Lab ≠ Mesocosms
Emily Bernhardt, Ben Colman

**AgNPs: No effect**
**AgNO₃: Small effect**

**AgNPs: Large effect**
**AgNO₃: No Clear Effect**

**Lab Incubation Sediment**

**Terrestrial Mesocosms**

**Wetland Mesocosms**

**Methane (ppm)**

**N₂O (µg N kg⁻¹ sed)**
Organisms are exposed to transformed NPs

Greg Lowry, Matt Hotze

AgNP

Ag(0)/Ag₂S

Ag(0)/Ag₂O

Oxidation

Sulfidation

Ag₂S

3 - Shihng
4 - coatings and tox
5 - Nano all along
6 - Trophic Transfer
7 - Maternal Transfer
8 - Risk Forecasting
9 - Light induced aggregation
10 - Detection
11 - High Throughput
12 - Protocols

Organic Matter

Biomacromolecules

homoaggregation

heteroaggregation

Macromolecule

Adsorption

NSF EF-0830093
Deposition of Nanoparticles
--Effect of Size and Surface Modification
Shihong Lin, Mark Wiesner

More accurate evaluation of electrical double layer interaction for nanosized particles (equation developed for conventional colloids significantly overestimate the repulsion at low ionic strength).

Surface coatings destabilize particles (more sticky) via bridging when only present on the particle surface; They stabilize the particles (less sticky) via steric interaction when present on both the particle and collector surfaces.
Impact of NP coating on bacterial toxicity

For NPs releasing toxic metal cations, coatings that bind metal cations (like NOM) prevented toxicity.

For redox active NPs, all coatings prevented NP-bacteria contact and prevented toxicity.

For particles producing ROS, only coatings that scavenge ROS prevented toxicity.
Nano has been here all along

Mike Hochella, Mark Wiesner

All matter in the universe, except H and the inert gases, has at some time existed in a nanoparticle. Nanoparticles present at the time of the formation of this solar system, 4.6 billion years ago, are preserved in meteorites.

Life on this planet, likely originating earlier than 3.5 billion years ago, did so in the presence of “environmental” nanoparticles. All life is still bathed in a vast variety of nanoparticles today.

On an annual basis, soils worldwide naturally produce much more weight in nano-scale particles than the entire nanoparticle industry combined.

Even species such as silver nitrate, typically considered “dissolved,” may transform to nanoparticles, confounding our ability to differentiate between the effects of dissolved and nanoparticle species.

Silver nanoparticles formed from silver nitrate in the presence of bacteria.

Nanodiamonds from the Murchison meteorite

<< 1 Tg/yr
(est. 100,000 mt/yr = 0.1 Tg/yr)

1,000’s Tg/yr

NSF EF-0830093
Trophic Transfer of Au Nanoparticles

J. Judy, P.M Bertsch, J.M. Unrine

Au Lα fluorescence

Au IV

Hot spot

Au foil

Au La1 XANES

COVER STORY
CHEMICAL YEAR IN REVIEW
C&EN highlights the major research achievements of 2011 and revisits trends in research from a decade ago. PAGES 13, 17

NANOMATERIALS IN THE FOOD CHAIN

nanoparticles show tremendous promise for drug delivery, and they are already being used as functional materials in consumer products such as paint and cosmetics. But scientists demonstrated this year that the tiny materials warrant additional scrutiny as they’ve begun to swirl down drains and otherwise end up in the environment.

studies showed that not only do some nanoparticles transfer from organism to organism in the food chain but that they also increase in concentration,

NSF EF-0830093
Detection of Nanomaterials in Complex Media
J. Unrine, B. Colman, A. Gondikas, A. Bone, C. Matson

- Ag NPs and ions cause aquatic plants to release exudates.
- These exudates modify particle aggregation and dissolution behavior in a coating dependent manner.

Advanced detection and characterization techniques reveal dynamic interactions between nanoparticles and ecosystem components (both biotic and abiotic).
Citrate-coated Ag NPs undergo maternal transfer in *Caenorhabditis elegans*

Xinyu Yang, Appala Badireddy, Mark Wiesner, Joel Meyer

CIT₇ Ag NPs are ingested (panel A) along with bacterial food in *Caenorhabditis elegans*. They are transferred to offspring (panel B), which could be observed in this case because of bagging (retention of developing embryos), a phenotype sometimes observed in stressed *C. elegans*.

![Image](image_url)
1. Risk forecasting work begins with estimates of nanomaterial production.

<table>
<thead>
<tr>
<th>Product</th>
<th>Lower bound (tpy)</th>
<th>Upper bound (tpy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>nano-TiO₂</td>
<td>7,800</td>
<td>38,000</td>
</tr>
<tr>
<td>nano-Ag</td>
<td>2.8</td>
<td>20</td>
</tr>
<tr>
<td>nano-CeO₂</td>
<td>35</td>
<td>700</td>
</tr>
<tr>
<td>CNT</td>
<td>55</td>
<td>1101</td>
</tr>
<tr>
<td>Fullerene</td>
<td>2</td>
<td>80</td>
</tr>
</tbody>
</table>

2. Value chain assessments determine where and how nanomaterials will be used and potential exposure pathways.

3. Production estimates serve as inputs for Monte Carlo simulations of a given exposure pathway (ex. wastewater).

4. Monte Carlo results serve as input to a Bayesian Network to forecast exposure - in this case at the scale of a river basin.
Toxicity Reduction of AgNPs by Sunlight

Y. Cheng, L. Yin, S. Lin, M. Wiesner, E. Bernhardt and J. Liu

2-days sunlight treatment

Root length increase and has normal hair after sunlight treatment

NSF EF-0830093
Cross-Referencing Nanomaterial Properties with Nanomaterial Bioactivity (CEINT collaboration with EPA)

Stella Marinakos, Raju Badireddy, Amy Wang, Keith Houck, Mark Wiesner, and Jie Liu

~45 nanomaterials
e.g. Ag, Cu, TiO2, SiO2, ZnO, CNTs

Physical and chemical characteristics

Oxidative Stress vs Metal Response

Cu and Ag (Oxidative stress/metal response)
Zn (Oxidative stress/strong metal response)
SiO2 (Oxidative stress/metal response)

Profile Matching

High-throughput screening (HTS), in vitro, ~700 assays (cell and zebrafish embryo)

NSF EF-0830093
NIST-CEINT collaboration – Protocol development
Julian Taurozzi

Goal: Develop standardized methods for the preparation of ENM dispersions for nano-EHS assessment

This collaboration has resulted in seven publications to date, including NIST protocols and journal articles:


“A standardized approach for the dispersion of titanium dioxide nanoparticles in biological media,” Nanotoxicology (accepted for publication)

Open access protocols available online at http://www.ceint.duke.edu/allprotocols:


2008-12: CEINT Impacts Partner University Programs

- 14 new courses + 23 modified to infuse CEINT research across 6 universities
- Carnegie Mellon & Howard Universities lead IGERT to create core curriculum
  - “Educating at the Interface: Nanotechnology-Environmental Effects & Policy”
  - 7 core graduate courses to be implemented
  - new courses taught by distance learning across 3 universities

- New Center-wide REU Program links undergraduates & research cross-sites
  - Duke, Virginia Tech, Carnegie Mellon & the CEREGE in France
  - 17 CEINT faculty mentors across interdisciplinary research
  - Integration features: videoconferencing; online collaboratories
  - Virtual presentations link US students with international collaborators

NSF EF-0830093
2008-12: CEINT Outreach Expands Nationally

- **Over 8,500 visitors to CEINT partner museums: NanoDays 2009-11**
  
  CEINT partnered with NISE Net for NanoDays since 2009.
  NISE Net is the largest network of informal science educators/researchers for fostering awareness of nanoscale science/engineering in U.S.

  CEINT Partner Museums:  
  N.C. Museum of Life and Science  
  Marbles Kids Museum, Raleigh, NC  
  Children’s Museum of Pittsburgh

*NanoToss*: CEINT activity adopted by NISE Net

What does stickiness have to do with it?

CEINT Video on NISE Net Website & NanoDays ‘12 Kits

Does Every Silver Lining Have a Cloud?