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Hearing on Nanotechnology Education

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Mr. Chairman, Ranking Member Ehlers, and Members of the Subcommittee, thank you for inviting me to testify today about the ways in which nanotechnology education can help inspire people to pursue careers in science, the importance of nanotechnology as an element of a twenty-first century science education, and the key role of informal education in this process.

I serve on the staff of the Oregon Museum of Science and Industry (OMSI)—a non-profit, independent, scientific, educational, and cultural resource center dedicated to improving the public's understanding of science and technology. Founded in 1944, OMSI is considered one of the top ten science centers in the United States and has earned an international reputation in science education. Its facilities include a 219,000-square-foot museum featuring five exhibit halls, eight hands-on public labs, a planetarium, an OMNIMAX theatre, and the USS *Blueback* submarine. OMSI also offers a wide range of educational and outreach programming, including residential camps, summer classes, museum camp-ins, after-school science clubs, and traveling programs that deliver hands-on experiences to communities throughout Oregon and six other western states. In addition, OMSI provides professional development opportunities for K–12 teachers, including workshops, a science teaching resource center, and distance-learning programs targeted at educators in rural communities.

The Teacher Education Department at OMSI is uniquely positioned to provide teacher professional development programs in Science, Technology, Engineering, and Math (STEM) education throughout the northwest. Distance education technology, supporting delivery of professional development, allows OMSI to contribute our five decades of science education experience to a national and even international audience through live videoconferences and on-line, on-demand server-based programs. Currently, this type of flexibility combined with a world-class facility and staff make OMSI a significant resource for teachers worldwide.

In 2003 OMSI began working with rural communities in Oregon to bring earth and space science programs to students, particularly those from K-8. Through partnerships with the Libraries of Eastern Oregon and the Oregon Department of Education we began establishing videoconferencing connections in schools and libraries in rural parts of the state. We have invested in professional development for K-8 teachers and librarians, community programs in science and technology, telecommunications infrastructure, and delivery of science and space science programs electronically and in-person to lifelong learners of all ages. We have also worked to develop our own curriculum focusing on issues of particular interest to students in the Pacific Northwest, and have worked to get scientists into the schools, in person and via videoconference links, to provide rural schools with advantages they would otherwise not see.

In 2006, approximately one million people enjoyed OMSI's innovative science education opportunities. In addition to a team of motivated and experienced science educators and demonstrators, OMSI employs a team of highly skilled and qualified exhibit and program developers, designers, evaluators, and fabricators.

OMSI is a leader in innovative science education and is always looking for opportunities to captivate our patrons' attention and to provide immersive, hands-on experiences. Nanotechnology is an important component of OMSI's educational mission in inspiring, informing, and exposing our visitors to cutting edge scientific research. The Nanotechnology in the Schools Act will help OMSI accomplish its goals, and we strongly support the bill.

I would like to respond to the questions you raised in your invitation to testify at this hearing. In the process, I believe it will become clear how helpful this legislation is to us and to other science museums.

1) **Please describe the nanoscale science and engineering educational activities the Oregon Museum of Science and Industry (OMSI) is engaged in and OMSI's role in the Nanoscale Informal Science Education Network.**

As a member of the Nanoscale Informal Science Education Network (NISE Net), OMSI is active in the development of exhibits and programs designed to inform the general public on the topic of nanoscale science and engineering. OMSI is also participating in the network's effort to develop recruitment and distribution plans to provide exhibits, programs, and professional development on nanotechnology to science museums across the United States.

NISE Net, currently beginning its third year, has as its goal to create a functioning network of 100 science and technology centers across the United States working together to present the nature and potential impacts of nanoscale science and engineering. This is a powerful vision and it is the largest collective effort across the field of science and technology centers to advance knowledge and understanding of a specific topic—nanotechnology.

OMSI is one of ten working partners on the NSF grant funded project under the leadership of the Museum of Science-Boston, The Exploratorium, and the Science Museum of Minnesota. Because the general public knows very little about nanoscale science and its applications, OMSI's approach, consistent with the other working partners of NISE Net, is to present nanoscale science and technology in a way that inspires wonder and motivates the user to seek more depth and understanding of the topic. As experiences within a science museum are largely self-directed and free choice—that is, museum guests move at their own pace, follow their own interests, and build on their prior knowledge—successful exhibits and programs must have a balanced mix of educational content and attracting or motivational elements. Evaluation and museum visitor studies of the work performed by NISE Net members indicate success in creating engaging experiences for the museum audience that build awareness of and provide context for science and engineering at the nanoscale.

One innovative area of focus of OMSI and the NISE Net is in the development of nanotechnology forums where participants are encouraged to discuss important economic, social, environmental, and ethical issues regarding emerging nanotechnologies. By creating an atmosphere where experts and lay persons can come together in conversation, a greater understanding of the social and scientific context for nanotechnology can be achieved. Two of these nanotechnology forums were held as part of OMSI's Science Pub series at which science is discussed in the informal setting of a local restaurant. Additional forums were held in Eugene and La Grande, Oregon, creating opportunity for people around the state to join in the discussion.

2) **Would H.R. 2436, the Nanotechnology in the Schools Act, be a beneficial resource for informal science education institutions? What priority should it be given relative to other kinds of support for informal science education activities? How would science museums integrate advanced equipment into their educational activities?**

H.R. 2436 will provide needed resources, educational materials, and professional development to assist informal science education institutions in presenting the concepts of nanotechnology to their audiences. Science and Technology centers are motivated to present emerging and cutting edge concepts in science and technology. It is inherent in our missions to strive to present the latest advancements and breakthroughs. Typically such concepts can be difficult to present to museum audiences—information and educational materials may not readily be available to the museum educator and exhibits and programs that have been tested and shown to be effective at communicating intended educational messages may not exist. Additionally, science museums are challenged by the wide demographic of people that visit. The level of knowledge and awareness on any particular science topic varies greatly among visitors. This challenge is amplified when referring to cutting edge topics. Often the approach of the science museum is to provide context and background information to help museum visitors begin to develop a conceptual framework of emerging concepts.

The NISE Net research has shown that most people who visit science museums know very little about nanotechnology. The concept of the scale involved alone is beyond the grasp of even many practicing scientists and engineers—as well as most museum education staff. H.R. 2436 provides resources for educational materials and training specific to nanotechnology. Without this type of support, it would be difficult for museums to introduce these concepts. However, once awareness and knowledge are established, it is more likely the museums will continue to maintain and increase coverage of the topic.

There is great need in the informal science industry for educational tools and equipment designed specifically for informal science learners. It is only recently that tools and equipment in the forms of exhibits, simulations, and educational props on the subject of nanotechnology have been developed and tested with museum educators and museum visitors. Nano is a difficult and abstract topic to tackle in the informal setting. Additional resources are needed to help our field advance new methods for creating context and relevance for our audiences.

3) What types of professional development opportunities are available to informal science educators? What types of programs would need to exist to ensure that these educators understand both the scientific concepts, as well as the equipment?

Professional development opportunities for Informal Science Education interpretive staff are not common in the science museum field. Where they do exist, they are typically in the form of institution specific programs, which often focus on content rather than interpretive skills. Professional development opportunities are available to science museum educators through Association of Science-Technology Centers (ASTC) sponsored programs that provide a forum for museum professionals to network, to expand their knowledge base, and to identify resources. However, relatively few science centers have the resources to provide these opportunities to their museum education staff. Cross-institutional programs also exist, such as the Exploratorium led ExNet and the Fort Worth Museum of Science and History led TexNet, which provide staff training as part of an exhibit rental program. Government agencies, such as NASA and NOAA, offer workshops, and the National Parks Service offers interpretive training, to name a few. Largely, opportunities for professional development are based on specific projects with associated funding opportunities. Nonetheless, these opportunities are rare in the field.

OMSI's research indicates that science centers value this training. In 2006, OMSI surveyed interpretive staff managers at 57 large science centers around the country. Eighty-nine percent of respondents indicated that they consider "exhibit content training" to be either "extremely valuable" or "very valuable."

In addition, research strongly indicates the value of skilled interpreters in enhancing the visitor's experience and learning in science exhibitions: "live interpretation can support a wider range of visitors and encourage social learning behaviors," especially when facilitators are trained to promote constructivist [the active building of knowledge and skills], self-directed learning (Marino and Koke, 2003).

Programs for ISE staff should be based on best practices and research on adult learning and successful professional development models (e.g., Ingvarson et al., 2005; Morrow, 2004; Loucks-Horsley et al., 2003; National Resource Council, 1996a, 1996b; Cunningham, 2004).

Based on a review of the relevant literature, OMSI identified five characteristics common to successful professional development:

- continuously improves based on evaluations of visitor learning/experience
- creates structure for long-term support and continued learning opportunities
- is based on current learning theory/best practices
- teaches content, pedagogy, and the skills to apply this knowledge
- involves active participation by trainees during development, implementation, and evaluation.

Providing for the training of museum staff regarding the nature of and issues related to nanotechnology is an important element to the success of nanotechnology education in museums. To this end, availability of effective training materials and access to science experts are critical. Innovative to H.R. 2436 is the potential for focused professional development for museum educators on the use of proven educational materials and exhibits on nanotechnology. OMSI would encourage the development of user communities—possibly in connection with NISE Net—that would provide connections across the science museum education field for sharing outcomes and improvements based on experiences and best practices in the use of proven educational tools and techniques.

4) How do informal science education centers decide which subject matter they will focus on? What resources do they use to help create exhibits and programming that matches content to the knowledge level and interest of the audience?

OMSI's process for the selection of educational topics to feature in the museum is based on input from museum visitors and science education experts—including science researchers, classroom science teachers, university professors, and science museum educators. This input informs the museum both on what the public wants to learn about and what science academia believes is important for the general public to know. Content and educational approaches are informed also by the relevant national and state science standards and benchmarks. This approach is similar to the approach of many science museums in the field.

In particular, OMSI typically conducts front-end research with visitors to the museum in advance of selecting or developing a topic. Through visitor surveys, in-depth interviews, and focus group studies, we begin to develop a profile of what people generally know on a topic, what their interests are, and what are likely to be effective points of entry into a topic.

Museum visitor research and evaluation continues through the development of exhibits and programs in the form of prototype testing. During this phase of development, early mock-ups of planned exhibits or programs are presented to a cross-section of museum visitors to begin to assess how effective the strategies are in communicating intended educational messages, how engaging the experiences are, and how intuitive, or easy to use or grasp, the activities are. Also during this phase, expert advisors and content specialists inform the accuracy of content and advocate for alignment with research and science standards—they help the development team figure out what is important to communicate.

As part of this ongoing process, OMSI has determined that nanotechnology is an important subject for our visitors to understand. This is partly because of the rapid rise in nanotechnology's relevance to the rest of the scientific world. In addition, it reflects our surroundings in the Portland area, where major electronics companies like Intel are operating at the nanoscale every day.

The front-end work within the NISE Net has shown that less than half of the adult population of the United States has heard of nanotechnology and less than 20% can provide some level of basic definition. However, the studies also show that the general public is interested in the topic and possesses a positive sense about nanotechnology.

5) Do science museums have resources to maintain advanced equipment?

Commonly, science museums come in three varieties: large, medium, and small—defined by size of budget, physical size, and number of staff. In general, the larger institutions in the science museum field will have full-time technical support staff to repair and maintain advanced equipment. Smaller institutions will not. Through user communities, there is a potential for smaller institutions to partner with other science museums, school districts, or other entities increasing their capacity to afford and maintain advanced equipment and provide advantages they would not normally be able to obtain on their own.

Regardless, it is important that materials for use in museum programs and exhibits be designed for and tested in the science museum setting. As a result of science museums striving to engage visitors by involving them directly in the activity or phenomenon being presented, it is necessary that exhibits and educational props and materials be engineered for repeat use by an inexpert audience. They must be designed for durability, low or easy maintenance, and intuitive or ease of use. It may not be the case that equipment or materials designed for use in research facilities can be used straight out of the box on the museum floor—museum exhibit and program, developers, designers, and fabricators recognize the unique environment of the science museum and this knowledge informs the design of successful museum experiences.

It is worth mentioning that technology advances, specifically in electronics and computers, have made it possible to successfully create higher technology experiences that nonetheless are considered to be durable and low maintenance in the museum environment—and therefore accessible to all science museums. Assuming the intent of the Nanotechnology in the Schools Act is geared toward durable and low maintenance equipment, I might suggest that a maintenance provision be added to the bill to better enable institutions to take advantage of new and advanced equipment.

In conclusion, I would once again like to thank the Subcommittee for your attention to this important issue. Our future as a nation of discoverers, inventors, and innovators depends on education and inspiration. I believe that the Nanotechnology in the Schools Act will help ensure that our scientific future stays bright, and I look forward to the opportunity to take advantage of this program.

Raymond J. Vandiver 9/28/2007