

Wrap-up comments by David Garabrant

Thursday, Oct. 25

First off I am delighted and thrilled by the tremendous amount of participation and knowledge communicated today. I have heard remarkable things that please and stimulate and realize that we have a great deal of work to do.

We started with **Governor Whitman** and took away the theme that we must balance the risk of inadequate regulation with the risk of overprotection. There is a risk of action and a risk of inaction. If you don't take the time to explain what you are trying to do then you're going to damage your credibility so that your ability to implement future decisions will be impaired. These are the things we struggle with as risk assessors and risk managers. We need to be careful that we act with appropriate speed and care to insure that we maintain our credibility in the future. Inaction today can pose huge risks for tomorrow. Today's challenge principally is to increase the public's understanding of risk assessment. Misunderstanding of risk and risk assessment results in bad public policy and there's great potential for nanotechnology to improve people's lives. We must make sure that the risks are communicated properly so that the progress is not thwarted. We do not want to lose the opportunity to benefit from nanotechnology and to improve people's lives, though we must also understand and communicate the risks properly.

Dr. Andrew Maynard gave an absolutely delightful, provocative discussion of why nanotechnology is beneficial. Money, better products, consumer demand, societal benefits, safer products, but there's also reason to be concerned about potential risks – and, of course, the challenge is to develop socially acceptable nanotechnologies. He stressed, as many of today's speakers did, that we must have a good scientific foundation for action. What then is the science we need to assess risks properly? He proposed five grand challenges to be met, and rather than repeat them I would urge you to get the Nature article – see symposium background material on our website www.umriskscience.org. He also stressed that we must have multiway conversations and engagement among scientists, policymakers, nano-producers and end users. This is essential. I think that today's symposium illustrates that we can do that, we must do that. We all bring things to the table, we all have something to contribute.

Dr. Oberdörster summarized some of the dramatic developments in the laboratory about the toxicity of nanoparticles and how much of the toxicity is unknown. Showing that we know a little bit about the translocation of nanoparticles between biological compartments, but not enough, showing that differential absorption is based on physicochemical properties, showing that we should have concern about potential translocation of nanoparticles from the respiratory tract to the forebrain, showing that surface coating matters with respect to distribution in the body, and that physicochemical properties are important determinants of biokinetics and effects.

Dr. Warheit gave us more, basic information on toxicity and showed that some things are now known for some types of nanoparticles. Nanoparticles are cleared by alveolar macrophages but they may have novel and unpredictable properties and they may have unpredictable biological properties as

well. His experiments show that surface reactivity has the greatest impact on cytotoxicity - much more important than size or surface area. And then he described what I think are path-breaking developments in developing the nano-risk framework in cooperation with Environmental Defense. That has resulted in a base set of hazard tests that include pulmonary, skin, acute oral toxicity, eye irritation, genotoxicity and aquatic toxicity. Key issues now are to move forward to this standard set of tests and to get them implemented widely, to get them agreed upon and to develop a methodologic approach to toxicity evaluation.

Dr. Martin Philbert showed that surface modifications of nanoparticles really matter. We must be careful about incidental versus purposeful modifications. He also showed that nanomaterials go everywhere. Some of the laboratory work he's doing, as elegant as it is, leaves us still hanging as to where the bulk of the nanomaterials actually end up in the human body. Clearly this is an issue that has to be resolved for products that will reach the human body. Persistence does not equate to toxicity. We do need to know where particles go in the human body and for how long, and we have to recognize that engineered nanomaterials with high functionality may have very different effects in different tissues - some of them may be excreted quite rapidly. Studying their distribution and excretion is going to be critical.

Dr. Joel Schwartz gave us a summary of examples of air pollution, traffic particulate, and combustion aerosols showing increased all-cause mortality, cardiovascular effects, change in blood pressure, neurologic effects and raised our concern that nanoparticles may have toxicity like these other small and ultrafine particles. Clearly we need to revise our risk assessment methods to account for differential susceptibility and differential risks. We may see large risks in small populations, raising ethical issues on how to respond to these differential risks and benefits. Clearly our risk assessment methods do not adequately deal with these possibilities.

We then moved into all of the developments in regulations and there are many. **Dr. Bert Hakkinen** gave an overview of the rapid developments in the EU and emphasized that in the EU they recognize the importance of keeping research and development of nanotech competitive and they recognize the substantial benefits to be derived from nanotechnology. The research and regulatory process is moving forward systematically in Europe, there are parallels between the U.S. and EU. Clearly US nanoproducers must keep up to date with the developments in Europe.

Dr. George Gray gave a remarkable summary of the thoroughness and rigor with which the EPA is moving forward on nanotechnology. Laying out the framework for research and understanding and for the development of regulations and appropriately dealing with how society will view these materials.

Dr. Kathryn Kelly reminded us that we don't know what's acceptable if we don't know the risks and that the idea of 1 in a million risk is an arbitrary decision. It's now become the ceiling for acceptable risk and it wasn't intended to be used that way. She emphasized that the acceptability of risk varies among people and is a judgment made by those who take on the risks. People do vary.

Dr. Jane Wilson, beautiful summary of standards, how standards are established, how many different organizations are working on nano- standards: IEE, ASTN, ISO, NSF. Clearly there's a tremendous amount to keep track of for those of you who produce nanoparticles.

Dr. John Balbus provided a very nice capsulized summary of why we should be concerned about nanoparticles – the analogy to fine particle pollution, the ability of nanoparticles to move about the body in possible shared mechanisms of toxicity. We know that some forms of nanoparticles, particularly fullerenes and carbon nanotubes are built to last. Some of them have clearly dramatic toxicity and that sizes in the 10-40 nm range are uniquely suited to interact with biological machinery. The challenges that I think he highlighted and the key issues are that the information that we have and the critical uncertainties in our knowledge should guide the development of nanotechnologies. We need to achieve a good balance between risk and benefit, and that balance may differ for medical products, for other areas of commerce and we need to pay close attention.

Friday, Oct. 26

I'm going to be brief, I think this was an absolutely exciting morning. I don't think I've ever perceived the challenges as clearly or gotten as close to the solutions. I think we've really made some progress. I want to just summarize the main points I took away.

Clearly **Tony Collings** laid out for us, from a person who spent his career in the media, that a careful balancing of the information is important. Public perception is critical. You must know what the public perceives in order to have them get the story straight. Communication techniques matter. You have to connect with your audience. You have to keep your message simple, clear and relevant to what they need to know. And as we've heard over and over, the credibility of the communicator is critical.

Representative Schwarz gave us some insight into the legislation and legislators. Legislators want to do the right thing but don't know what the right thing is particularly on technical issues. Elected officials are overwhelmed by the volume of data thrown at them. I think it's really important to recognize their limitations and the amount of time they can devote to an issue are so small. I don't know how we can expect them to get it right.

Erich Pica, fabulous perspective. Credibility is all we have. Absolutely right. There is a role for healthy skepticism about chemicals and industry. The reference frame that people come with is tremendously important. We don't want to see another environmental disaster, and the concern is that nanoproducts have not been adequately tested and why are they in the market without adequate testing. If the public does not know that there are nanomaterials in the products they are using, they cannot assess the risk. The public does not understand technical research reports, they need information they can understand and there is a real opportunity to provide this information. That's a challenge to all of us. The public wants to trust the government and they want to trust people who provide good information. The public does not have the time to get the information, we need to make it easy to assess the risks.

Richard Harris – People don't want to understand why things work, they think technology is magic – they want the products. I agree with that. As my experience illustrated they want someone to tell them what they need to know. Here's what you need to know, here's what you need to do. Nothing more, they don't have time. An intriguing idea about nano, there are hypothetical risks. The news media are waiting for real risks, and the story about nano moves too slowly to keep reporting it. Britney Spears keeps changing every day – it's a better story. So what that says is there's not going to be any news coverage of nano until there's something dramatic.

Dr. John Graham. The precautionary principle has many versions: the hard version can preclude technological innovation, the soft version says that we should act even in the absence of conclusive evidence to take cost effective actions to reduce risk. The principles of communication are important. Technological stigma are easy to create, and very hard to remove. Once you get stained, it's hard to get the stain out. General considerations and lessons for nanotech: understanding risk is essential to credible development of safer products, the regulation of safety and promotion of technology are difficult to combine in the same agency and that these should be kept separate because they really have conflicting roles, and pre-market screening and approval of products can be overly stringent and inhibitory but it needs to be done, moreover, post market monitoring is important as well.

Dr. Dan Kahan, 15-20% of people have heard of nanotechnology but those people are different than the rest of us. I think we learned why they are different. The most important message was that people react in diverse ways to information on risk and that the reasons they react have to do with world views and cultural predispositions. Individuals receive the information and transform it in a manner that makes it consistent with their cultural preconceptions. We clearly need to think of the reference frame by which people perceive information.

Dr. David Garabrant's talk simply talked about some practical lessons in communication in a setting where there are deeply polarized and deeply held views. We learned some important lessons about the fundamental truths, such as the integrity of the speaker, and the integrity of the development of the message as the critical themes that allow us to reach out to people.