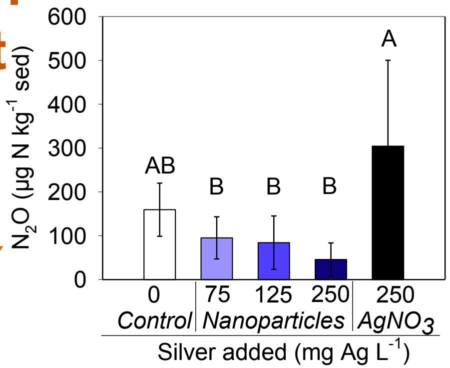
Lab ≠ Mesocosms

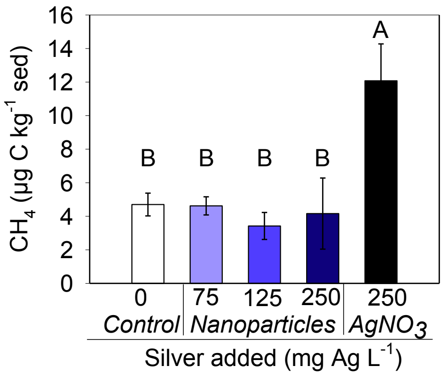
Emily Bernhardt, Ben Colman

Lab Incubation Sediment

AgNPs: No effect
$AgNO_3$: Small effect

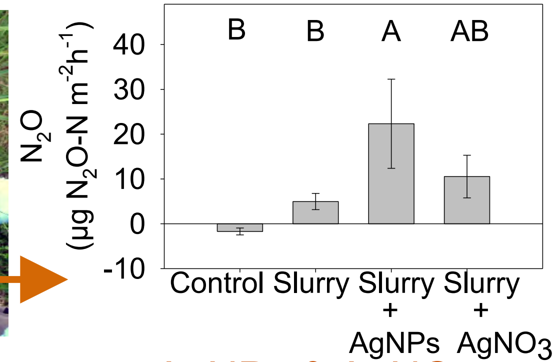


AgNPs:No effect
$AgNO_3$:Small effect



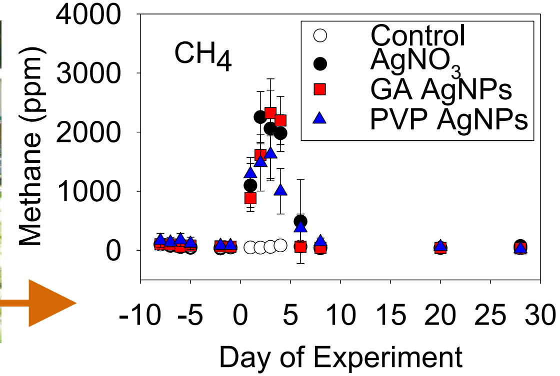
Terrestrial Mesocosms

AgNPs: Large effect
$AgNO_3$: No Clear Effect



Wetland Mesocosms

AgNPs & $AgNO_3$:
Marked effect



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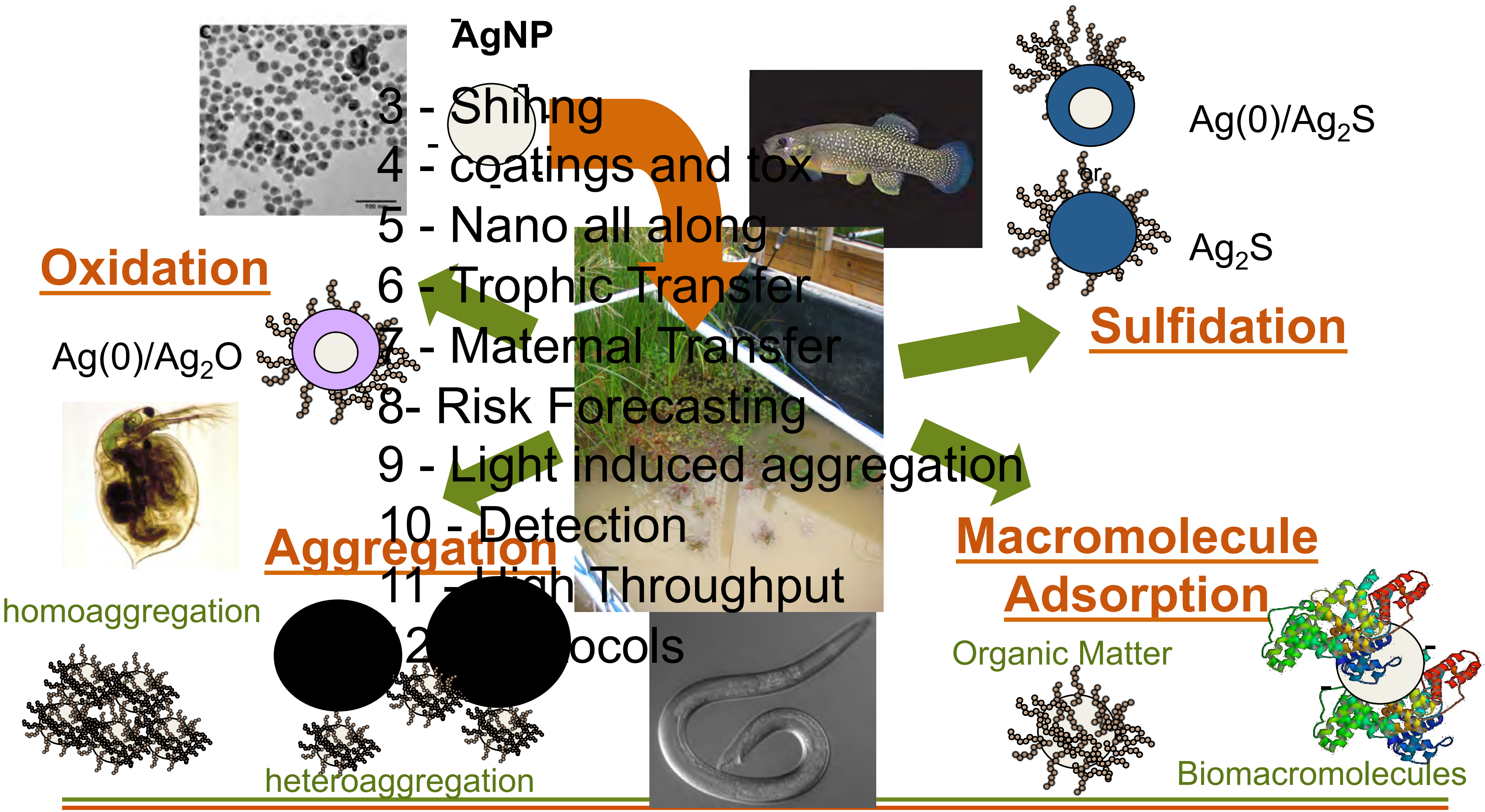
Organisms are exposed to transformed NPs

Greg Lowry, Matt Hotze



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 - [redacted]gh Throughput
12[redacted]ocols

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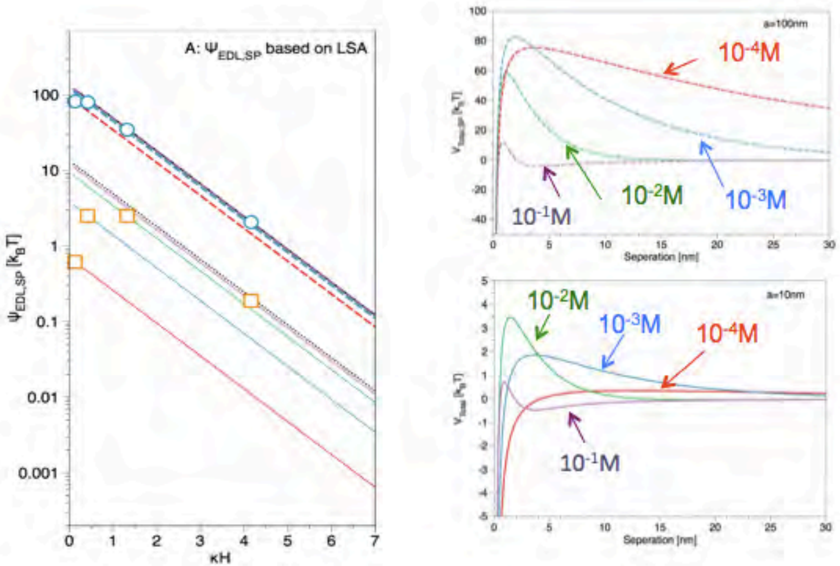
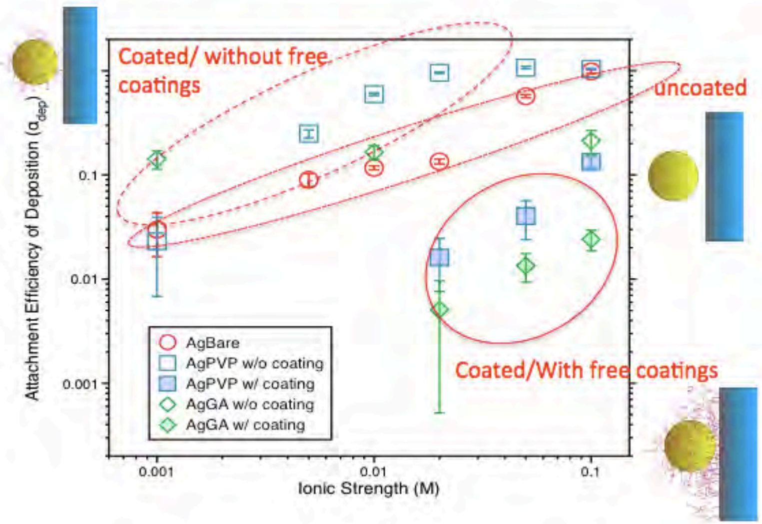
Deposition of Nanoparticles

--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.

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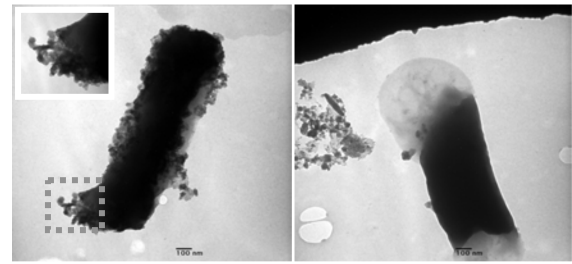
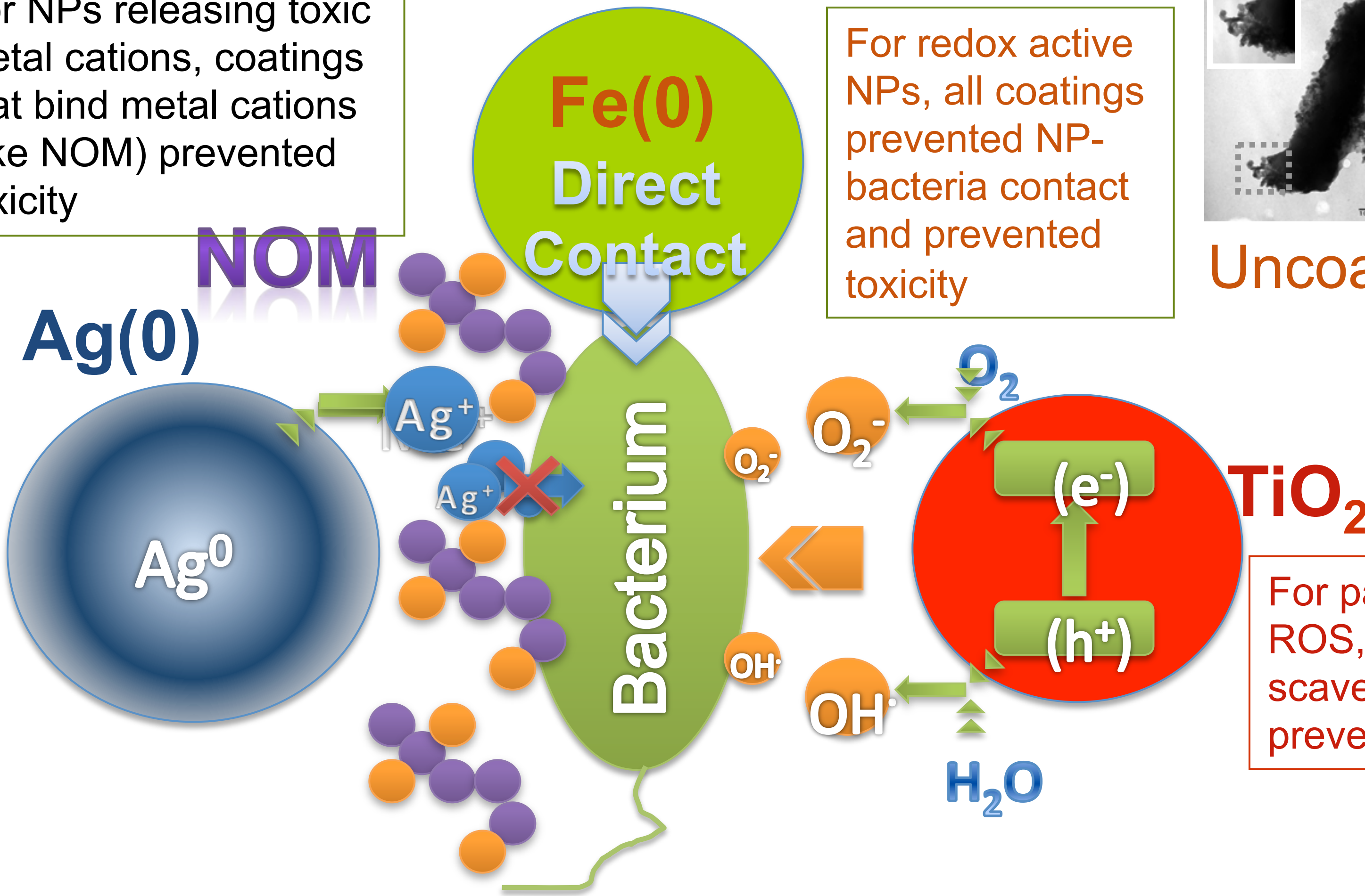
Impact of NP coating on bacterial toxicity

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



Uncoated   Polymer-coated



For particles producing ROS, only coatings that scavenge ROS prevented toxicity

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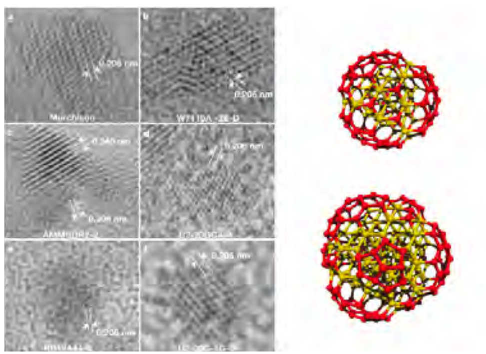
Nano has been here all along

Mike Hochella, Mark Wiesner

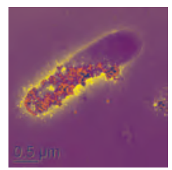
All matter in the universe, except H and the inert gases, has at some time existed in a nanoparticle.
Nanoparticles present at the time of the formation of this solar system, 4.6 billion years ago, are preserved in meteorites.

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.

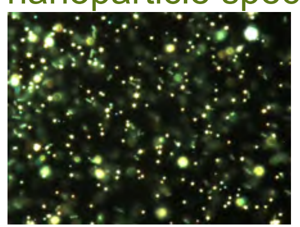
On an annual basis, soils worldwide naturally produce much more weight in nano-scale particles than the entire nanoparticle industry combined



Nanodiamonds from the Murchison meteorite



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.

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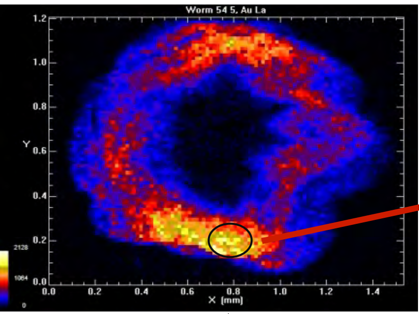
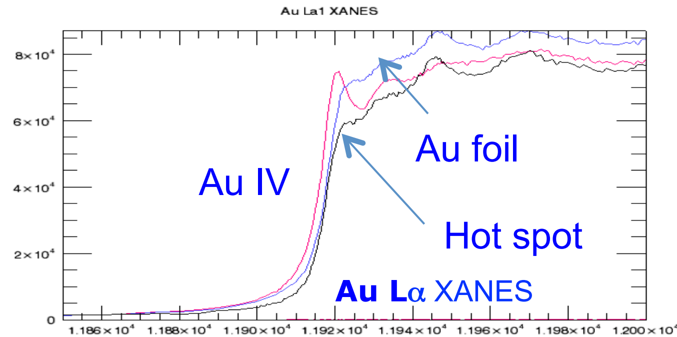
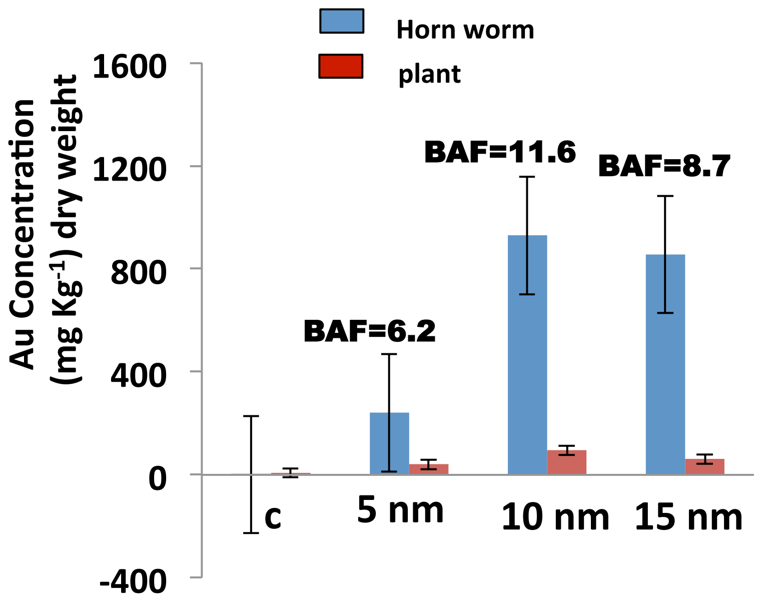
Trophic Transfer of Au Nanoparticles

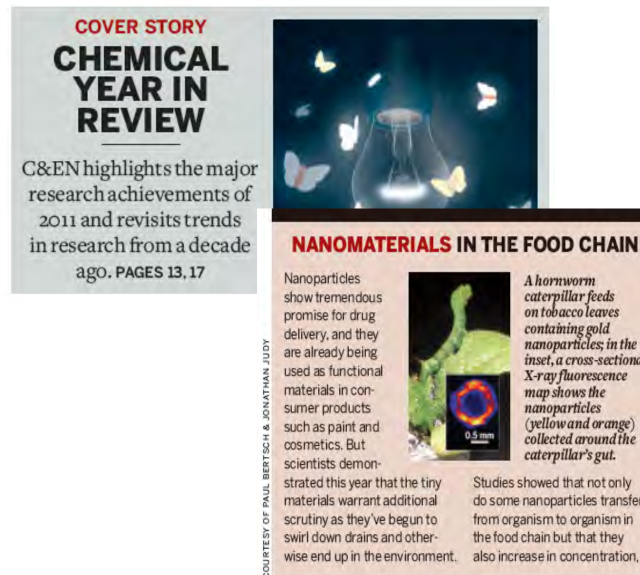
J. Judy, P.M Bertsch, J.M. Unrine

Au L_α fluorescence









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.

A hornworm caterpillar feeds on tobacco leaves containing gold nanoparticles; in the inset, a cross-sectional X-ray fluorescence map shows the nanoparticles (yellow and orange) collected around the caterpillar's gut.

COURTESY OF PAUL BERTSCH & JONATHAN JUDY

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

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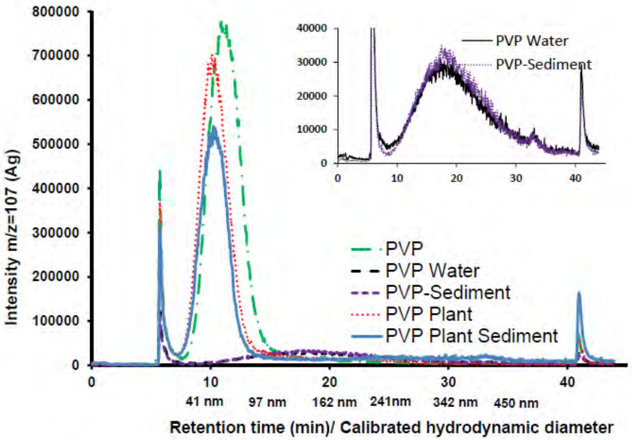
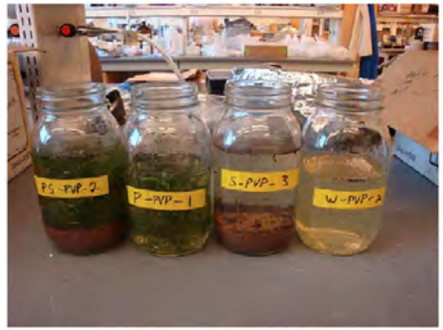
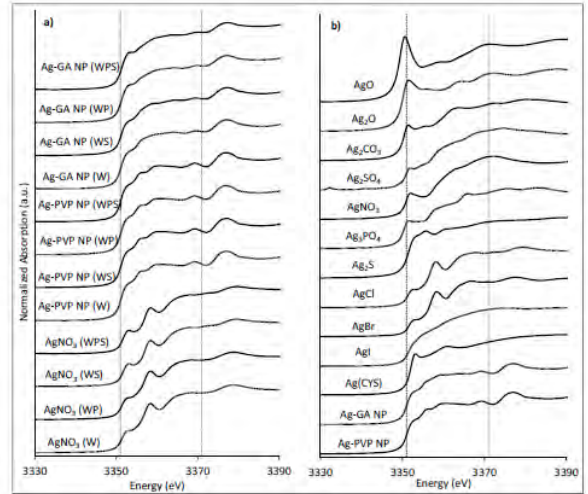
Detection of Nanomaterials in Complex Media

J. Unrine, B.Colman, A. Gondikas, A. Bone, C. Matson



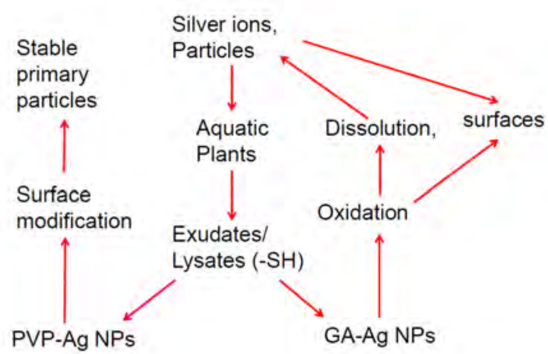




AF4-multi-detection

XANES

- 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).

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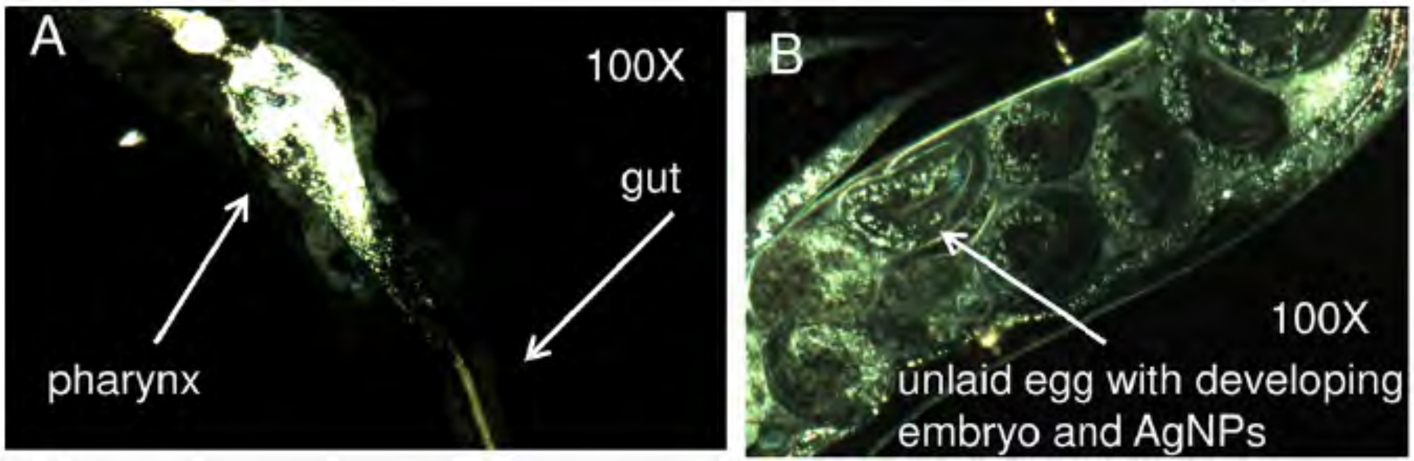
Citrate-coated Ag NPs undergo maternal transfer in *Caenorhabditis elegans*

Xinyu Yang, Appala Badireddy, Mark Wiesner, Joel Meyer

CIT_7 Ag NPs are ingested (panel A) along with bacterial food in *Caenorhabitis 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*.



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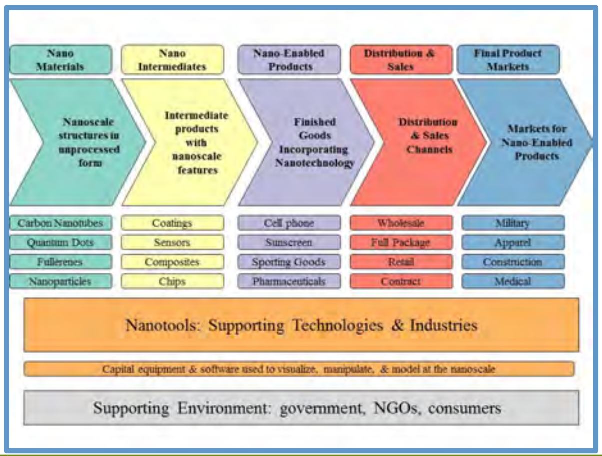
Risk Forecasting

Eric Money, Christine Hendren, Timothy Lenoir, Elizabeth Casman, Mark Wiesner

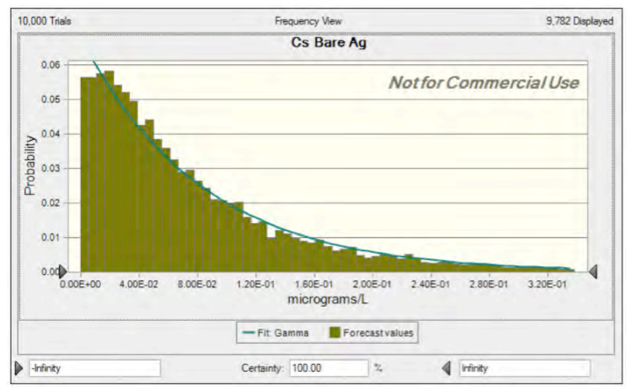
1. Risk forecasting work begins with estimates of nanomaterial production.

Product	Lower bound (tpy)	Upper bound (tpy)
nano-TiO_2	7,800	38,000
nano-Ag	2.8	20
nano-CeO_2	35	700
CNT	55	1101
Fullerenes	2	80

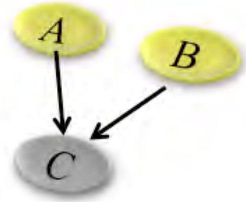
2. Value chain assessments determine where and how nanomaterials will be used and potential exposure pathways.

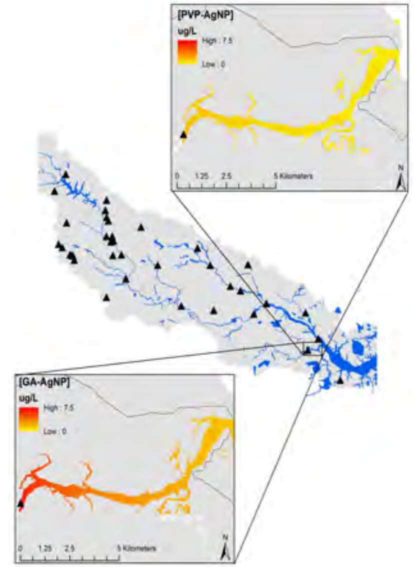


3. Production estimates serve as inputs for Monte Carlo simulations of a given exposure pathway (ex. wastewater)



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





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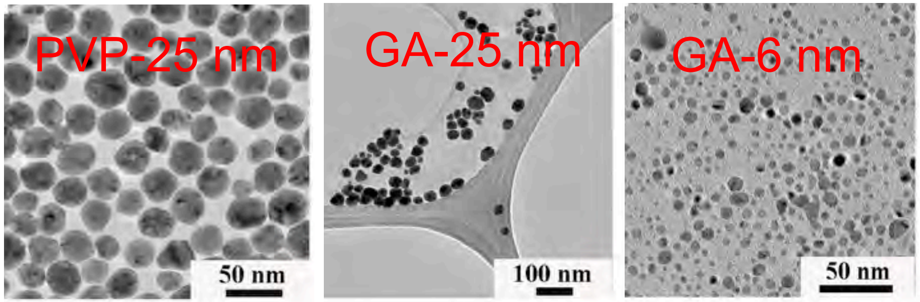
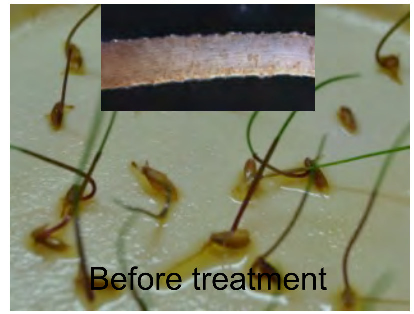
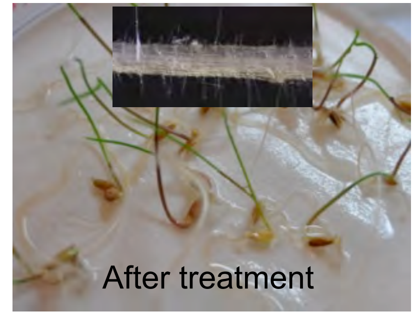
Toxicity Reduction of AgNPs by Sunlight

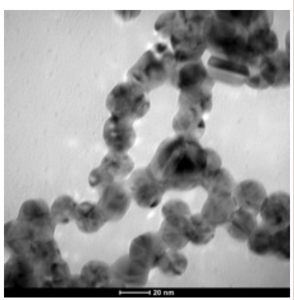
Y. Cheng, L. Yin, S. Lin, M. Wiesner, E. Bernhardt and J. Liu



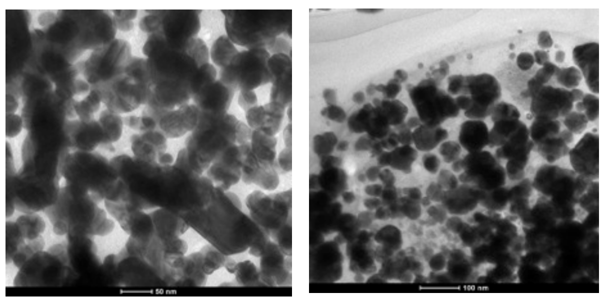




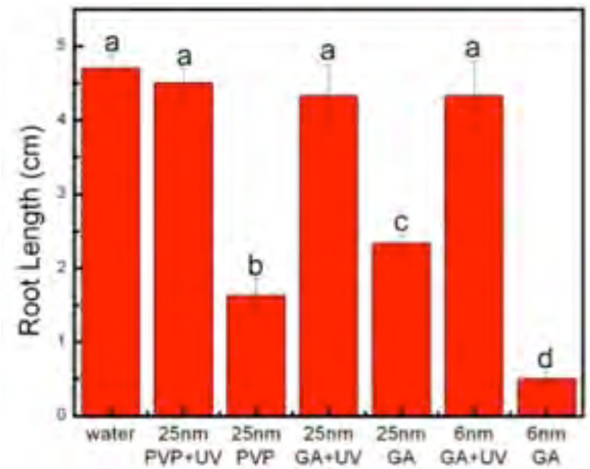
2-days sunlight treatment



Aggregation



Aggregation and precipitation



Root length increase and has normal hair after sunlight treatment

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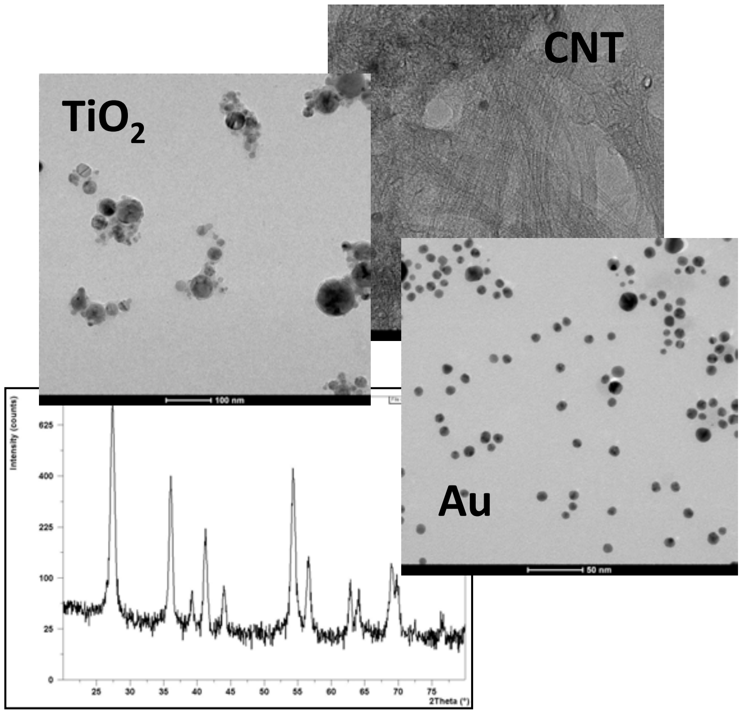
Cross-Referencing Nanomaterial Properties with Nanomaterial Bioactivity (CEINT collaboration with EPA)

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

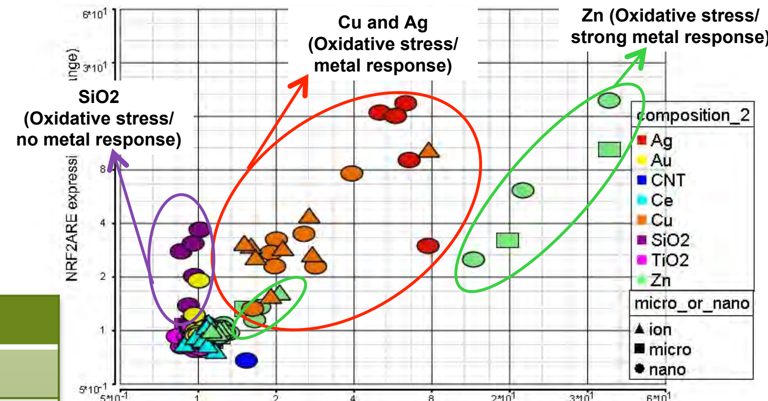
~45 nanomaterials
eg. Ag, Cu, TiO2, SiO2, ZnO, CNTs

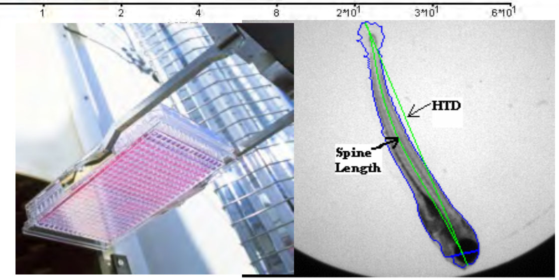


physical and chemical characteristics

Profile Matching

Oxidative Stress vs Metal Response





bioactivity

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

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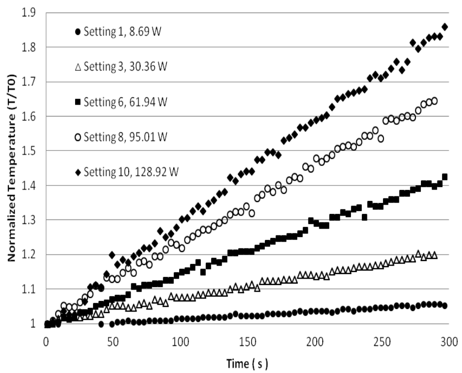
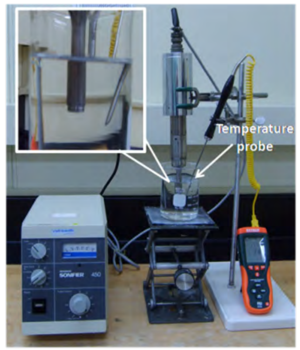
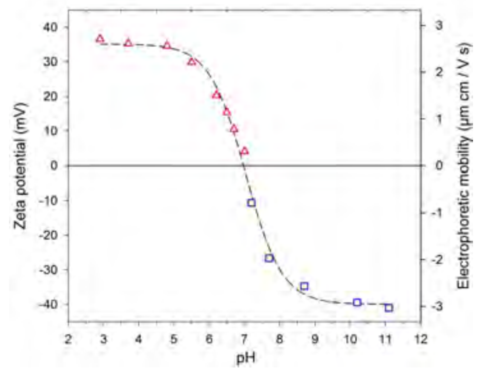
NIST-CEINT collaboration – Protocol development

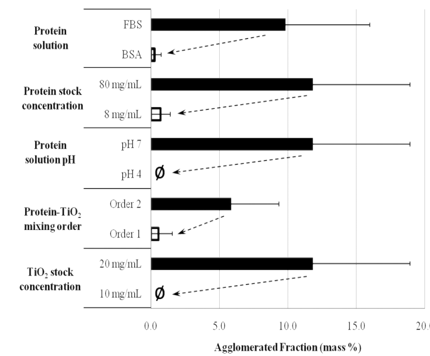
Julian Taurozzi

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:

"*Ultrasonic dispersion of nanoparticles for environmental, health and safety assessment - issues and recommendations,*" Nanotoxicology, Dec 2011, Vol. 5, No. 4, Pages 711-729

"*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:

"*Preparation of Nanoparticle Dispersions from Powdered Material Using Ultrasonic Disruption*" NIST/CEINT Protocol (2010)

"*Reporting Guidelines for the Preparation of Aqueous Nanoparticle Dispersions from Dry Nanomaterials*" NIST/CEINT Protocol (2010)

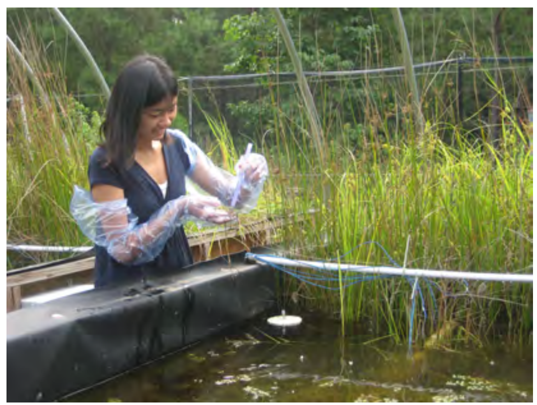
"Preparation of a Nanoscale TiO2 Aqueous Dispersion for Toxicological or Environmental Testing" NIST/CEINT Protocol (2011)

"Preparation of Nanoscale TiO2 Dispersions in Biological Test Media for Toxicological Assessment" NIST/CEINT Protocol (2011)

"Preparation of Nanoscale TiO2 Dispersions in an environmental Matrix for Eco-Toxicological Assessment" NIST/CEINT Protocol (2012)

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



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?