

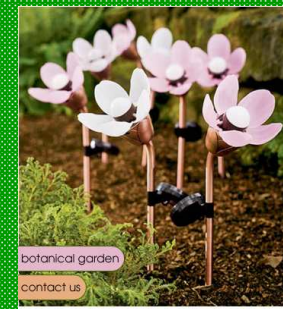


Nanotechnology Research Program

Nanotechnology: Springing Opportunities for Water



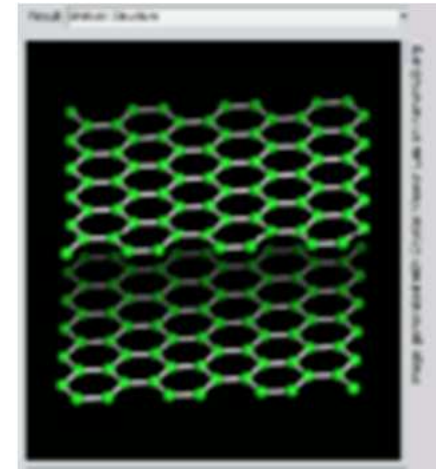
Nora Savage
Nano Team Lead
Technology & Engineering Division
National Center for Environmental Research
Office of Research & Development
US EPA



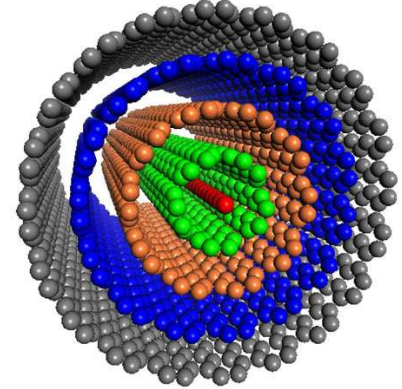
21st Annual Southwest Florida Water Resources Conference

OUTLINE

- Nano 101 = USG View
- Nano – Good, Bad, and Ugly
- Water Opportunities
- EPA Interests and Activities
- Focus on Sustainability
- Parting Message



What is Nanotechnology? What is Nanoscale?



- ❖ Research to discover new behaviors and properties of materials, from 1 to 100 nm
- ❖ Nanotechnology – applications of discoveries made at the nanoscale
- ❖ More than throwing together materials — manipulate and control of materials at that scale



Nanotechnology Research Program

What is the NNI?

National Nanotechnology Initiative

Collaborative, Multi-agency, Cross-cut Program Among 25 Federal agencies, 15 of which have specific nanotechnology budgets

Funds R&D to advance understanding and control of matter at nanoscale toward:

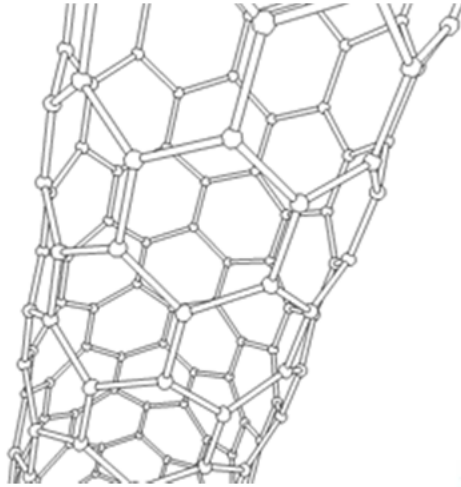
National economic benefit

National and homeland security

Improved quality of life



Nanotechnology Research Program



Nanotechnology Research Program



- **The NNI is not a separately funded line item in the Fed budget**
- **The NNI is not a funding agency**
- **NNI member agencies are investing in nanotechnology R&D: \$1.6 billion in 2009 and 2010**
- ***Contact NNCO if you need help identifying the appropriate NNI participating agency for your proposal***

NNI activities and documents inform agencies, report outcomes, and serve as resources



Nanotechnology Research Program



NNI Strategic Plan

Nanotechnology & Environment:

The Good

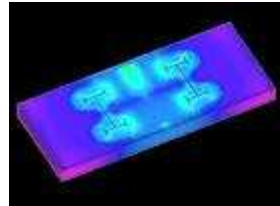
- Remediation



Treatment

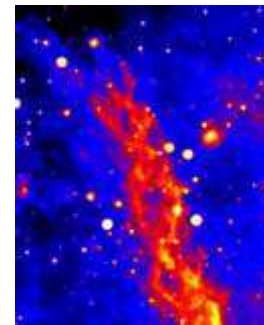


Sensors



Benign by Design

Office of Research and Development



Nanotechnology & Environment: The Bad

- Harm to Human Health
- Detrimental to Environment
- Adverse Economic Impact



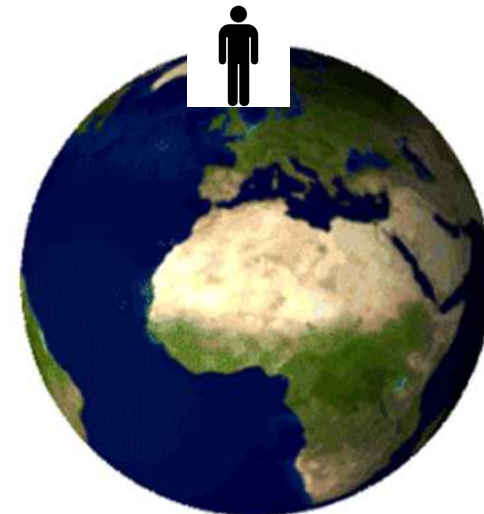
Nanotechnology & Environment:

The UGLY



CAN BE AVOIDED BY:

- Consider Full Life Cycle
- Benign Design
- Responsible Development



Nanotechnology & Environment:

Eliminate the UGLY

Unintended Adverse Outcomes

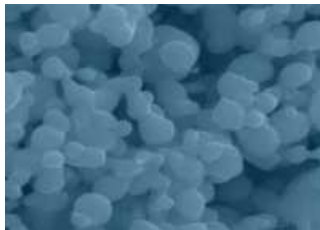
- Polluting land
- Impairing water sources
- Deteriorating Air
- Causing/Increasing Disease Incidence
- Harming Sensitive Populations



Nanoscale Materials

Engineered

- Carbon-based NTs, Fullerenes
- Metal Oxides
- Quantum Dots
- Nanotubes
- Nanowires
- Dendrimers



Office of Research and Development

Incidental

Particles from:

- Combustion
- Industrial Processes
- Vehicles
- Construction



Natural

Particles from:

- Plants, Trees
- Oceans, other water bodies
- Erosion
- Dust



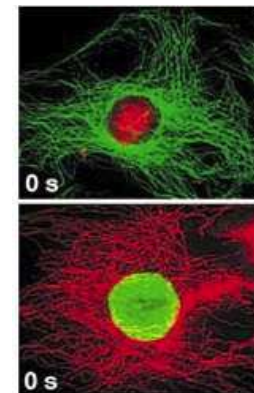
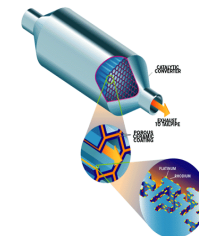
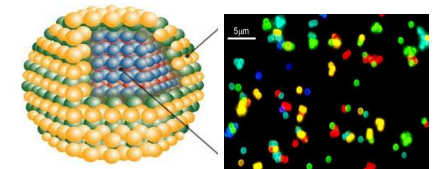
Water Challenges & Nano

- Almost 1 billion w/o access to clean water (WHO)
- Expensive treatment & remediation technologies
- Complex and lengthy technologies for treatment
- Over 1 million deaths → poor water quality (WHO)
- Increasing contamination of water bodies
- Assessment of Water Quality

- Effective treatment using nanotechnology
- Nanotechnology can present less expensive techniques
- Simple, point of use and rapid techniques
- Efficient destruction of pathogens
- Use of nano to create green design and P2
- Nano sensing devices

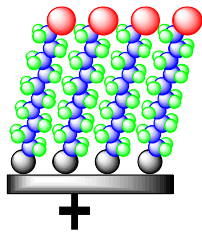
Nanotechnology Research Program

NANOMATERIAL	USE
TiO₂	Pigments, UV-absorber, catalyst
ZnO	Polymer filler, UV-absorber
Au, Fe, Ag	Remediation, clothing
CeO₂ / Ce₂O₃	Catalyst (cars), fuel additive
ZrO₂	Ceramic, catalyst support
Quantum dots CdSe/ZnS/InAs/InP/ nGaP	Medical imaging, drug delivery

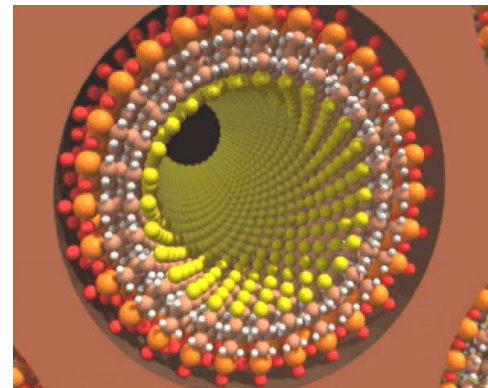
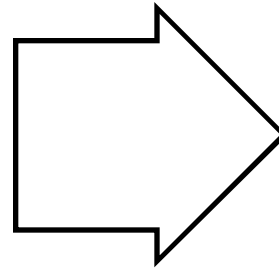
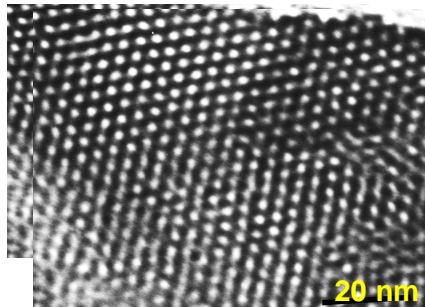


Nanotechnology - Materials and Technologies - Ready for prime Time

- Self Assembled Monolayers



B. Ordered mesoporous oxide



Ordered ligand arrays, easily accessible for binding heavy metals.

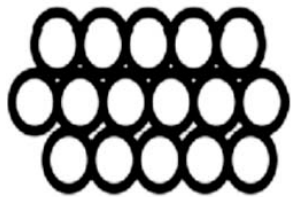
<http://samms.pnl.gov/>

NOTE: Slides on SAMMS were modified from slides provided by Glen Fryxell, Ph.D.,
Office of Research and Development
Pacific Northwest National Laboratory

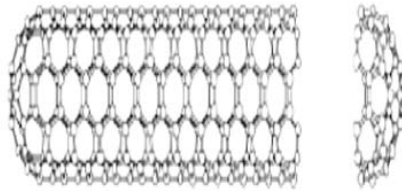
Nanotechnology - Materials and Technologies - Ready for prime Time

- Dendrimers
- Carbon Nanotubes

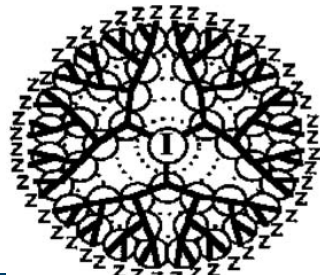
Metal-Oxide Nanoparticles



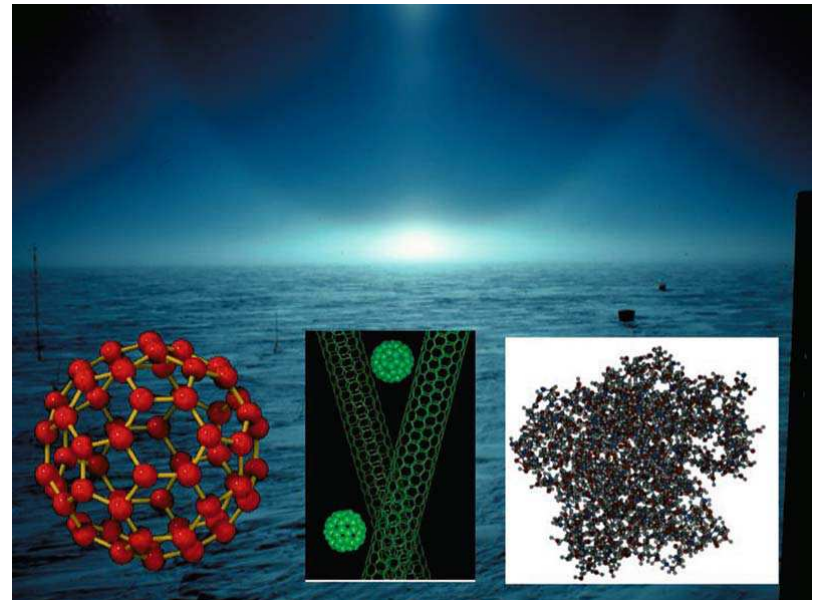
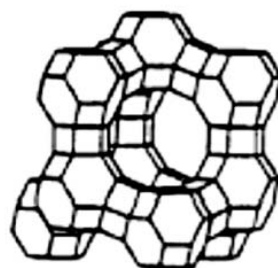
Carbon Nanotubes



Dendrimers

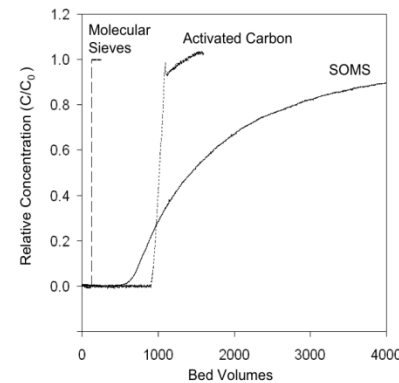
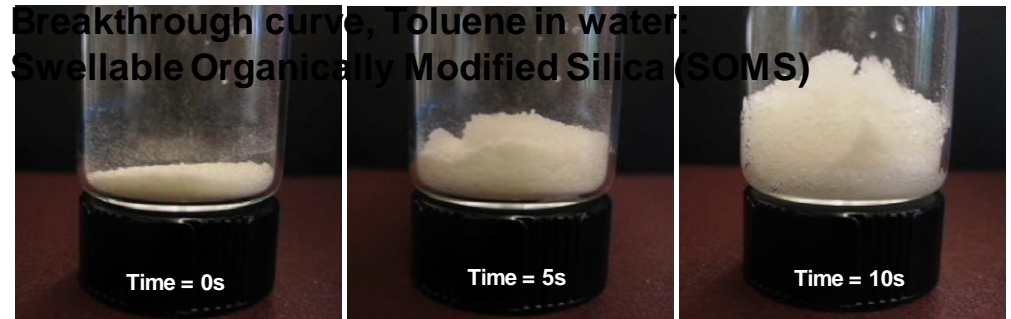
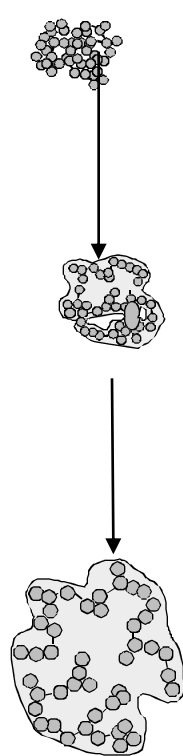
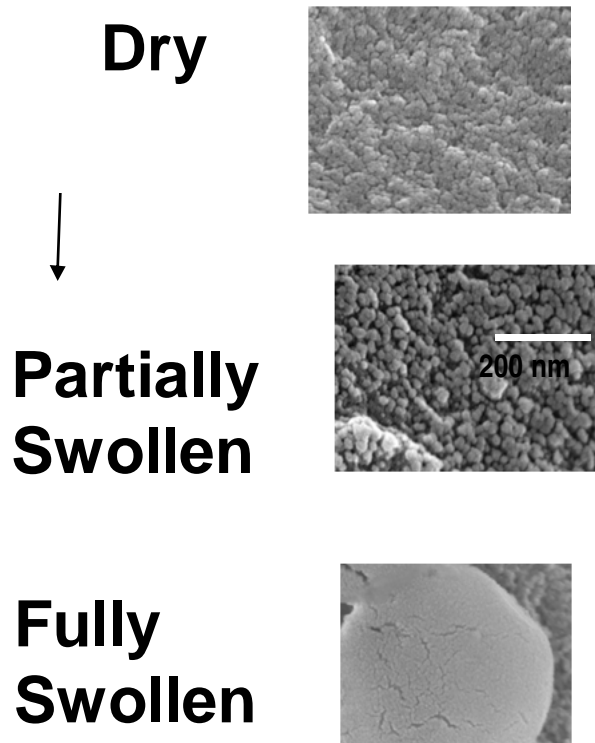


Zeolites



Nanotechnology - Materials and Technologies - Ready for prime Time

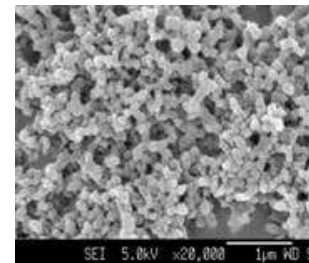
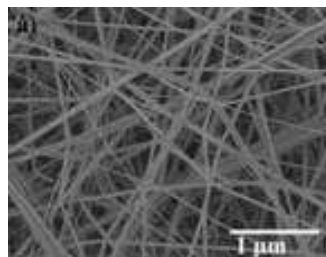
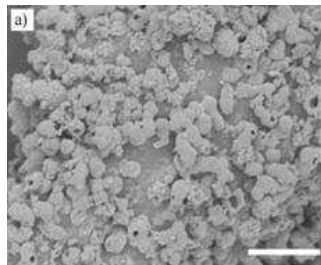
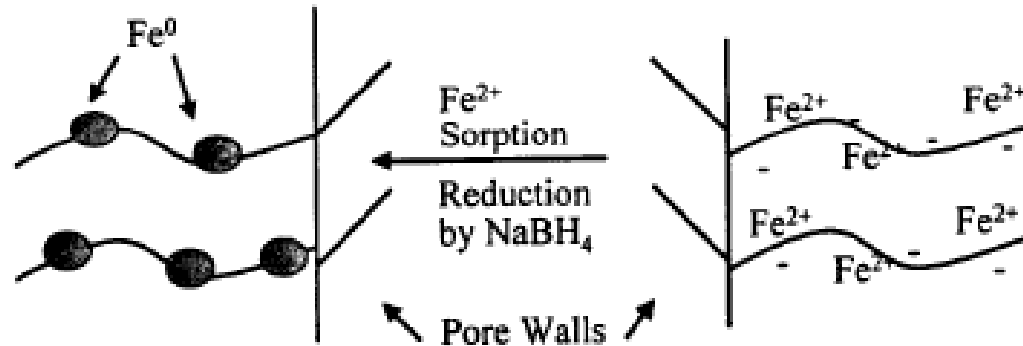
- Structured organic nanomaterials



**SOMS absorbs all small molecule organics from water
Swelling is completely reversible (organic sponge)**

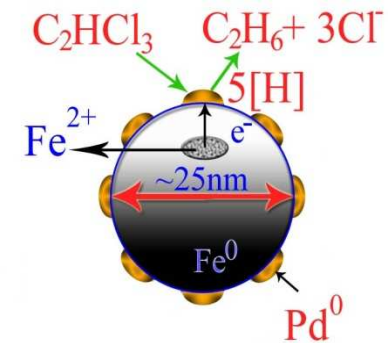
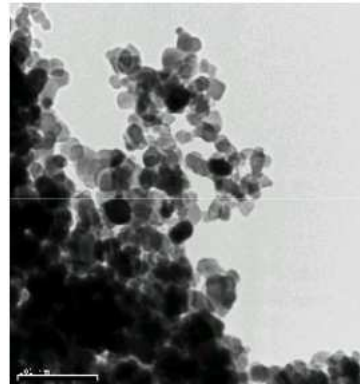
Nanotechnology - Materials and Technologies - Ready for prime Time

- MEMBRANE
 - Nano embedded
 - Nano filtration



Nanotechnology - Materials and Technologies - Ready for prime Time

- NZVI



W Zhang – Lehigh
G Lowry – Carnegie Mellon
D Zhao – Auburn
Y Lu, V John - Tulane

Nanotechnology Research Program Superfund Nano Opportunities

- Sub-surface remediation
- Ground water remediation & protection
- Real-time monitoring and detection



Macalloy Corp. Site, North Charleston, SC,
1000th Superfund site completed



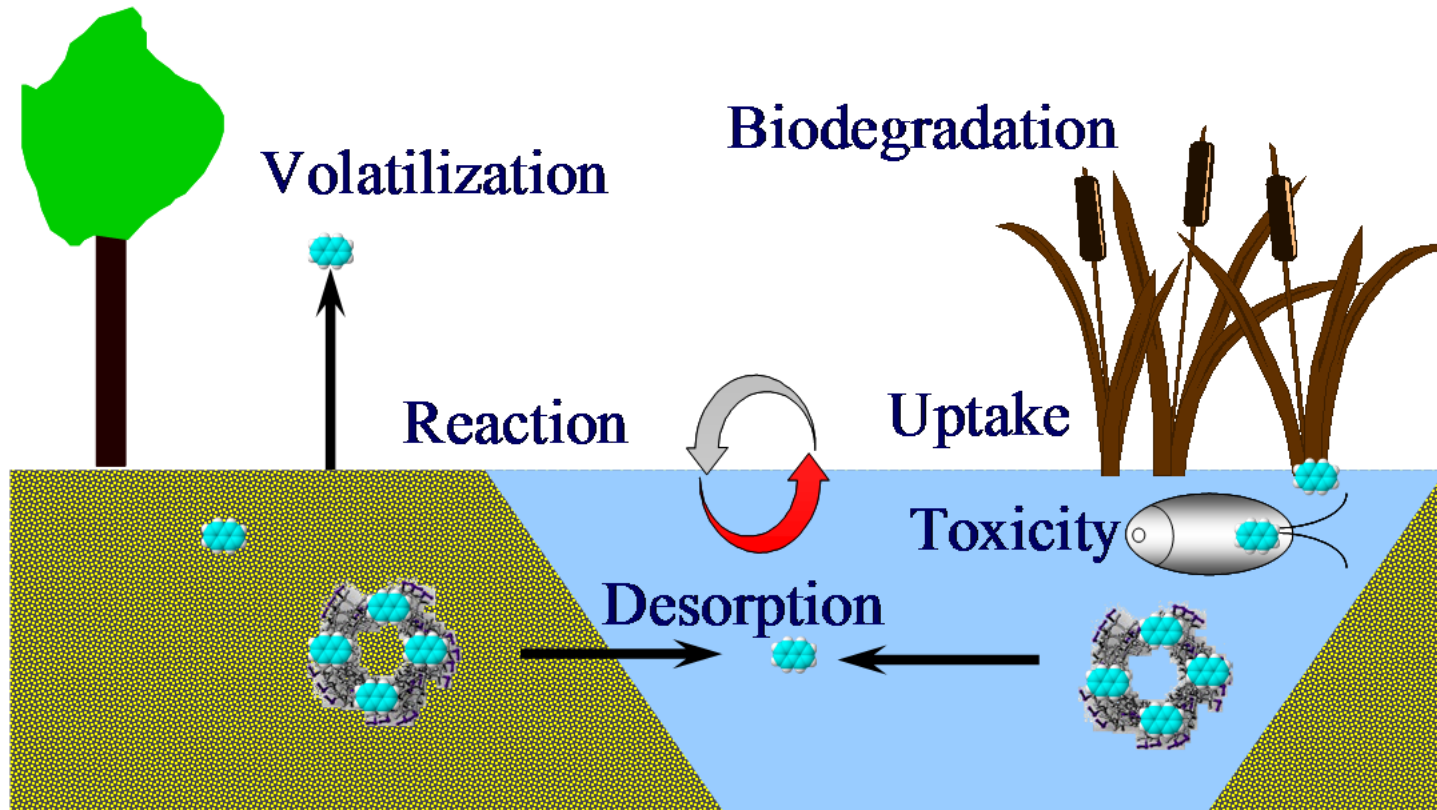
EPA RESEARCH EXAMPLES



Resolution: 5000 x 3750 px
Free JPG file download
www.psdgraphics.com

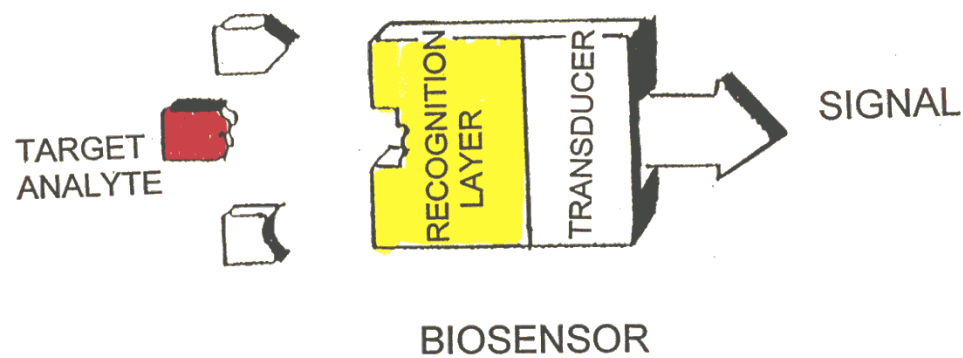
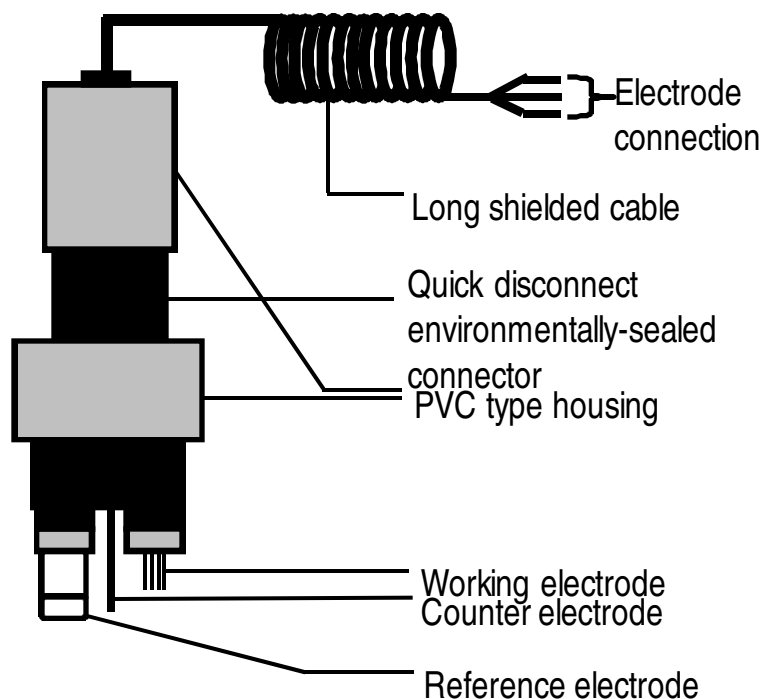
Science To Achieve Results
(STAR)

Nanotechnology Research Program



Absorption and Release of Contaminants Onto Engineered Nanoparticles
Mason Tomson, Rice University

REMOTE ELECTROCHEMICAL & BIO-SENSORS



J. Wang, Department of Chemical & Materials Engineering, Department of Chemistry & Biochemistry, The Biodesign Institute – Center for Bioelectronics and Biosensors, Arizona State Univ

Superfund Nano Opportunities: *Nanotechnology Research Program* Targeted Heavy-Metal Binding

Elastin Domain **Metal Binding Domain**



Fine tune ΔT by controlling amino acid sequence and no. of repeating unit $(VPGXG)_n$

Fine tune affinity with different binding sequence

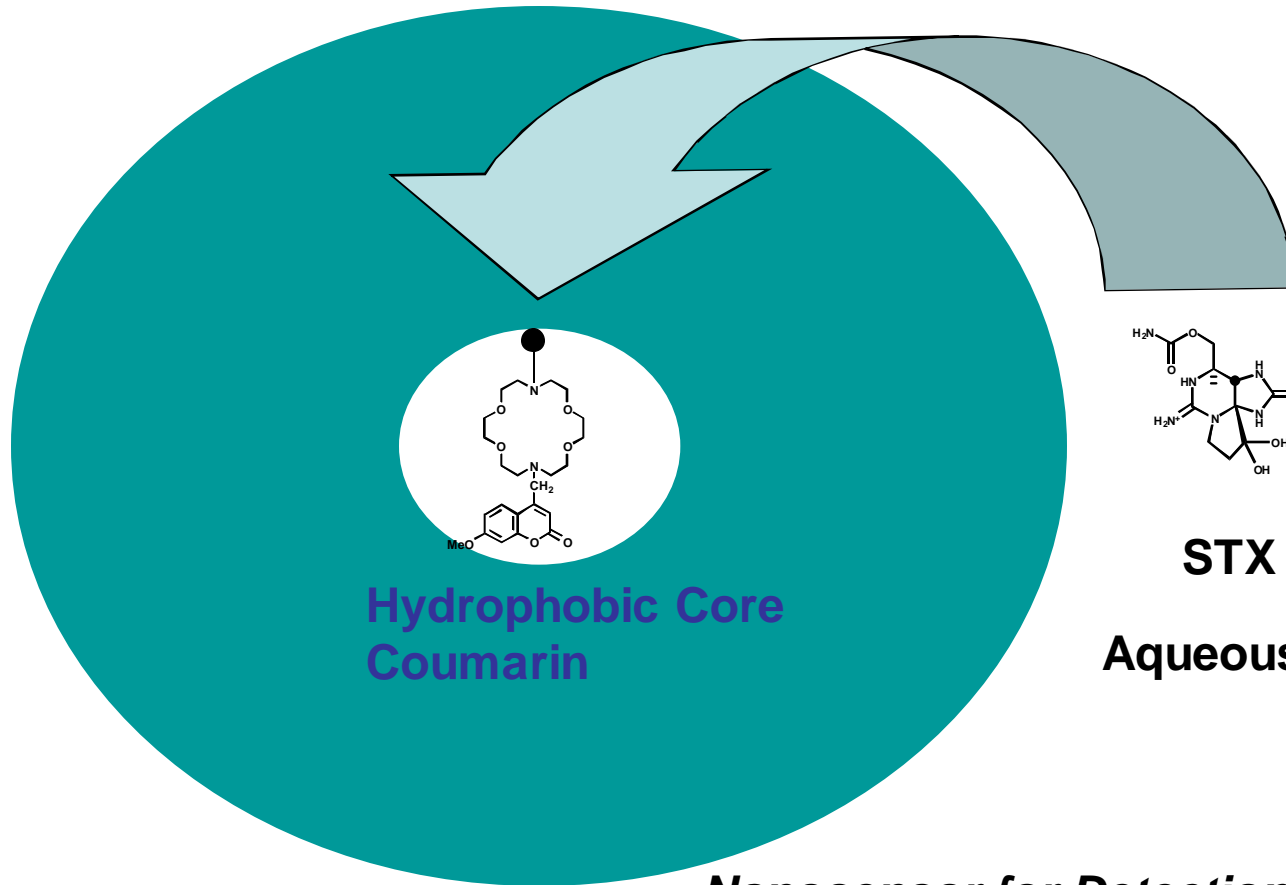
Utilization of a non-toxic polymer to bind heavy metals like arsenic in water or soil

Wilfred Chen, University of CA, Riverside

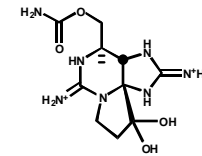
Nanotechnology Research Program

Coumarin Sensor Anchored in Dendrimer

Permeable Walls
of Dendrimer



Hydrophobic Core
Coumarin



STX

Aqueous Solvent

Nanosensor for Detection of Saxitoxin
Robert Gawley, University of Arkansas



Nanotechnology Research Program

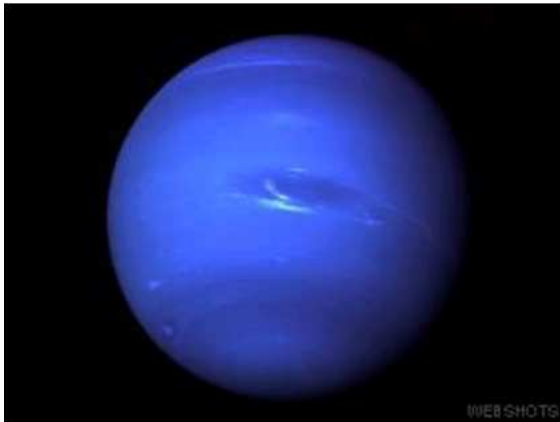
NCER's Nano Web Page

WWW.EPA.GOV/NCER/NANO



Nanotechnology has both applications and implications for the environment. EPA is supporting research in this technology while evaluating its regulatory responsibility to protect the environment and human health. This site highlights EPA's research in nanotechnology and provides useful information on related research at EPA and in other organizations.

NCER's Fellowships & P3 Programs



<http://epa.gov/ncer/p3/>

<http://epa.gov/ncer/fellow/>



Nanotechnology Research Program

Student Opportunities - Fellowships

2-yr financial support for students for Master's students

3-yr financial support for Doctoral students

Provides up to \$42,000 each yr

Up to \$12,000 for tuition and fees

\$25,000/yr for stipend

\$5,000 for expense allowance



Nanotechnology Research Program

110 selected Fall 2011

➤ 2012 Topic Areas

Global Change

Clean Air

Drinking Water

Water Quality

Human Health

Tribal Communities

Ecosystem Services

Pesticides and Toxic Substances

Land Protection

Science & Technology for Sustainability

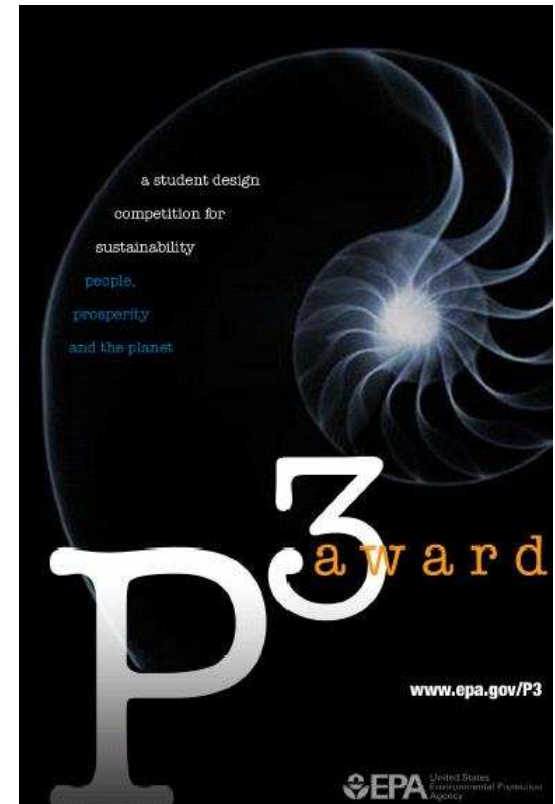
Emerging Environmental

Approaches: Informatics, Social Sciences, Entrepreneurship

Nanotechnology Research Program

Student Opportunities – P3 Awards People, Prosperity & Planet

- Two-phase research grant competition
- Student teams work on real-world projects
- Sustainability challenges worldwide
 - Water
 - Energy
 - Agriculture
 - Built Environment
 - Materials & Chemicals



Student Opportunities – P3 Awards People, Prosperity & Planet

- **P3 Phase I**

- Solicitation open (Sept-Dec)
- \$15,000 Phase I awards
- Participate in the National Sustainable Design Expo on the National Mall (April 21-23, 2012)

- **P3 Program - Phase II**

- Phase I teams submit written *Project Report*
- \$90,000 Phase II awards



Nanotechnology Research Program



Moving Towards....Sustainable Paradigm



Goal Improve QoL

Positive Economic Climate

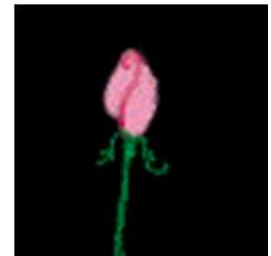
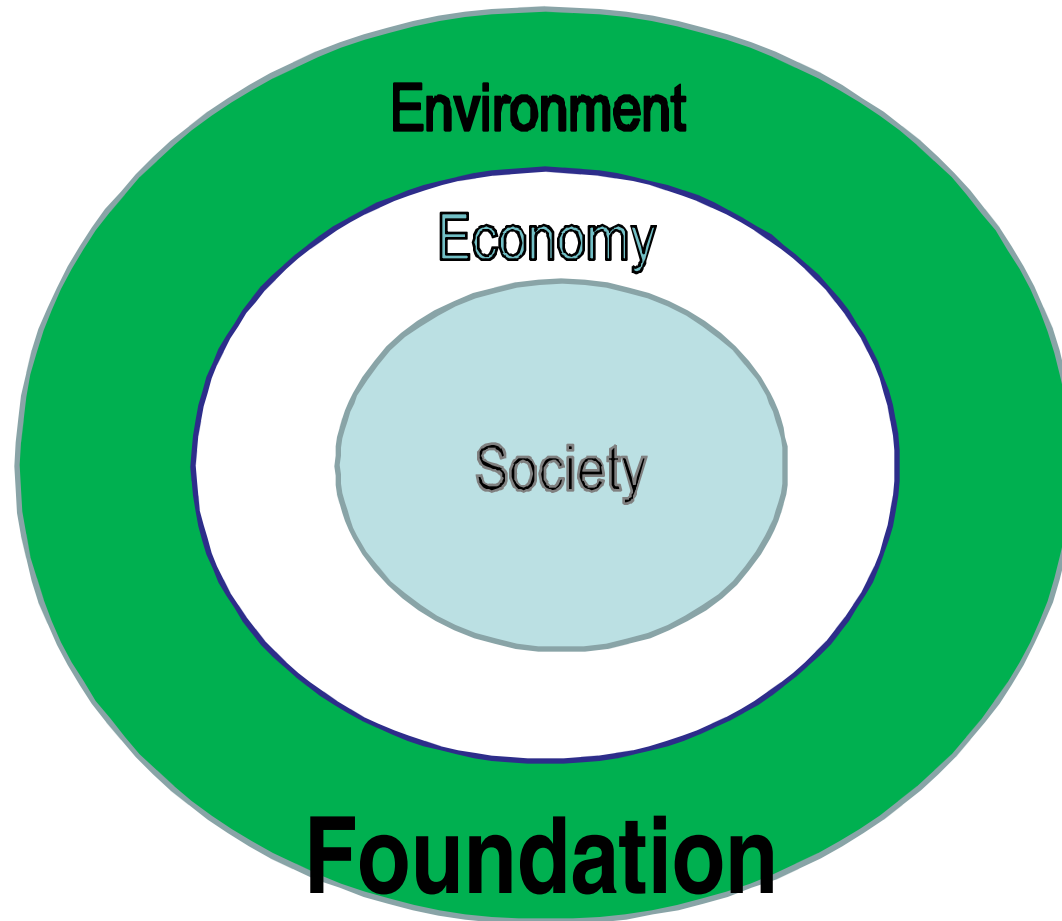
Foundation is Healthy Environment

Sustainable Paradigm

- If burdened with environmental toxins:
- Increased health problems → higher med bills
- Salary and poor air or water quality?
- Equity & Parity – increased and more pronounced divide between well-to-do and poor

Nanotechnology Research Program

Sustainable Paradigm





Nanotechnology Research Program

Contact Information

<http://www.wired.com/underwire/2011/09/nano-techno-rap/>

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National Center for Environmental Research

<http://www.epa.gov/ncer/nano>

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Office of Research and Development