Toxicology symposium highlights the flip sides of nanomaterials

By Sheila Yong

In the midst of Halloween spirit, attendees of the Duke University Integrated Toxicology and Environmental Health Program (ITEHP) *(http://sites.nicholas.duke.edu/envhealth/)* symposium, which is cofunded by NIEHS, gathered to hear the latest findings on the consequences of exposure to nanomaterials in the environment. Held at the Sarah P. Duke Gardens Oct. 31, the symposium was moderated by Mark Wiesner, Ph.D., and Richard Di Giulio, Ph.D.

The ITEHP symposium attracted participants from Duke, as well as other universities and research institutes in the Triangle, including NIEHS and the U.S. Environmental Protection Agency. (Photo courtesy of Steve McCaw)

Wiesner is the director of Duke's National Science Foundation-funded Center for the Environmental Implications of NanoTechnology (CEINT), *(http://ceint.duke.edu/)* which partners with the NIEHS-funded Duke University Superfund Research Program. Di Giulio is the director of ITEHP.

This year's symposium, "Rapidly Emerging Nanomaterials: Insuring Human and Environmental Health," featured presentations on nanomaterial synthesis and properties, as well as the effects of nanomaterial use on living organisms and the ecosystem. "The topic today is scary," said Wiesner, as he welcomed the attendees. It was scary indeed, as speakers showcased their findings on how nanomaterial use might negatively impact the environment and well-being of humans and other organisms.

Nel, an NIEHS grantee through the NanoHealth and Safety program, started off the day's program with his talk on nanomaterials and human health. "Many properties of nanomaterials are actually detrimental to the cells, such as their ability to produce reactive oxygen species and cause chronic toxicity," he explained. (Photo courtesy of Steve McCaw)

Nanomaterials are beneficial, or are they really?

Talks by Andre Nel, Jamie Lead, and Kam Leong focused on the use of different types of nanomaterials in various applications, and the effects their properties may have on living cells and tissues. Nel pointed out that many of these characteristics actually do more harm than good. He urged the use of high throughput screening of nanomaterials to characterize their risks and predict exposure outcomes, which could be helpful in regulating nanomaterial synthesis and use.

Lead discussed how nanomaterials of various sizes and properties behave in different solutions, such as those found in various environmental and biological systems. He explained that the stability of nanomaterials depends on what they are made of, and the coating used can also affect their characteristics in solution. Acknowledging Nel's comment on nanomaterial screening, Lead said, "There needs to be a balance between the science and regulation."

Kam Leong's talk brought the audience back to the benefits of nanomaterial use. His research focuses on using nanotechnology to create a safe and cost-efficient gene delivery method to treat hemophilia, a bleeding disorder that slows down the blood clotting process.

Nanomaterials in the ecosystem

In the lab, scientists often use reagents at levels far beyond the normal range encountered in the environment. Emily Bernhardt emphasized, however, that nanomaterials could still create havoc in the ecosystem even at extremely low concentrations.

Amy Ringwood agreed with Bernhardt's view. "Instead of waiting for the consequences to occur, can we be proactive for a change?" she asked. Using oysters as her model, Ringwood found that filter feeders, who obtain food by filtering particles from water, could ingest and excrete agglomerated, or clustered, nanoparticles, leading to resuspension and reexposure. Therefore, once in the ecosystem, nanoparticles never go away.

Nanomaterial effects at the cellular and organismal levels

Former NIEHS trainees Tara Sabo-Attwood, Joel Meyer, and James Bonner discussed the effects of nanoparticle exposure on cells and living organisms. Meyer and Bonner are also NIEHS grantees.

Sabo-Attwood and Bonner study nanoparticle exposure effects on the respiratory system. Explaining that many nanoparticles are airborne and may cause respiratory diseases, Sabo-Attwood showed that lung epithelial cells exposed to nanotubes are more susceptible to influenza virus infection, suggesting that nanotube exposure may alter host immunity. "We plan to use animal models to determine the mechanism of infection and if there is any nanoparticle-specific effect," she added.

Bonner studies the health risks associated with occupational and environmental exposure to carbon nanotubes. He showed that mice that inhaled carbon nanotubes developed air way and lung irritation, which often precedes respiratory diseases, such as asthma and mesothelioma.

Meyer found that nanoparticles cause lysosomal toxicity in the nematode *C. elegans*, identifying mutants that are sensitive to toxicity from dissolved metals and nanoparticle-induced oxidative stress. Interestingly, some of these toxic effects are nanoparticle-specific, and are more prominent in certain genetic backgrounds. "The interesting question is how we can incorporate the genetic variability among the population into the toxicological assessment of nanoparticles," he said.

(Sheila Yong, Ph.D., is a visiting fellow in the NIEHS Laboratory of Signal Transduction.)

Fall 2013 ITEHP Symposium speakers list

- Andre Nel,M.D., Ph.D.,
  (http://www1.cnsi.ucla.edu/institution/personnel?personnel_id=8739)
  University of California, Los Angeles
  Nanomaterials and Human Health: The Good and the Bad
- Jamie Lead, Ph.D.,
  (http://smartstatesc.org/jamie-lead)
  University of South Carolina
  Dynamic Transformations of Manufactured Nanoparticles in Complex Environmental and Biological Media
- Tara Sabo-Attwood, Ph.D.,
  (http://www.epi.ufl.edu/?q=node/1041)
  University of Florida
  Close Encounters of an Infectious Kind: The Influence of Nanoparticles on Pathogens
- Joel Meyer, Ph.D.,
  (http://fds.duke.edu/db/Nicholas/esp/faculty/jnm4)
  Duke University
  Using Genetic and Microscopic Analysis to Understand Mechanisms of Silver Nanoparticle Toxicity in Caenorhabditis elegans
- Emily Bernhardt, Ph.D.,
  (http://fds.duke.edu/db/Nicholas/esp/faculty/ebernhar)
  Duke University
  Nanomaterials in the Real World - Nanomaterial Impacts in Ecosystems
- Amy Ringwood, Ph.D.,
  (http://clas-pages.uncc.edu/amy-ringwood/)
  University of North Carolina at Charlotte
  Lysosomes as Targets for Nanoparticles - Cellular and Ecotoxicological Models
- James Bonner, Ph.D.
  (http://tox.sciences.ncsu.edu/people/james-c-bonner/)
  North Carolina State University
  Nanomaterials as a Potential Cause of Lung Disease
- Kam Leong, Ph.D.,
  (http://fds.duke.edu/db/pratt/BME/kam.leong)
  Duke University
  Quantum Dots Applied to Improve Theranostics of Nanotherapeutics

Organized by Duke environmental toxicologist Edward Levin, Ph.D.,
(http://fds.duke.edu/db/Nicholas/esp/faculty/edlevin)
and ITEHP Program Manager Eve Marion, the ITEHP annual symposium series features daylong events in the fall and spring of each year.

Sabo-Attwood responded to questions from the audience after her presentation. Her group at the University of Florida studies the effects of nanoparticle exposure on pathogenic infection. (Photo courtesy of Steve McCaw)

Di Giulio introduced Meyer, right, while he was getting slides ready for his presentation. Meyer, now an assistant professor of environmental toxicology at Duke, obtained his Ph.D. from Di Giulio's lab. (Photo courtesy of Steve McCaw)

Bernhardt showed that aquatic wetland plants die when exposed to silver nanoparticles in the water. "Their roots dissolved, and the plants spilled their guts out," she said. These phenomena eventually result in increased levels of nanoparticle aggregates and greenhouse gases in the environment. (Photo courtesy of Steve McCaw)

Ringwood introduced the audience to the hepatopancreatic cells that make up the oysters' gut. She explained that the gut of filter feeders is the first to encounter any pollutant or toxin in the environment. She showed that nanoparticles enter the oysters and accumulate in the lysosomes, which are intracellular vesicles containing degradative enzymes. This response results in lysosomal disruption and reduction of embryonic viability. (Photo courtesy of Steve McCaw)

Besides giving the welcome speech, Wiesner also served as an emcee for the symposium and introduced several of the speakers before their presentations. (Photo courtesy of Steve McCaw)

Bonner studies the potential of nanoparticles to cause lung disease. "There are no human diseases identified so far, but susceptible individuals will be affected first," he said. (Photo courtesy of Steve McCaw)

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