklin Institute,** Philadelphia, in partnership with the Penn State Materials Research Science and Engineering Center and the Cornell University Center for Materials Research, began creating a series of cart-based nano activities in 2000. The first set was distributed in 2002, and a third set will launch this year. The new set has three themes: Materials Matter explores the unusual behavior of materials like aerogels, shape-memory alloys, and polymers; Zoom in on Life focuses on body functions at the nanoscale, and structures like DNA, molecular motors, and cell membranes; and Small Wonders: Find the Nano in Your Life includes nanotechnology applications relevant to everyday life. All three sets have been offered to museums across the ASTC community.

Nanotechnology, a traveling exhibition developed by India's **National Council of Science Museums** (NCSM), opened at Bangalore's Visvesvaraya Industrial and Technological Museum in September 2006. A larger permanent exhibition is planned for the museum at a later date. *Nanotechnology* introduces nanoparticles, explores some of their unique properties, and discusses the potential of nanotechnology. Now touring India, the exhibition has already visited Kolkata and Guwahati.

Pacific Science Center, Seattle, Washington, is the home of "Nanopalooza: The Smallest Science Fair on Earth." This activity cart was developed by teen volunteers in the center's Discovery Corps Program, with a grant from AAAS and in collaboration with the University of Washington. Facilitated by a science interpreter and aimed at general audiences, the cart's activities have been tested over the past year and will be featured when the science center hosts the *Strange Matter (www.strangematterexhibit.com)* exhibition in 2008.

In October 2007, Missouri's **Saint Louis Science Center** opened a new NanoTechnology Center in its *Cyberville* gallery. Visitors can learn about nanotechnology basics and regional research and public policy issues through media, exhibits, hands-on activities, staff-led demonstrations, and presentations by local researchers. A flexible infrastructure will support new exhibits and program materials. This project was partially funded by the *Nanotechnology: Convergence of Science and Society* grant, a collaboration among Oregon Public Broadcasting, AAAS, and seven science centers.

Among the upgrades currently planned for **Sony Wonder Technology Lab** in New York City is a dedicated nanotechnology area. Exhibits here will demonstrate applications and uses of nanotechnology and show how nano will affect people in their everyday lives. The newly designed exhibits are scheduled to open in late 2008. ■

Compiled by Margaret Glass, NISE Net Communications Coordinator, ASTC. Our thanks to Michael Bowers (Pacific Science Center), Jayatri Das (The Franklin Institute), Corrine Doron (Sony Wonder Technology Lab), Sunil Kumar (Visvesvaraya Industrial and Technological Museum), Keith Ostfeld (Children's Museum of Houston), Mike Rathbun (Discovery Center Museum), and Christine Roman (Saint Louis Science Center). Details about many of these projects are available at www.exhibitfiles.org.

Mint or bubble gum? A visitor discovers that molecules can be too small to see but not too small to smell. *Photo © Garry Hodges, www.jonreis.com/courtesy Sciencenter*

that are too small to see with just your eyes; that scientists and kids can use tools to observe these small things; that there are many small things within my own body; that all living things are made of cells; and that "nano" refers to things that are very, very small.

Larger (5,000 square feet) and designed for an audience of 8- to 13-year-olds, *Too Small to See* began traveling in 2006. Its key concepts are more sophisticated. We hope visitors will come away knowing that all things are made of atoms, that atoms bond together to form molecules, that atoms and molecules are always moving, that there are 1 billion nanometers in a meter, and that nanotechnology is the making of new materials and tiny devices smaller than 100 nanometers in size.

How did we determine what would work in our two exhibitions? The most important lessons came from the front-end and formative evaluations. These consisted of focus groups, surveys, and interviews with teachers, children (5–8 years and 8–13 years), adults, and scientists, conducted in New York and Florida at schools, museums, and non-museum locations, such as malls.

The front-end work gave us useful information right away. We learned that

• children find it difficult to understand scale, and teachers find it difficult to teach scale;

• the smallest objects most young children can think of are things like an ant, a penny, a grain of sand, or dust (not a cell, a molecule, or an atom);

• children have difficulty learning about things too small to see or experience directly; and

• visitors have limited vocabulary and knowledge, as well as misconceptions, about the microscale and the nanoscale. For example, many know a bit about what DNA is, but don't know its relative size or how it works.

An iterative process of formative evaluation allowed our team to revise learning goals and prototypes repeatedly to ensure that concepts we chose were appropriate for target audiences. It also meant we had to let go of promising ideas that were simply too obscure for most visitors to comprehend or that required too many levels of abstraction.

Summative evaluation reports conducted by Edu Inc. for both exhibitions can be found at *www.itsananoworld.org* and *www.toosmalltosee.org,* or at *www.exhibitfiles.org.* For those looking to develop their own nanotechnology exhibits, here are some recommendations based on the overall evaluations:

• *Know your audience and design for their interests and knowledge.* Refer to the nanotechnology applications that interest people the most (e.g., medical advances and tech gadgets). Relate content to visitors' own bodies (our visitors can explore their skin, hair, and clothing with a handheld video microscope) and to familiar objects (e.g., butterfly, penny, salt).

• *Don't focus on the numbers.* Provide an orientation to relative scale by stair-stepping or zooming down in size. Use sensory experiences to allow visitors to explore microscopic things (e.g., smelling molecules that are too small to see; feeling tactile molecular models). Use beautiful, colorful images for things invisible to the eye.

• *Keep it simple.* Use clear language and a limited vocabulary. Repeat and reinforce key concepts and vocabulary. ■

Catherine McCarthy is grant projects director at the Sciencenter, Ithaca, New York.

NanoDays: A Week of Public Outreach

By Susan Koch

As part of its public outreach effort, the NISE Net project has chosen March 29 through April 6, 2008, for its inaugural NanoDays event, a weeklong festival of community-based educational outreach designed to raise public awareness of nanoscale science and engineering. NISE Net is providing a kit of basic materials to support planning of NanoDays events in communities across the United States. Our web site, *www.nisenet.org,* is a resource for many more participants than the kits will reach. The events themselves will be coordinated locally by informal science education institutions (ISEs), research centers, and other community partners.

This first of what we hope will become an annual celebration will be a prototype, intended to answer the following questions:

• Will U.S. ISEs and research centers conduct nano public outreach events using their own resources if NISE Net facilitates and supports the planning, presentation, and documentation of those events?

• What kinds of partnerships support or grow up around these events?

• What kinds of public events do communities conduct? What works about those events, and what could we do better next time? What would the communities like to do next time?

• What are the best and most cost-effective strategies for supporting the planning, presentation, and documentation of local NanoDays?

A prototype NanoDays kit was displayed in the ASTC Resource Center at the 2007 ASTC Annual Conference in Los Angeles last October. Completed kits are being distributed this January to approximately 100 ISEs, research centers, and community partners. Each contains a printed planning workbook, supplies and instructions for six nano tabletop demos, marketing materials, six books about nano, and miscellaneous program guides.

Although no more kits will be available, NanoDays planning and marketing materials can be found online at the NISE Net site. Site visitors can see what other institutions are planning and read comments from museums that have done nano outreach in prior years. Following NanoDays 2008, documentation of all events held will appear on the web site, and evaluation and self-reported results from this initial effort will be used to improve planning and support strategies for future events. For more information, or if your institution is interested in holding a NanoDays event, write to nanodays@nisenet.org. ■

Susan Koch was manager of exhibit programs at the Science Museum of Minnesota, St. Paul, until November 2007. NanoDays is now being managed by Karen Pollard.

Resources for Nanoscale Science and Technology Learning

Readings

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• Rejeski, David. "Hey, Have You Heard About Nanotechnology? Improve Nanotech Awareness through a Word-of-Mouth Campaign." *Nanotechnology Now,* September 17, 2007. Accessed 21 November 2007 at *www.nanotechnow.com/columns/.*

Web sites

• **Center for Nanotechnology in Society at Arizona State University (CNS–ASU):** *http://cns.asu.edu*
One of two centers (the other is at the UC–Santa Barbara) funded by NSF to study nanotechnology in society.
• **Cordis Nanotechnology:** *www.cordis.lu/nanotechnology*
A web service that provides an overview of nanotechnology-related activities at the European Commission.
• **Foresight Nanotech Institute:** *www.foresight.org*
This think tank and public interest institute on nanotechnology focuses on guiding research, public policy, and education.
• **Nanooze:** *www.nanooze.org*
An NSF-funded online magazine for kids, produced by the National Nanoscale Infrastructure Network and the Cornell Nanoscale Science and Technology Facility.
• **Nanoscale Informal Science Education Network:** *www.nisenet.org*
A clearinghouse for the work of NISE Net partners and more.
• **NanoEd Resource Portal:** *www.nanoed.org*
Web site of the NSF-funded National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT).
• **National Nanotechnology Initiative (NNI):** *www.nano.gov*
A multi-agency U.S. government program that coordinates research, facilitates technology transfer, develops educational resources, supports infrastructure and tools, and encourages responsible development.
• **Project on Emerging Nanotechnologies:** *www.nanotechproject.org*
A partnership between the Woodrow Wilson International Center for Scholars and the Pew Charitable Trusts that collaborates with researchers, government, industry, NGOs, policymakers, and others to look at nano in the long term and identify gaps in knowledge and regulatory processes.
• **The NanoHub:** *www.nanoHUB.org*
Under "Resources," click on "Online Presentations" to access voice-over PowerPoint presentations on nano topics.
• **Small Talk:** *www.smalltalk.org.uk*
A collaboration among the Royal Institution, the BA, Ecsite-UK, and Think-Lab that offers guidelines for public dialogue; links to reviews of events and debates; and a collection of web resources.
• **University of Wisconsin–Madison, Internships in Public Science Education:** *http://mrsec.wisc.edu/Edetc/IPSE/about*
A museum-university collaboration, IPSE emphasizes professional development in science communication and interdisciplinary interaction.—*Compiled by Margaret*

By Carolyn Sutterfield

Shared Visions: ASTC 2007 in Los Angeles

Every conference has at least one signature event. For the 2007 ASTC Annual Conference in Los Angeles, it would be hard to choose. Was it the night "on the beach" at the California Science Center, complete with lifeguards, sand, and the danceable contemporary covers of L.A.'s retro Antics? Or was it the lively exchanges between Disney Imagineer extraordinaire Marty Sklar and feisty science fiction master Ray Bradbury?

Perhaps it was Harlem Children's Zone president Geoffrey Canada's passionate challenge to science centers to "engage parents as partners ... and create a continuum of support for children." Or the stunning images and hard-hitting statistics offered by the POLAR-PALOOZA scientists. Or maybe it was the informal Q&A session with Jamie Hyneman and Adam Savage that seemed to please the MythBusters as much as it did their fans.

You probably have your own favorite. What's certain is that, even under cool and cloudy skies, Los Angeles lived up to its advance billing as a world-class venue and justified the new records set in conference attendance and Exhibit Hall bookings. Our thanks to Jeff Rudolph and the rest of the hard-working California Science Center team for partnering with ASTC to make this one of the most successful conferences ever.

In all, 1,933 registrants from 33 countries participated in ASTC 2007, with the largest non-U.S. delegations coming from Canada (72), the United Kingdom (30), and Mexico (19). In our biggest Exhibit Hall ever, 176 vendors filled 217 booths with the latest in informal science education products and services. And in more than 150 sessions, delegates explored topics from subzero science to storytelling, from visions of the universe to the science of the infinitely small, and forged new friendships and promising partnerships.

If you missed a session you had

planned to attend or want to revisit a particular discussion, head to the Convention Recordings International web site, *www.conventionrecordings.com,* and click on "Conference Listings" to view available recordings. Individual sessions are $20 each; a complete set of recorded sessions in MP3 format is $149.

Taking care of business

Official business was neatly tucked into Saturday's opening program, as outgoing ASTC president Wit Ostrenko, MOSI, introduced ASTC's board of directors and announced the results of this year's board elections.

Taking over as ASTC president is Lesley Lewis, director general of the Ontario Science Centre, Toronto, Canada. Lewis and her institution will also host the 5th Science Centre World Congress this June. Other members of the new executive committee include vice president Bryce Seidl, Pacific Science Center; secretary/treasurer Nancy Stueber, OMSI; member-at-large Tuan Chiong Chew, Singapore Science Centre; and now past-president Ostrenko. One new director—David Chesebrough of COSI Columbus—was elected to the board, and two current members—Eric Jolly, Science Museum of Minnesota, and Mary Sellers, Science Center of Iowa—were reelected to three-year terms.

In her final report as secretary/treasurer, Lewis relayed the 2007 auditors' comment that "ASTC could not be more healthy." The association's 578 members worldwide include 442 science centers and museums, of which 68 have qualified as Governing Members. Grant support is up, most notably with a $5 million grant from the National Science Foundation for the new Center for Advancement of Informal Science Education (CAISE), and ASTC has an invested reserve of more than one year's core operating expenses.

Plaudits for Pelle

At the board's discretion, ASTC presents its highest honor, the Fellow Award for Outstanding Contribution, to an individual who merits "special recognition for significant contributions to the advancement of public understanding of science and technology or to ASTC itself." At ASTC 2007, the association so honored Per-Edvin "Pelle" Persson, director of Heureka, the Finnish Science Centre, in Vantaa, Finland.

Per-Edvin "Pelle" Persson accepts the 2007 ASTC Fellow Award. *Photo © Lee Salem Photography Inc.*

Trained as a limnologist, Persson served as director of the Federation of Finnish Scientific Societies before moving to the science center field. He began as director of science at Heureka in 1987 and took over leadership in 1991. Under his guidance, the science center hosted the 1st Science Centre World Congress in 1998. Persson was one of the first presidents of Ecsite, the European science center network, and served as ASTC president in 2004–2005.

The citation this year praised Persson "for joining an unwavering belief in sound science with a truly global vision for the science center field" and for his tireless travels on behalf of ASTC and its members. In his acceptance, Persson spoke of science centers' capacity and responsibility to touch minds and inspire learning. "We need to spread the voice of reason—to advance knowledge for the good of humankind, for a healthier planet, for a more prosperous future for our children," he said. "Only by working together can we succeed."

Six 'Edgies' Awarded

Four ASTC-member organizations and two science center professionals were recognized with Roy L. Shafer Leading Edge Awards at Saturday's annual banquet. Now in their third year, the "Edgies" recognize both small and large ASTC members and/or their employees for extraordinary accomplishments in Visitor Experience, Business Practice, and Leadership in the Field during the past three years. Winners receive an etched glass award and a paid registration to the next ASTC conference.

Jury member Emily Fox, CEO of Discovery Center of Springfield, presented the Leading Edge Award for Business Practice (Large Institution) to EdVenture Children's Museum, Columbia, South Carolina, for its

Calendar

FEBRUARY

17–23 **National Engineers Week (U.S.)** "Engineers Make a World of Difference." ***Details:*** www.eweek.org

APRIL

8–12 **Museums and the Web 2008.** Montreal, Quebec, Canada. ***Details:*** www.archimuse.com/conferences

24–26 **Interactivity 2008.** "Let's Play!" Annual meeting of the Association of Children's Museums. Denver, Colorado. ***Details:*** www.childrensmuseums.org

27–May 1 **American Association of Museums Annual Meeting.** "Leadership: An Open Mic for New Ideas." Denver, Colorado. ***Details:*** www.aam-us.org

MAY

29–31 **Ecsite Annual Conference 2008.** Hosted by the Hungarian Natural History Museum, Budapest. ***Details:*** www.ecsite-conference.net

JUNE

15–19 **5th Science Centre World Congress.** Hosted by the Ontario Science Centre, Toronto, Canada. ***Details:*** www.5scwc.org

ASTC Notes

Silvia Singer, left, with members of her MIDE team show off their Roy L. Shafer Leading Edge Award for Visitor Experience. *Photo © Lee Salem Photography Inc.*

Afterschool Initiative. With four distinct programs—Club EdVenture, Enrichment Field Studies, Future Leaders, and Science Jam—the initiative has not only boosted attendance (15,000 additional youth participants per year) but also become a net revenue source, with annual income exceeding $200,000.

The three recipients for Visitor Experience were announced by jury member Alan Nursall, of NEXT Exhibits + Creative Communication. In the Small Institution category, the winner was the Clore Garden of Science, in Rehovot, Israel, for its Eco-Sphere, a geodesic glass structure in which visitors can experience and explore environmental phenomena through hands-on experiments.

In the Large Institution category, the jury gave two Visitor Experience awards. MIDE, Museo Interactivo de Economía, Mexico City, Mexico, won for pioneering an interactive museum in which economics, science, history, architecture, and art meet. Opened in July 2006, in a restored 18th-century convent, MIDE invites visitors to discover and discuss both basic economic concepts and complex social issues. The museum's Market Simulator, created with Magian Design Studio, won AAM's 2007 Gold Muse Award for Interpretive Interactive Installations.

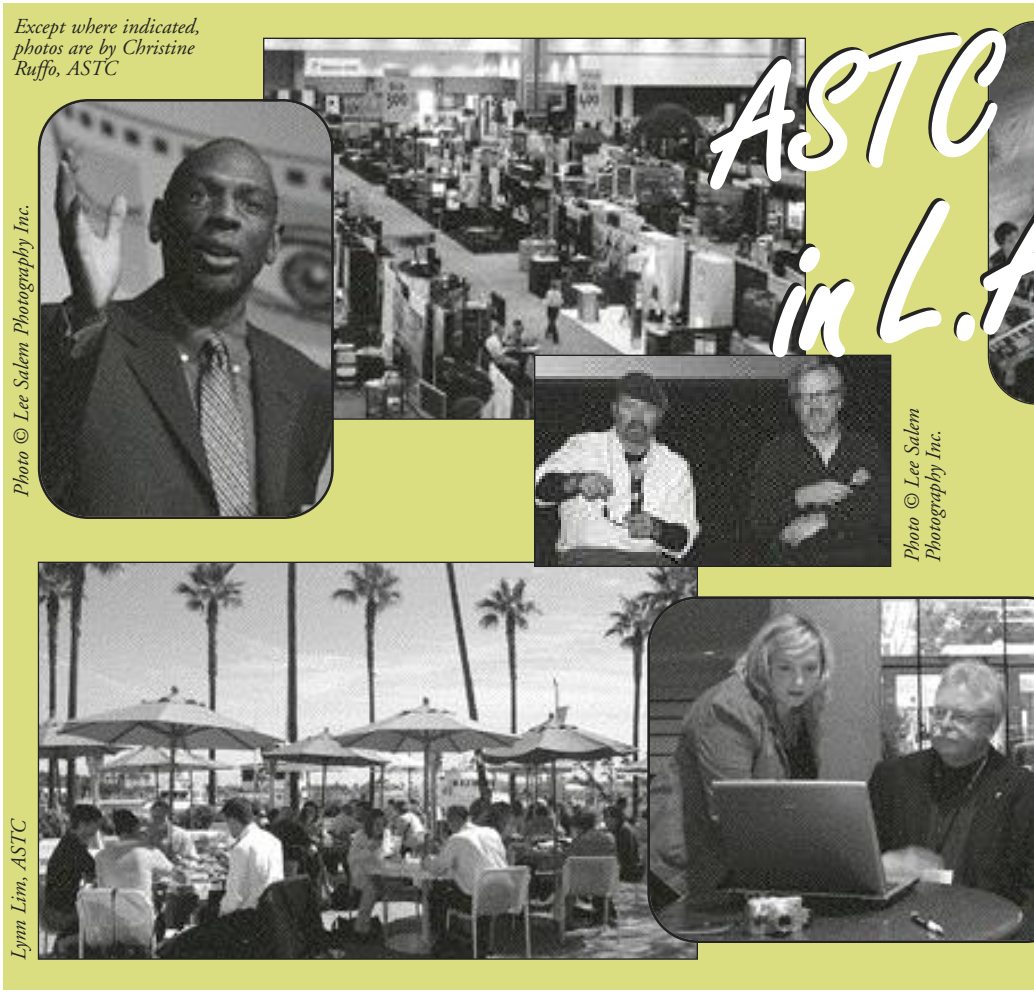
OMSI, in Portland, Oregon, received an Experience "Edgie" for partnering with libraries through the NASA-funded STARS (Science, Technology, and Rural Students) project to provide underserved rural communities with access to high-quality science education. STARS has offered workshops to more than 240 teachers, librarians, and administrators in 18 counties and brought OMSI's portable planetarium to nearly 50 communities.

Jury chair Dennis Schatz, vice president of education at the Pacific Science Center, presented the two Leading Edge Awards for Leadership in the Field. The recipient for New Leadership was George Sparks, president and CEO of Colorado's Denver Museum of Nature & Science since November 2004. Sparks has worked closely with staff to engage DMNS in new community partnerships, attract and retain a diverse workforce, and make the museum more attractive and accessible.

Jane Werner, executive director of the Children's Museum of Pittsburgh since 1999, received the Experienced Leadership in the Field award. Werner not only led the museum through a $28 million capital campaign that culminated in the grand reopening of their LEED-certified expanded facility in 2004; she also linked local cultural and educational groups by inviting organizations like Reading is FUNdamental Pittsburgh and the Public Schools Head Start/Preschool Program to move into the building with the museum.

ASTC extends congratulations to all 2007 winners and sincere thanks to the awards jury. Besides Fox, Nursall, and Schatz, members included Julie Johnson, Science Museum of Minnesota; David Leverton, TELUS World of Science–Edmonton; and Charlie Trautmann, Sciencenter. Kudos also to the governing member sponsors of the awards: the Franklin Institute; Heureka, the Finnish Science Centre; Pacific Science Center; Singapore Science Centre; and Technopolis, the Flemish Science Centre.

Guidelines and nomination forms for the 2008 "Edgies" are available online (*www.astc.org/about/awards/*



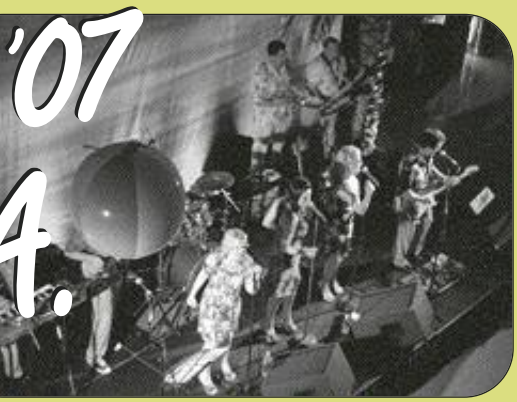
leading_edge.htm). The application deadline is March 28, 2008. For more information, contact ASTC membership director Diane Frendak, 202/783-7200 x112; dfrendak@astc.org.

IGLO in L.A.

Prominently featured in this year's program were a number of events and sessions associated with ASTC's International Action on Global Warming initiative. On Friday, more than 50 attendees gathered for a full-day workshop sponsored by IGLO and ably hosted by the Aquarium of the Pacific, Long Beach. Featured speakers included retired Navy vice admiral and current NOAA administrator Conrad C. Lautenbacher; Waleed Abdalati, head of the Cryospheric Sciences Branch at NASA's Goddard Space Flight Center; and NOAA meteorologist Keith W. Dixon, of the Geophysical Fluid Dynamics Laboratory at Princeton University.

Two Saturday sessions, "Global Warming: From Uncertainty to Action" and "How Do We Know What We Know about Earth's Climate?" kept the conversation going. On Saturday evening, attendees at the annual banquet were treated to a preview performance of POLARPALOOZA: *Stories from a Changing Planet.* Hosted by *New York Times* science reporter Andy Revkin and featuring Abdalati, polar engineer Alberto Behar, exobiologist Darlene Lim, and oceanographer Stephanie Pfirman, this NSF- and NASA-funded multimedia presentation will travel to U.S. science centers and museums through 2009.

In Sunday's "Storytelling for the International Polar Year," oceanographer turned storyteller Kendall Haven explained how to make a story stick. And on Monday, Lesley Chilcott and Davis Guggenheim, producer and director respectively of the Oscar-winning film *An Inconvenient Truth,* talked about the challenge of translating scientific evidence into a compelling narrative. ASTC presented the two with awards commending their contribution to public understanding of the science behind global warming.



Memorable moments at ASTC 2007 included (clockwise from far left) Geoffrey Canada's keynote, a record-setting Exhibit Hall, the dance party at the California Science Center, the annual Live Demo Hour, Tuesday's closing reception, the science-rich POLARPALOOZA show, an ExhibitFiles tutorial, the IGLO workshop at the Aquarium of the Pacific, and question time with the Myth-

Photo © Lee Salem Photography Inc.

To the founders of the feast

Finally, our thanks to the 53 sponsors who generously supported ASTC 2007—particularly our California sponsors, who brought an abundance of that for which L.A. is famous: celebrities, the moving image, technical expertise, and more. Total contributions, in cash and in kind, came to $215,000, with $55,000 of that raised by the California Science Center.

Major sponsors included the Annenberg Foundation (Gold Partner); AMX and PPI Consulting, Edwards Technologies Inc., Panasonic, E&S Spitz, and Sodexho (Emerald partners); Turquoise sponsor SurveyWorks; and Jade sponsors Ansel Associates Inc., CineMuse Network, Electrosonic, Gyroscope Inc., Jeff Kennedy Associates, K2 Communications, Lexington, National Geographic, Sennheiser, Thinkwell Design and Production, and VISTA–A Ticketmaster product.

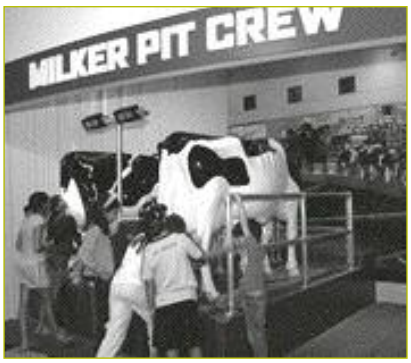
To them and to the many other sponsors of ASTC 2007, we offer our sincere gratitude.

On to Philly

Looking ahead, we anticipate another record turnout in Philadelphia, Pennsylvania, for the 2008 ASTC Annual Conference, October 18–21. The theme is "In the Public Eye: Science Centers at the Crossroads of Science and Culture." Fittingly enough, in the city where Benjamin Franklin helped launch the American Philosophical Society, with the aim of sharing useful knowledge and undertaking "all philosophical Experiments that let Light into the Nature of Things," our host will be the Franklin Institute Science Museum. Together, we'll explore research in learning, public policy and controversial issues, innovative leadership, and many other aspects of "civic science." Please plan to join us. ■

Spotlights

By Christine Ruffo



Visitors test their milking skills at *Farm Tech.* *Courtesy Museum of Science and Industry*

FARM FORWARD—Things have changed down on the farm. In the seven years since the **Museum of Science and Industry,** Chicago, Illinois, opened its permanent exhibition *The Farm,* the agriculture industry has developed many technologies to make the food we eat healthier, fresher, and more abundant. In August, the museum updated the 4,000-square-foot exhibition and renamed it *Farm Tech,* to emphasize the role that technology plays on today's large farms.

Visitors begin their exploration at a dairy farm. After discovering how robotic milking technology makes it possible for nearby farms to milk more than 15,000 cows per day, they can join the Milker Pit Crew and test their own milking skills. Poop to Power reveals how the waste produced by all those cows can be converted to methane to help power farms, and a nearby hog shed demonstrates how technology helps farmers to raise healthy pigs, with automated feeders to keep them lean and biosecurity methods to help prevent disease.

Not Your Father's Tractor features a tractor and combine—popular attractions from the original exhibition, but this equipment has been updated with on-board navigational computers to control steering and Global Positioning Systems that can track exact positions in the field and gather data during planting and harvesting. A computer simulation here allows visitors to "plant" and "harvest" their own crops.

Other exhibits focus on specific crops. A film shows how corn goes from harvest to corn syrup, ethanol, and animal feed. In the kitchen, an exhibit reveals the role of soybeans in many household products. Finally, visitors can step into the greenhouse to learn about biotechnology and see how farmers and scientists are trying to improve crops by creating plant hybrids, farming organically, and using hydroponics.

Major funding for the exhibition was provided by Deere & Company, the Illinois Farm Bureau, and Fair Oaks Farms.

Details: Lisa Miner, director of public relations, lisa.miner@msichicago.org

Turning the wheel generates a watt of energy. *Photo courtesy Reuben H. Fleet Science Center*

POWER UP—Where does (or should) electricity come from? *So Watt! An Illuminating Look at Energy,* a new 500-square-foot permanent exhibition at the **Reuben H. Fleet Science Center,** San Diego, California, invites visitors to explore electricity production, alternative sources of energy, and basic conservation strategies. The bilingual exhibition (English and Spanish) is presented in five sections.

Visitors start from scratch in *Make a Watt*, turning a crank to learn exactly how much energy it takes to create one watt. At *Watt's the Difference?,* they can learn about the pros and cons of the six most common sources of electricity—fossil fuels, nuclear, hydroelectric, geothermal, wind, and solar— and then find out where most of California's power comes from. Visitors can also drop coins into clear tubes to vote for the energy source they think should be used most for generating electricity in the next 20 years.

Watt's in the Sun? puts guests in the role of solar engineers as they adjust a small photovoltaic (PV) panel, lining it up with a light source to create enough electricity to power a small fan. Afterwards, they can use an interactive touchscreen in *Watt's on the Roof?* to investigate real-time and historical data on how much electricity is produced by the science center's own 10,000-square-foot rooftop PV system. Finally, *Watt about Me?* demonstrates a variety of simple ways to conserve electricity at home and at work. By flipping switches on a scale model of a "typical house," visitors can observe how energy consumption changes as they implement various conservation measures.

Funding for the $110,000 exhibition was provided by grants from San Diego Gas & Electric (SDG&E), Shell Trading, and the Kenneth T. and Eileen L. Norris Foundation. The rooftop PV system is owned and operated by SDG&E.

Details: Jeremy L. Pyle, public relations manager, jpyle@rhfleet.org

SKIES AND SEAS—On October 7, **Catawba Science Center,** Hickory, North Carolina, opened its renovated 14,000-square-foot CSC Planetarium Building, expanding the center's program and exhibition space by 50 percent. The facility is not only home to the new Milholland Planetarium; it also invites visitors to explore worlds nearby through six permanent aquarium exhibits.

The journey begins with a look at local waterways. Two walkthrough exhibits allow visitors to explore the banks of the Catawba River, with its snakes and painted turtles, and Lake Hickory, home to catfish, bass, and walleye fish. Next, visitors travel to Coastal North Carolina, where they can touch horseshoe crabs, conchs, and sea stars as they learn about coastal environments. Another nearby touch tank holds stingrays and nurse sharks, inhabitants of the ocean waters off the southeastern U.S. coast. Finally, two Wall of Life exhibits, one saltwater and one freshwater, each feature four aquaria filled with creatures from around the world.

Not to be outdone, the new 65-seat planetarium features full-dome digital technology that can simulate up to 140,000 stars as seen from any planet

A young visitor touches a ray in Catawba's new aquarium exhibition. *Photo courtesy Catawba Science Center*

or star at the edge of the Milky Way, at any time from 500,000 years into the past to 500,000 years into the future. Regular programming will also include live looks at the Catawba sky.

The $3.8 million expansion also includes 2,400 square feet of temporary exhibit space; an Inventor's Workshop, where visitors can tinker with robots, circuits, and simple machines; and a special events area. Funding for the project was raised through the museum's Touch the Future capital campaign.

Details: Mary Katherine Creel, marketing coordinator, marketing@catawbascience.org

OCEAN VOYAGE—How is technology used on the high seas? A new 7,500-square-foot traveling exhibition at **Heureka, the Finnish Science Centre,** in Vantaa, Finland, invites visitors to explore both the history of seafaring and modern technologies used by the shipping industry today. Comprising 30 interactive exhibits, *Ships and the Sea* features five themed areas.

In Ships, visitors become acquainted with the vessels themselves. Options include using miniature boats and fans to test principles of sailing, rocking a ship to see how its anti-rolling system works, and teaming up with a partner to start a ship's engine.

Man Overboard allows visitors to experience what it's like to rescue and be rescued at sea. A computer simulation puts users in the driver's seat of a rescue boat searching for a lost sailor. In an adjacent exhibit, roles are reversed, as visitors try to climb out of a blue ball pit into a real rescue raft.

Navigation demonstrates that traffic rules and instructions are as important on the water, as they are on roads. At Port Heureka, a 750-square-foot pool, guests can guide remote-controlled ships along a marked lane to transport cargo from one port to another.

Harbors connects visitors to ports around the world, providing real-time information on maritime traffic in the Gulf of Finland, the English Channel, Houston, and Singapore. Visitors can also sit inside the cabin of an actual "reachstacker" (a large forklift) and use a computer simulator to move cargo-filled sea containers.

Finally, Seafarers shows how the life of a sailor has changed over time. Peering into portholes at historic and modern-day scenes, visitors can compare current onboard working conditions to those 100 years ago. In a nearby seamen's pub, a jukebox plays seafaring tales and songs.

Ships and the Sea will remain at Heureka through January 2009 and then tour other museums through 2012. The € 1.3 million ($1.9 million) exhibition is sponsored by 20 Finnish marine companies and associations.

Details: Mikko Myllykoski, experience director, mmyl@heureka.fi

Visitors to *Ships and the Sea* guide remote-controlled vessels across a 750-square-foot pool. *Photo courtesy Heureka Image Bank*

Grants & Awards

The **Oregon Museum of Science and Industry** (OMSI), Portland, is one of five museums to receive a 2007 National Medal for Museum and Library Service from the (U.S.) Institute of Museum and Library Services. Given also to five libraries each year, the award is the nation's highest honor for these cultural institutions. Honorees receive a newly minted medal and a $10,000 prize at a special ceremony in Washington, D.C.

• The **Boston Children's Museum,** Boston, Massachusetts, received $423,214 under the Institute of Museum and Library Services' 21st Century Museum Professionals grant program for a partnership with the Chicago Children's Museum to incorporate family learning research into staff training. Matching funds are required.

• The **New York Hall of Science,** Queens, along with two partners—the **Visvesvaraya Industrial and Technological Museum,** Bangalore, India, and the **National Council of Science Museums** (NCSM) of India—was awarded funding from the American Association of Museums' 2007 Museums & Community Collaborations Abroad (MCCA) competition. The grant ($60,000, with matching funds required) will enable the partners to adapt the New York Hall's Science Career Ladder program for use in Indian museums and fund outreach programs for visiting staff from partner nations.

• The **Shenandoah Valley Discovery Museum,** Winchester, Virginia, received $500,000 from Frederick County toward construction of its new facility in Jim Barnett Park, bringing the campaign total so far to $6.1 million. The new building will feature and highlight sustainable elements, including a sod roof, photovoltaic cells, and cellulose insulation.

• The **Lawrence Hall of Science** (LHS), at the University of California–Berkeley, is one of five recipients of a 2007 Environmental Literacy grant from the National Oceanic and Atmospheric Administration (NOAA). LHS received $709,992 for its "Ocean Sciences" curriculum sequence for grades 3–5.

• New Hampshire's **Children's Museum of Portsmouth** has received a $25,000 grant from the Otto Fund, an advised fund of the New Hampshire Charitable Foundation. The money will provide capacity-building support for the museum, which hosts 97,000 visitors a year.

• The Verizon Foundation has awarded **MOSI,** Tampa, Florida, $20,000 to fund a new outreach program, "Blast Off with Science," intended to expose students from Title I schools to potential careers in physics and aerospace.

People

The new director of the Science Museum of Virginia, Richmond, is **Richard Conti.** As executive director of Nauticus, in Norfolk, Virginia, for the past 10 years, Conti led the effort to create a new $36 million mixed-use cruise terminal and meeting center for the city; to date, the facility has brought more than 475,000 cruise passengers to Norfolk (many of them to the museum as well). He succeeds second SMV director emeritus **Walter R.T. Witschey,** who retired last July and now teaches at Longwood University.

Joan Stephens Hadly is the new senior vice president for advancement at the Museum of Science, Boston. A longtime administrator and fundraiser in academic medicine and community hospitals, Hadly was most recently campaign director of the Cape Cod Healthcare Foundation.

The Science Museum of Minnesota, St. Paul, has added **James Fairman** to its management team as vice president of the science division. A chemist, inventor, and entrepreneur, Fairman previously founded and served as president of Pando Technologies, a Bloomington, Minnesota firm that specializes in technology consulting and product development.

TELUS World of Science–Calgary, in Canada's Alberta province, announced the appointment of **Jennifer Martin** as vice president, programs and operations, effective October 9, 2007. Martin was previously director of visitor experience at the Ontario Science Centre, Toronto, where she played a major role in the $47 million *Agents of Change* initiative. Her position is a new one for the Calgary science center, which is planning to open a new facility in 2011.

The Great Lakes Planetarium Association (GLPA) has elected **John Schroer,** planetarium education coordinator at Michigan's Detroit Science Center, to a two-year term as GLPA president.

We were saddened to learn of the death in late October of **Bob Miller,** artist, scientist, educator, and a pioneering contributor to San Francisco's Exploratorium. He was 72. Light, color, and perception were Miller's chosen subject matter; he created the museum's luminous Sun Painting exhibit and was famous for his inquiry-based Light Walk excursions. For more on Miller and a photo of the Sun Painting, visit *http://exhibitfiles.org/sun_painting.*

ASTC recently welcomed two new staff members. **Lynn Lim** is project communication coordinator for ASTC's International Action on Global Warming (IGLO) initiative; she was previously an account manager with Griffin & Company Inc., a Washington, D.C. marketing/public relations firm. Joining us as staff accountant is **Binaya Dhakal.** A native of Nepal, Binaya worked previously for the Australian Trade Commission and Danish International Development Assistance (DANIDA). ■

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