Nanotechnologies for Site Remediation

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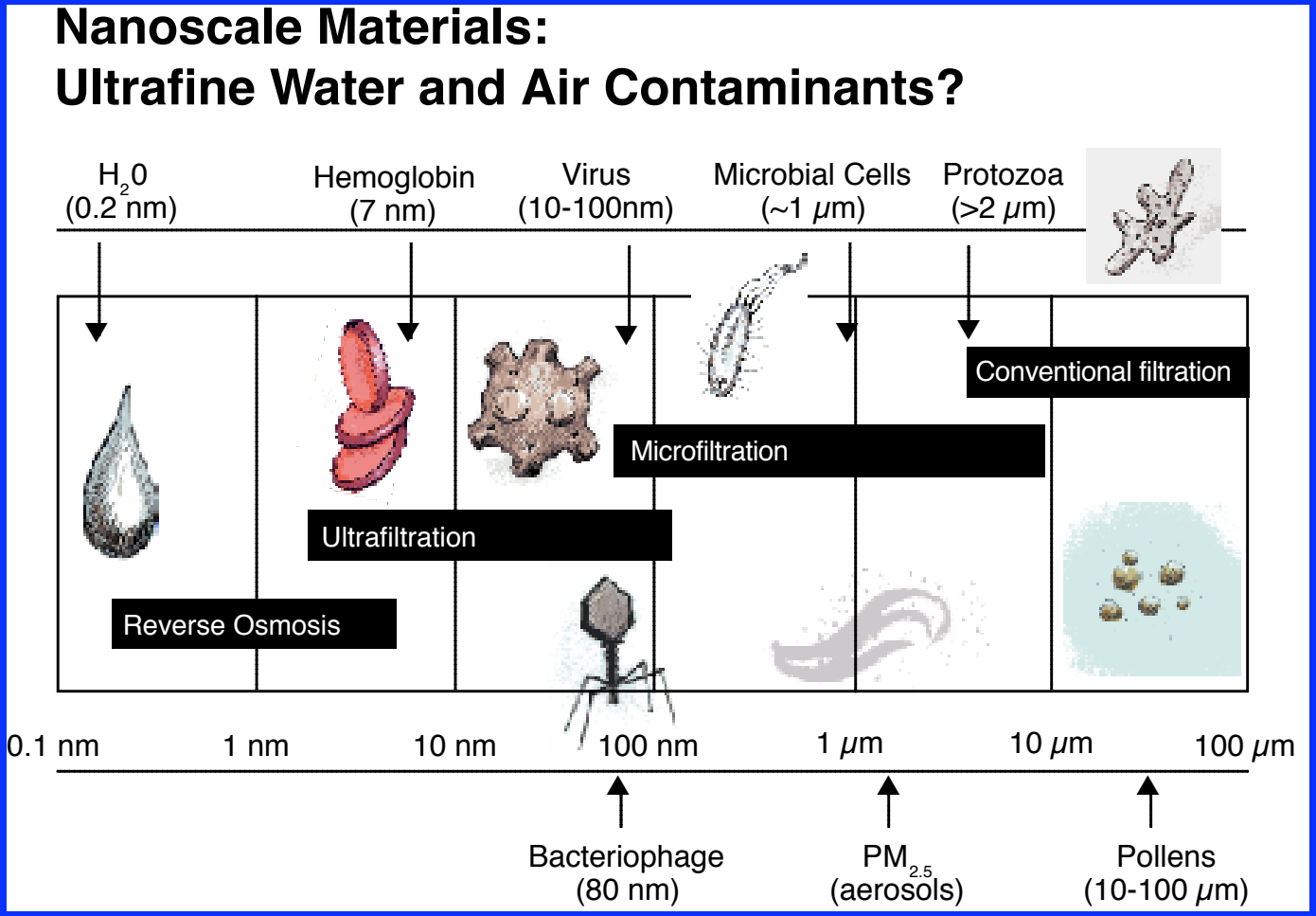
Environmental Engineering
Advanced Materials & Nanotechnology

LEHIGH University

Nanoscale has already been with our profession …



Micropollutants

Nanopollutants

Nanotechnology is…

the art and science of manipulating matter at the atomic or molecular scale

Size

a billionth (10^{-9}) meter

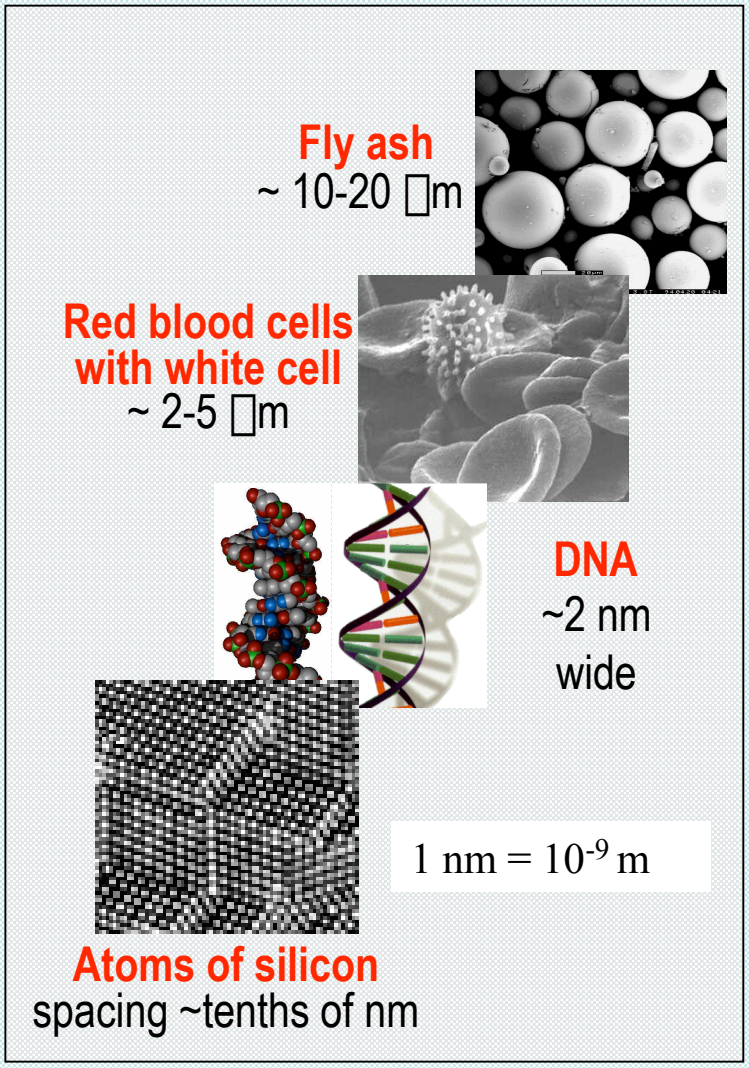
Structure

How things are put together -- arranged or assembled.

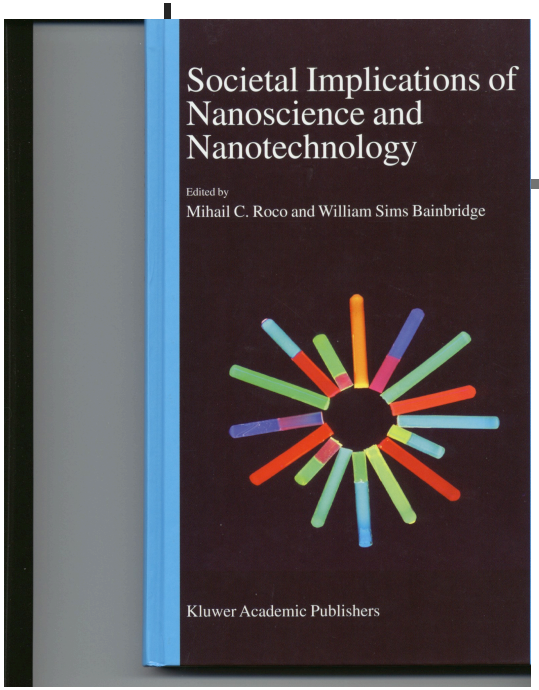
Novel properties

Novel and significantly changed physical, chemical, and biological properties

The ultimate goal of nanotechnology is to build essentially anything from scratch, atom by atom



Societal Implications of Nanotechnology



10^{12} dollar economy in 15-20 years

Impact on Productivity & Equity

Economic scenarios

Implications to Quality of Life

Ethical, historical, governance, risk, uncertainty

Public policy, international aspects

Converging Technologies

Social networks

Education, human development

A Framework for Nano & Environment

Applications

reactive to existing problems

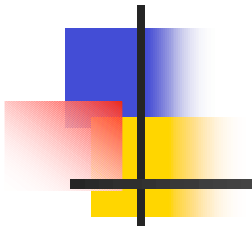
or

proactive in preventing future problems.

Implications of

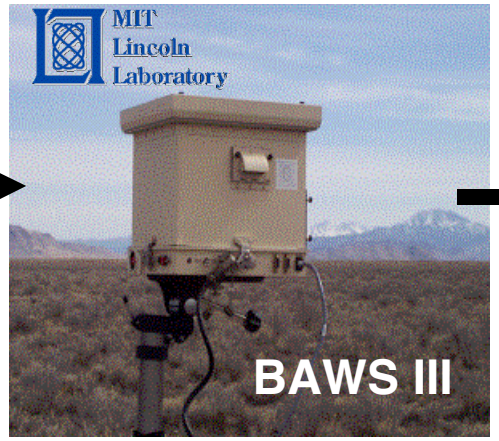
interactions of nanomaterials with the environment and possible risks that may be posed by the use of nanotechnology.

Environmental Technologies at the Nanoscale

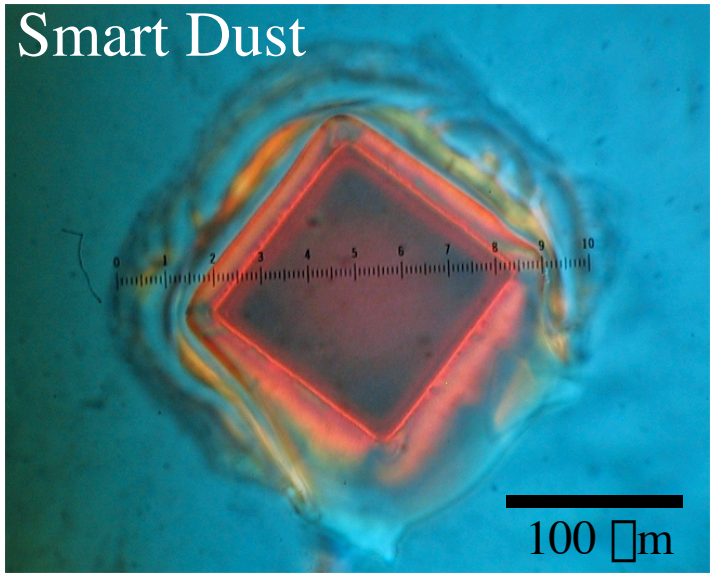


Nano Sensors

Nano Sensors



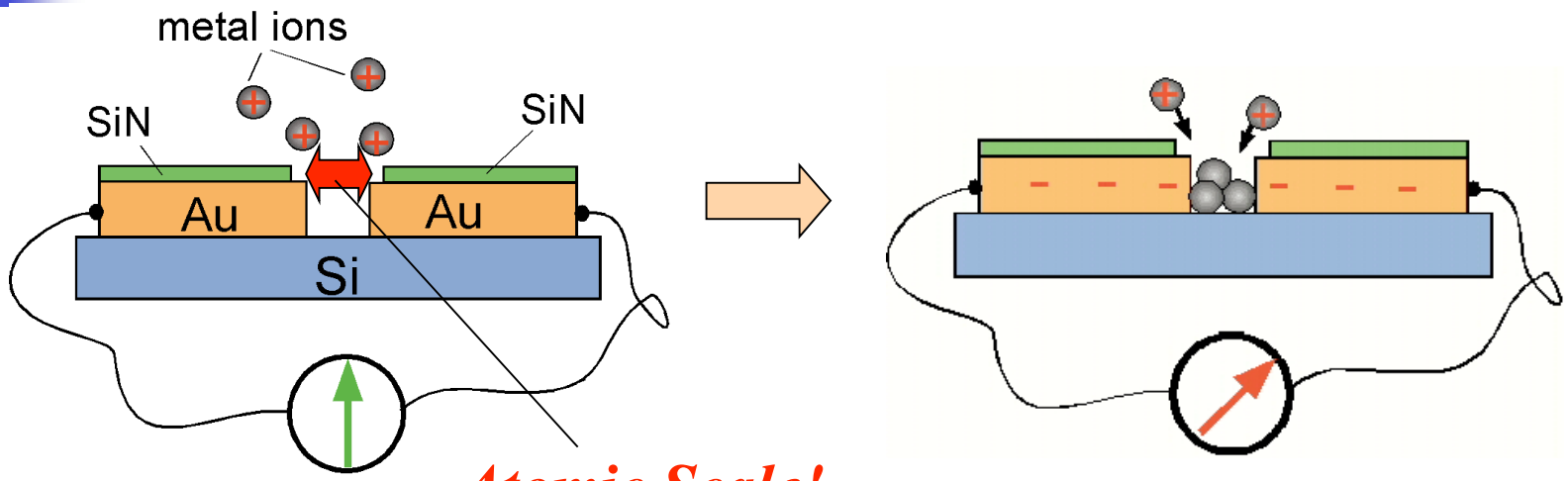
Small
Low Power
Highly distributed
Cheap



Nature Materials **2002**, *1*, 39-41.

Nanocontact Sensor

N.J. Tao (Arizona State)

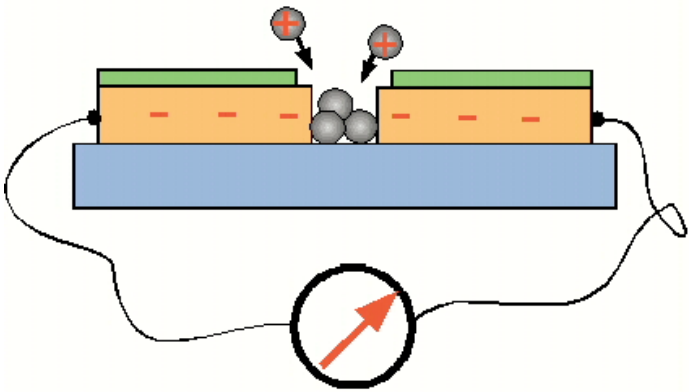


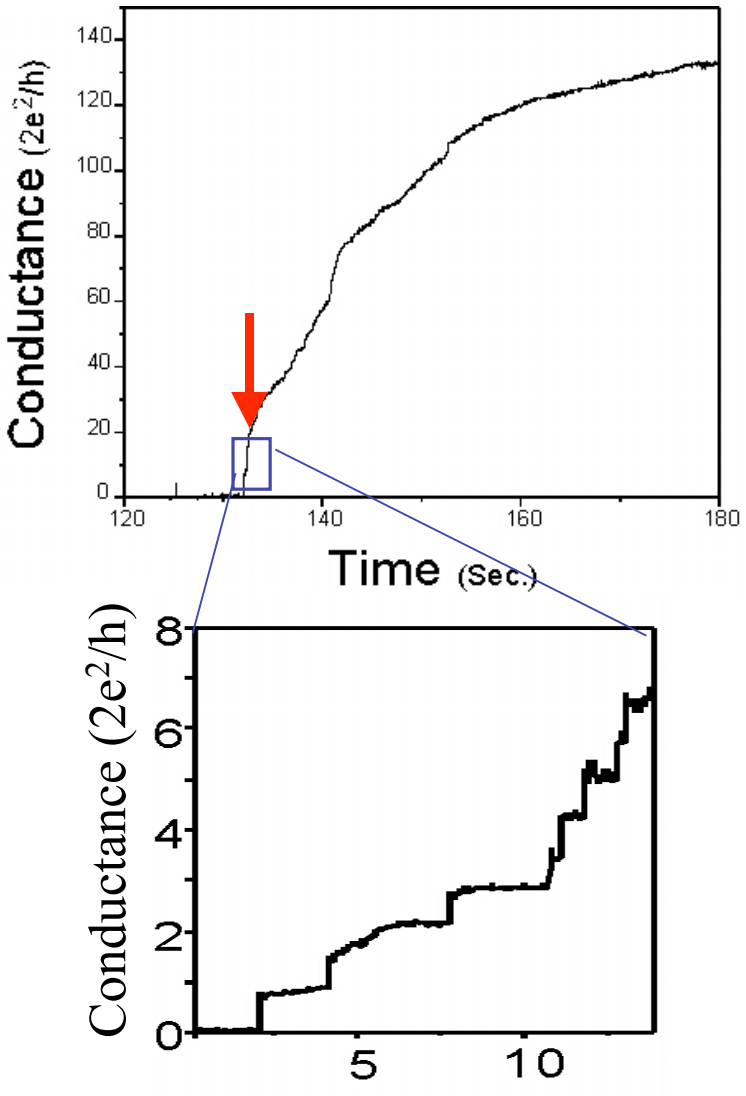
Atomic Scale!

Sensitivity:

The electrodes are separated with an atomic-scale gap,
so **a few ions can be detected**.

Deposition of Metal Ions

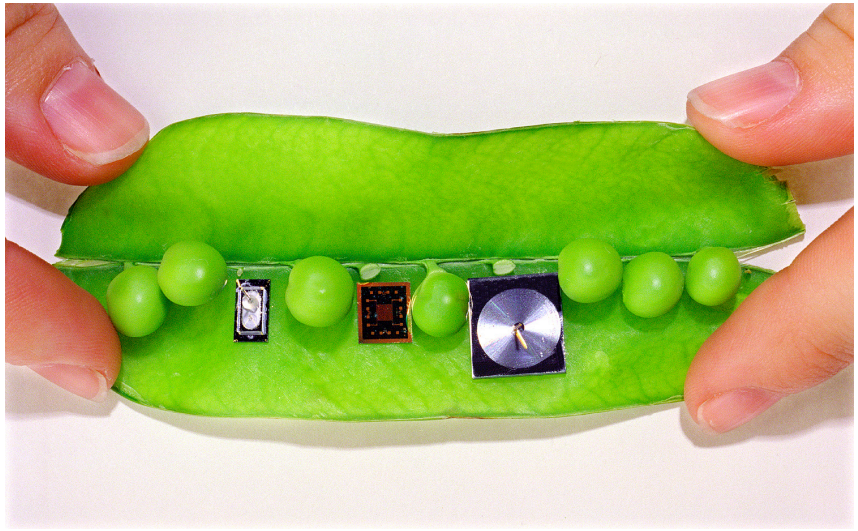




➢ **Conductance Quantized!**

Number of metal atoms ~ Conductance in quantum unit ($G_0=2e^2/h$).

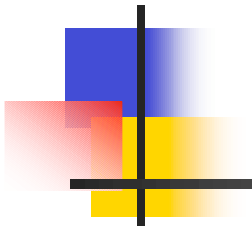
LAB IN A PEAPOD
(Sandia Lab)



Three principal components of Sandia's integrated micro chem lab are small enough to fit easily inside a snow-pea pod. Shown from left to right are a surface acoustic wave sensor array, a preconcentrator that collects chemical vapors for gas-phase analysis and a miniature gas chromatograph column. The entire system, designed to also analyze liquid samples, fits into a package about the size of a thick paperback book. (Photo by Randy Montoya)

http://www.sandia.gov/media/NewsRel/NR2000/labchip.htm

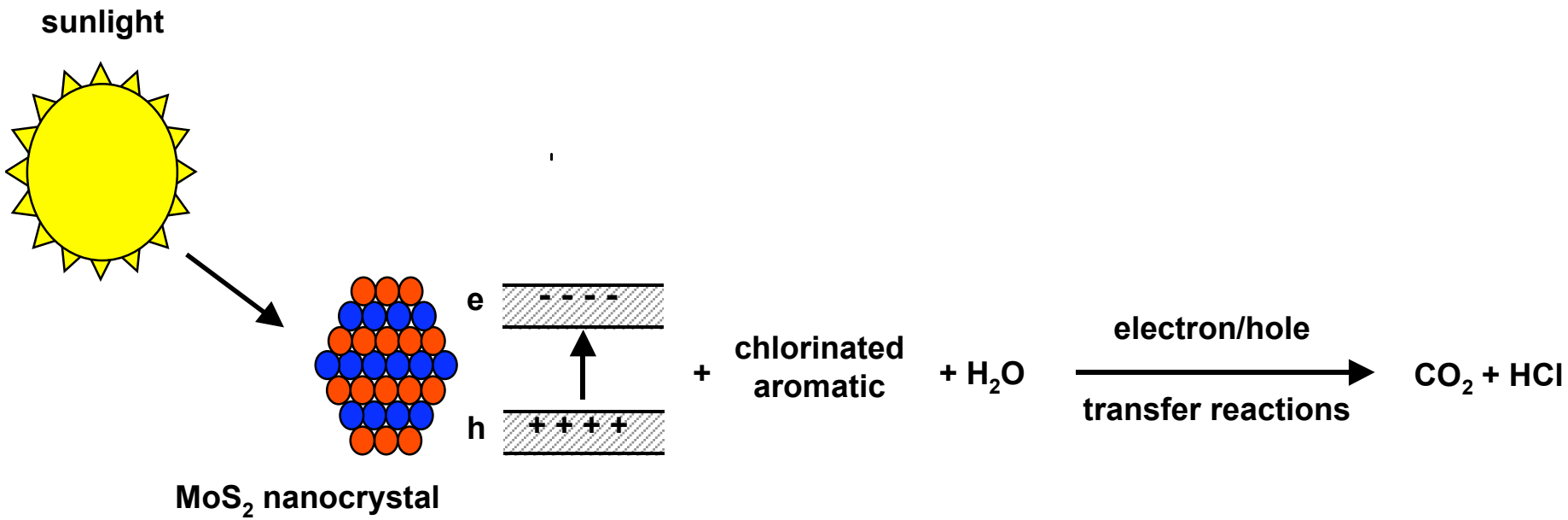
Environmental Technologies at the Nanoscale



Nano Catalysts & Reactants

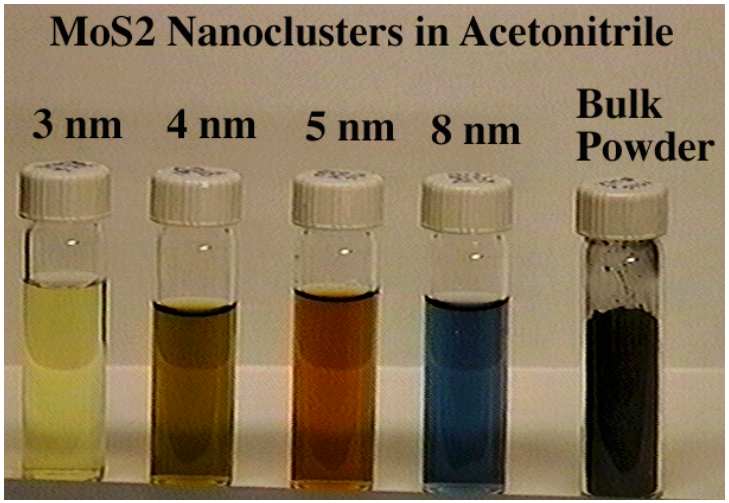
Photochemical Transformation

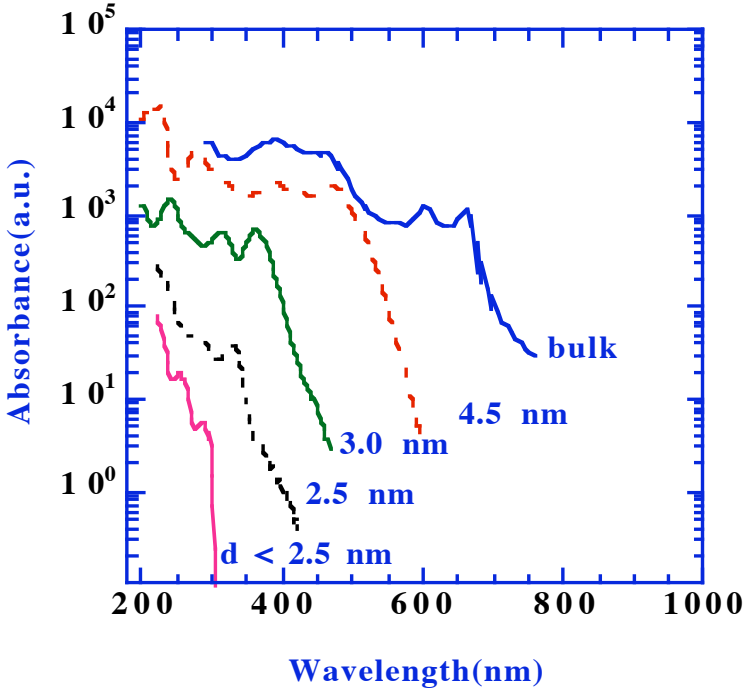
Use stable, inorganic, semiconductor nanoclusters with tunable bandgaps to oxidize organic chemicals using sunlight



Clusters can be used in both dispersed and heterogeneous forms (supported)

Quantum Size Effects influence the optical and electronicproperties of the resulting solutions-

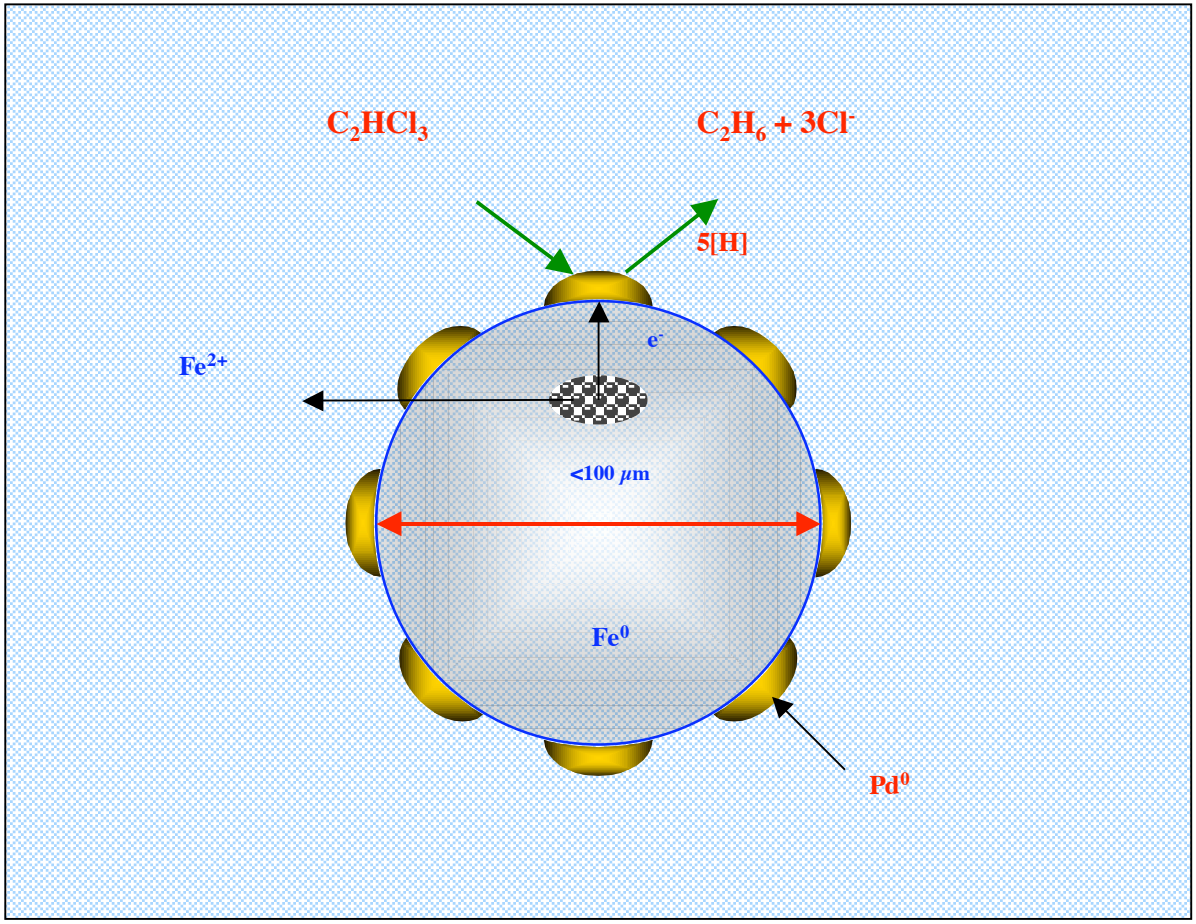




By adjusting the size alone, the conductance and valence band energy levels can be shifted allowing new types of photocatalytic behavior to occur

Wilcoxon, Sandia

Nanoparticles (~50 nm)

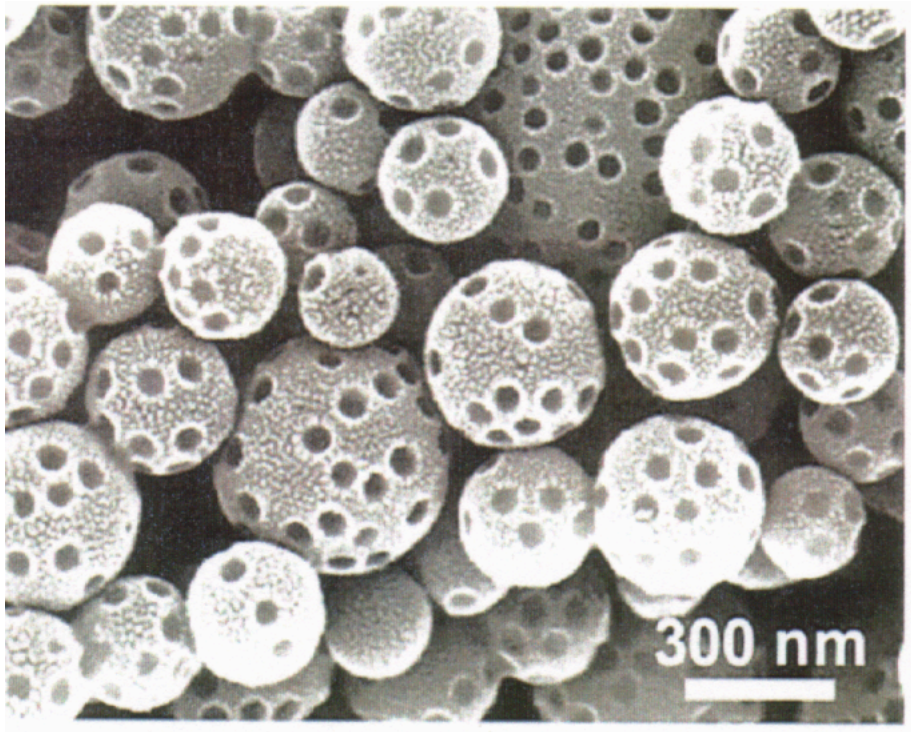


Environmental Technologies at the Nanoscale

Nano Sorbent

Nanocomposites

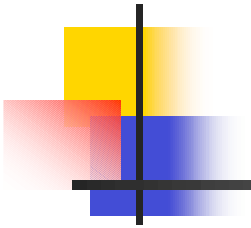
TECHNICOLOR SORBENT
A mesoporous silica support with a mercaptopropylsiloxy monolayer covering the pore surfaces is shown at bottom, and an enlarged view of a monolayer-coated pore is in the background. Red spheres = oxygen, orange = silicon, magenta = carbon, white = hydrogen, yellow = sulfur, and blue = mercury, which binds to sulfur and is thus sequestered from solution.



Nanotube as Supersorbent

SWNT for Dioxin Sorption (Long & Yang, 2001, JACS)

Sorbent	E (kJ/mol)	B (atm^{-1})
SWNT	315	2.7×10^{52}
Activated Carbon	119	1.3×10^{18}
□-Al_2O_3	47.9	4.5×10^{5}



There is always potential for harm to human health and the environment

Potential Problems

a lot of nano pollution?

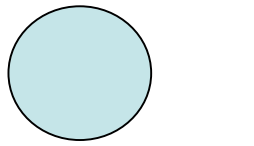
May create waste or inhibit disposal and recycling efforts

May release hazardous materials into the environment

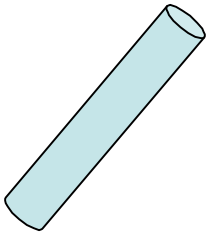
Could lead to biological harm by possibly penetrating and accumulating in cellular material.

May facilitate transport of toxic materials in the environment

"Nanomaterials Won't be 'Inert'"



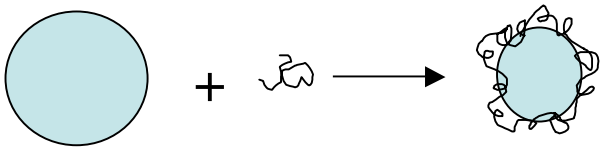
Nanocrystals



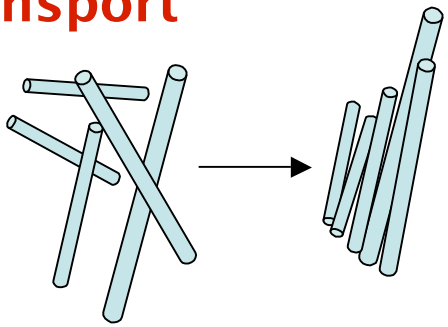
Nanotubes

Colvin and Weisner
Rice University

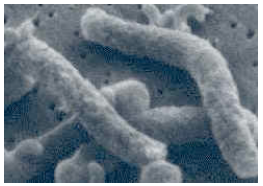
1) Adsorption



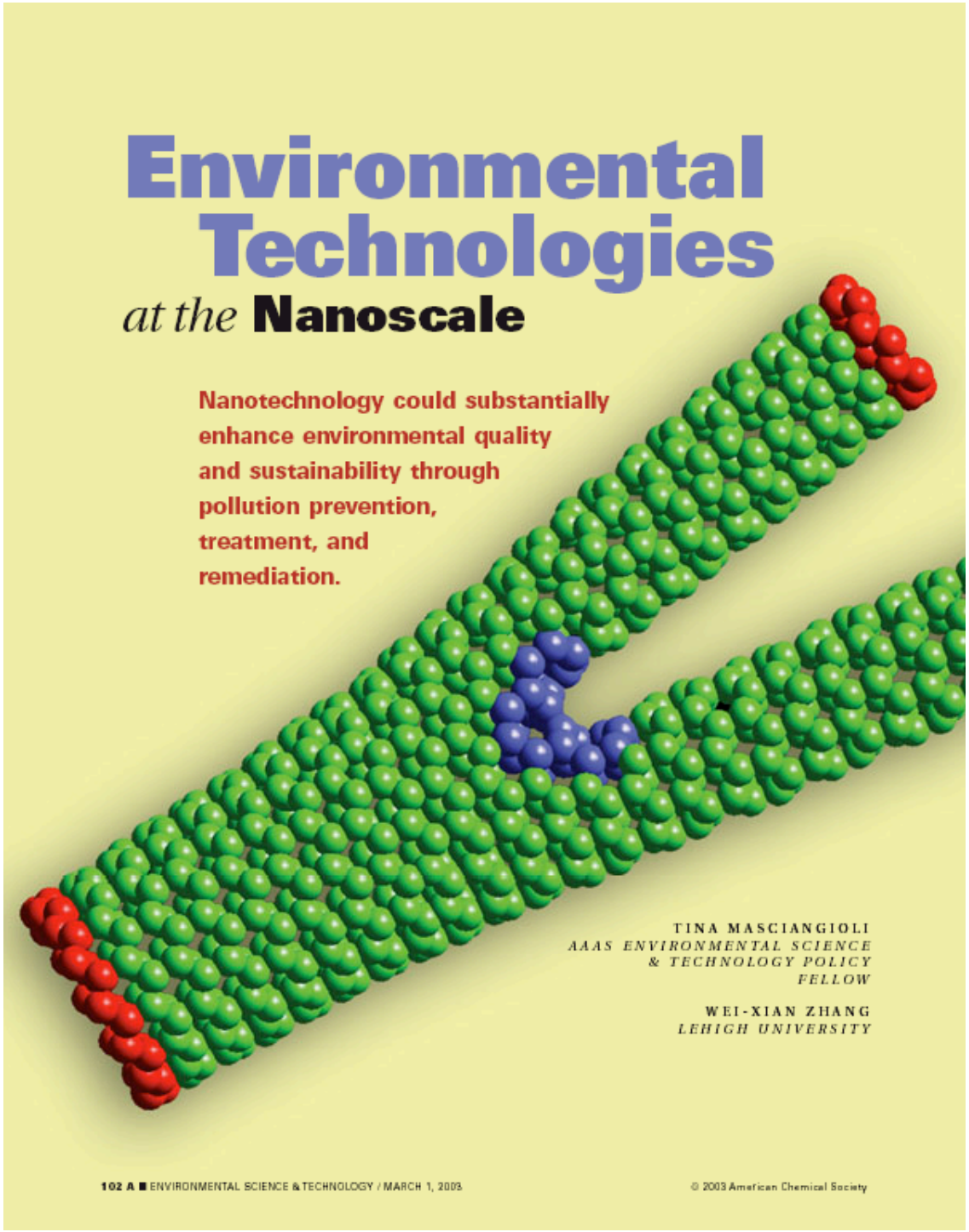
2) Transport



3) Biotic Uptake



4) Toxicity



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73A - 112A

Masciangioli
&
Zhang