나노 기술의 이해
(Understanding Nanotechnology)

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Lecture 4.
Problems and Challenges in Nanotechnology

Lecture Review

Lecture 1

History of Nanotechnology

- Definition of Nano Size
- Feynman's Lecture

Lecture 2

Introduction to Nanotechnology

- Definition of Nanotechnology
- Briefing about the Advancement of Nanotech.

Lecture 3

Scanning Probe Microscope

- STM
- SEM, TEM

Fundamental Problems in Nanotech.

Biological & Environmental Problems

Uncertainty of Nano-scale phenomenon

Social Responsibility, ethics...

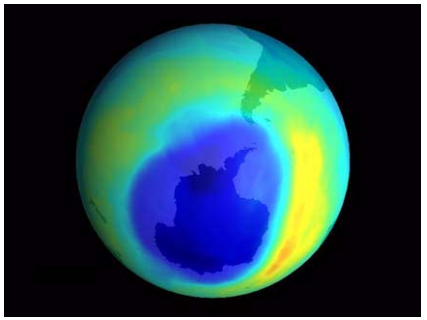
Biological & Environmental Problem

Lessons from Earlier Technologies

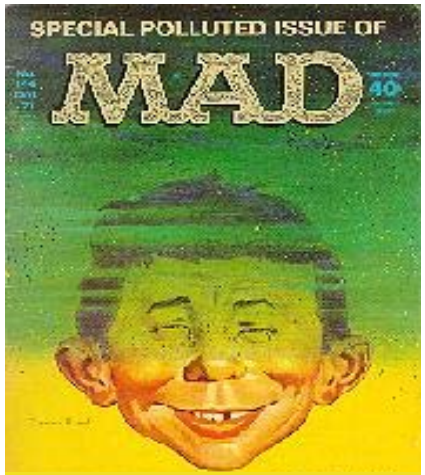
- Past failures to consider environmental consequences early have been costly:
  - ✓ semiconductor industry (metals, solvents)
  - ✓ synthetic chemicals (PCB, DDT, Freon)
  - ✓ applications of natural compounds (chlorine, asbestos)
  - ✓ transportation, energy (air pollution, global warming, nuclear wastes)

- Small adjustments early in the trajectory of a technology have large consequences.

- Must introduce the environmental perspective early into the culture of emerging technologies (research and educational missions).



Ozone hole



What – Me Worry ?

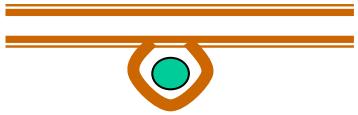
Biological & Environmental Problem

- **Naturally occurring "ultrafine particles"**
  - *Virus – 10 nm to 60 nm*
  - *Bacteria – 30 nm to 10 μm*
  - *Dust from deserts - ~100 nm*
  - *Volcanic ash, Forest fire smoke*
- **"Ultrafine particles" from established technologies or by-products of conventional processes**
  - *Combustion soot – 10 nm to 80 nm*
  - *Paint pigments – 80 nm to 100 nm*
  - *Welding fumes – 10 nm to 50 nm*
  - *Diesel exhaust particles – (small mode) 7 nm to 40 nm*
  - *Carbon black for photocopier toner – 10 nm to 400 nm*
- **Engineered nanoscale materials – "nanomaterials"**
  - *Fullerenes - buckyballs – 1 nm; nanotubes – 1 nm to 5 nm X 10 μm*
  - *Quantum dots – 5 nm to 20 nm*
  - *Semiconductor wires*

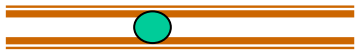
Biological & Environmental Problem

Nanoparticles may enter living cells via:

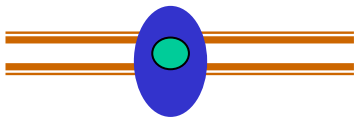
- ✓ **Endocytosis**
  - Receptor activation for initiation



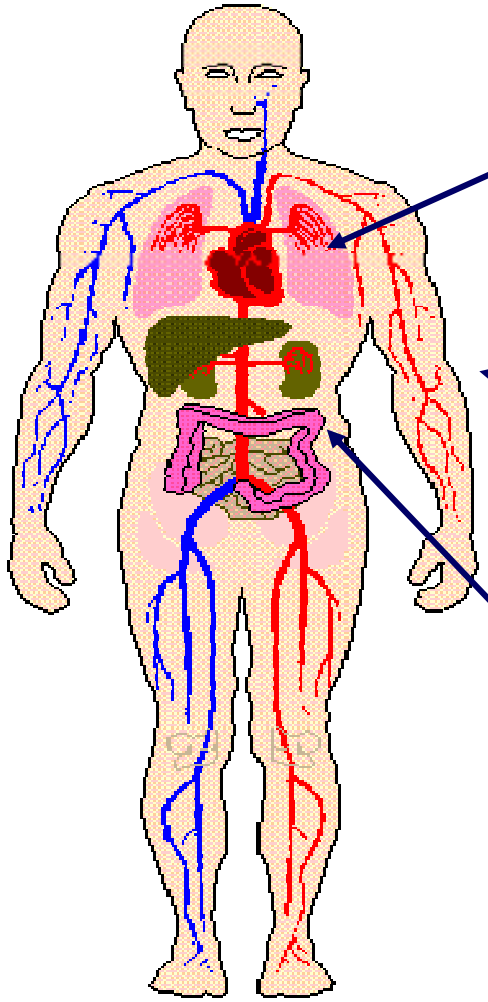
- ✓ **Membrane penetration**
  - Generally occurs with very hydrophobic par ticles



- ✓ **Transmembrane channels**
  - May be seen with very small nanoparticles (< 5 nm?)



Biological & Environmental Problem



Inhalation: Inhaled particles induce inflammation in respiratory tract, causing tissue damage.
Example: Inhalation of silica particles in industrial workers causes “silicosis”.

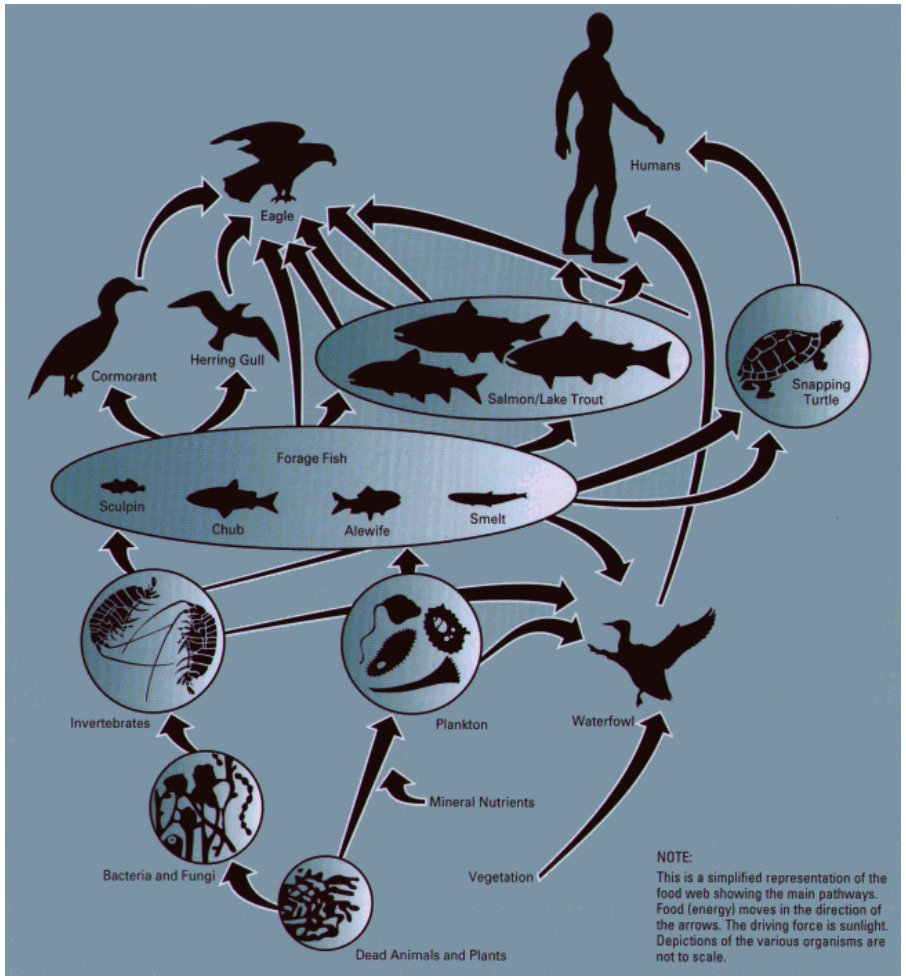
Dermal exposure: Particles may enter body through the skin. Potential hazards are unknown at present.

Ingestion: nanoparticles may cause liver damage. Ingested nanoparticles (i.e. for oral drug delivery) have been found to accumulate in the liver. Excessive immune/inflammatory responses cause permanent liver damage.

Biological & Environmental Problem

Bio Accumulation & Bio Uptake

- Accumulation of a substance within a species due to lack of degradation or excretion
- Most nanoparticles are not biodegradable
- If nanoparticles enter organisms low in the food web, they may be expected to accumulate in organisms higher in the food web



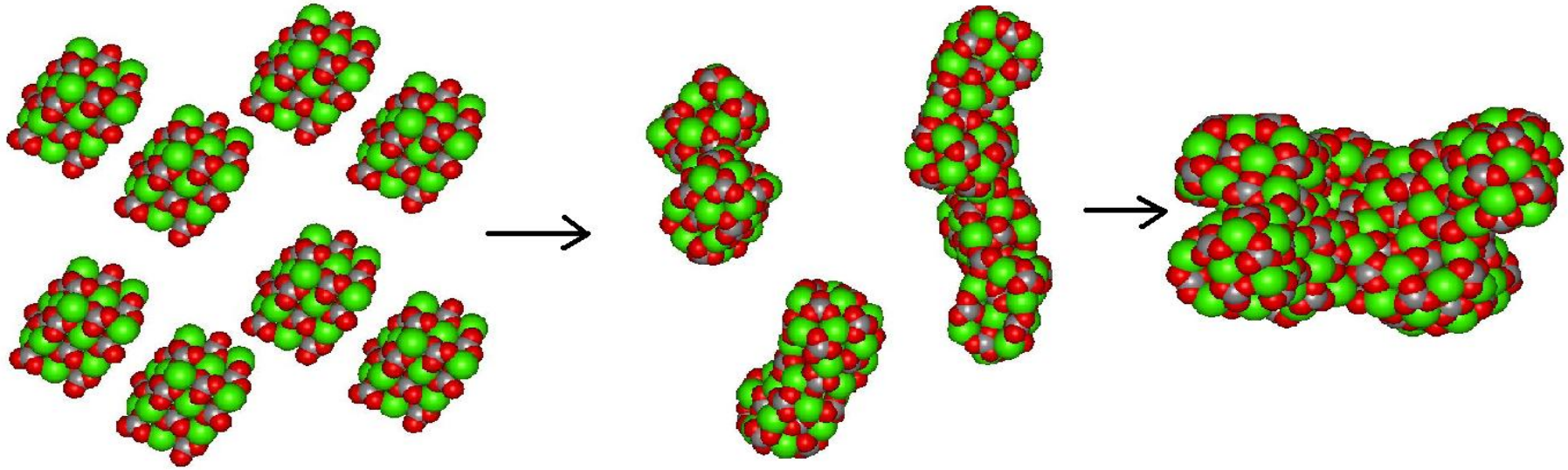
Biological & Environmental Problem

- Accumulation of a substance within a species can occur due to lack of degradation or excretion.
- Many nanoparticles are not biodegradable.
- If nanoparticles enter organisms low in the food web, they may be expected to accumulate in organisms higher in the food web.

Very little is understood about possible health effects of nanoparticle exposure !!

Uncertainty of Nano-scale phenomenon

< Aggregation >



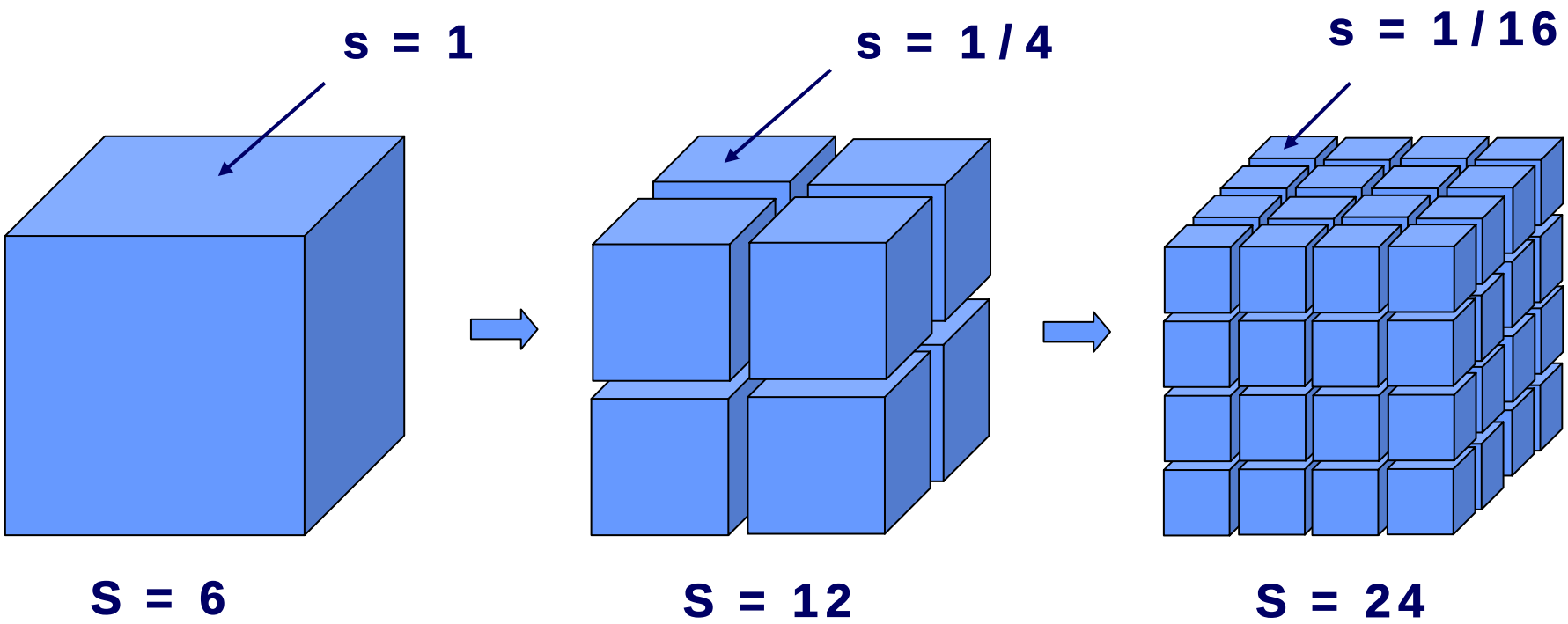
Initial configuration of 8 calcite nanocrystals

Aggregation occurs

Final configuration

Uncertainty of Nano-scale phenomenon

Main reason of Aggregation



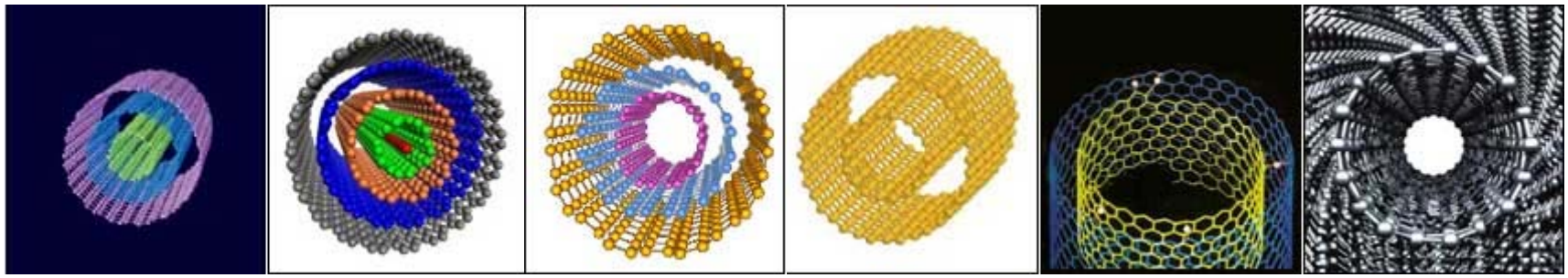
Surface area ↑, Reactivity ↑

Uncertainty of Nano-scale phenomenon

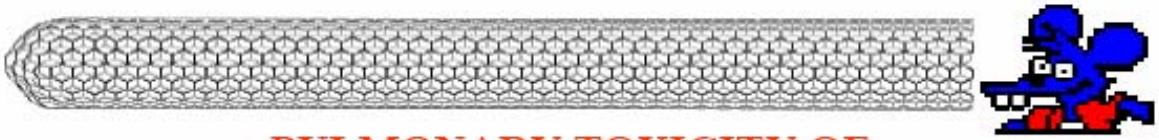
< Toxicity with Usefulness >

Ex) CNT(Carbon Nano Tube)
- Young's modulus : 1.2 terra pascals
- Light weight
- Thermal conductivity
- Electrical conductor
- Composed by C60

Bring about Cancer
DNA damaged



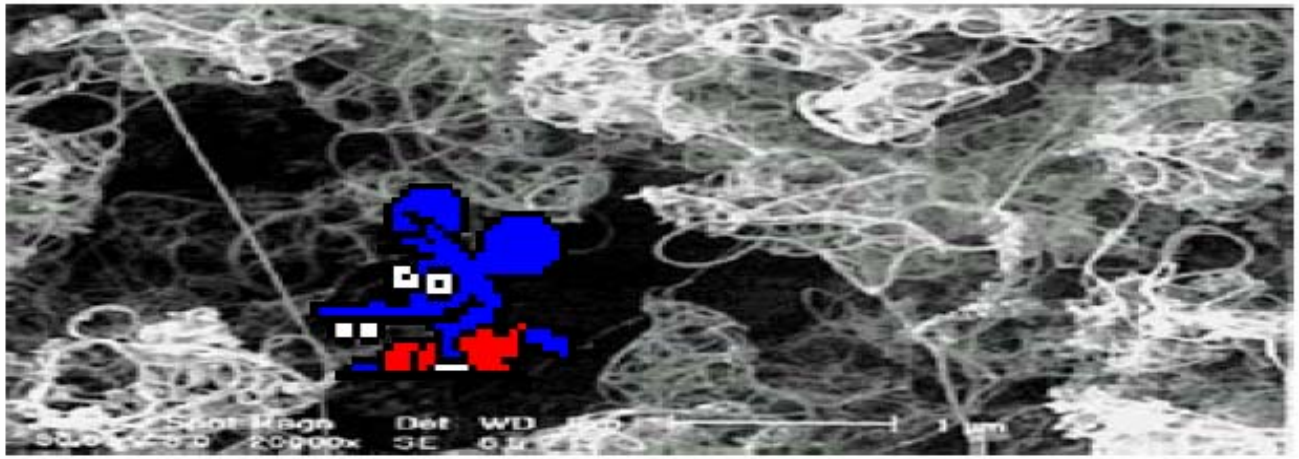
Uncertainty of Nano-scale phenomenon



PULMONARY TOXICITY OF SINGLE-WALLED NANOTUBES IN MICE

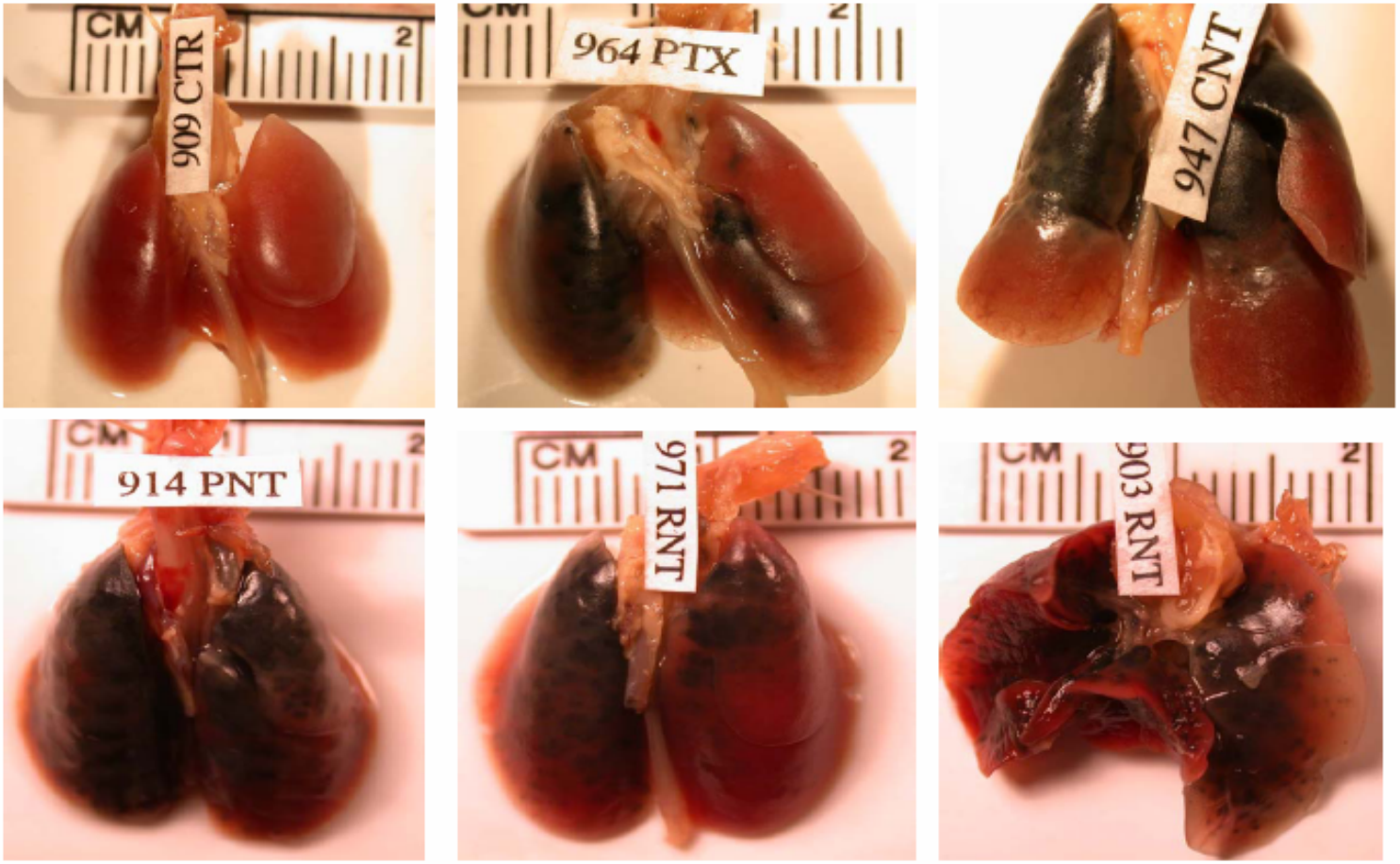
Chiu-wing Lam, Ph.D.
JSC Toxicology Group, and Wyle Laboratories
NASA Johnson Space Center, Houston, TX

John T. James, Ph.D. /NASA
Richard McCluskey, M.D., Ph.D/NASA
Robert L. Hunter, M.D.,Ph.D./UT Med. Ctr.



Uncertainty of Nano-scale phenomenon

Lungs from Mice of HD-90d Groups



Uncertainty of Nano-scale phenomenon

< Same material Different color >

Ex) Quantum Dot

Is there any possibility of misuse??

Social Responsibility, ethics…
Need Understanding & Responsibility

"Military applications of molecular manufacturing have even greater potential than nuclear weapons to radically change the balance of power."

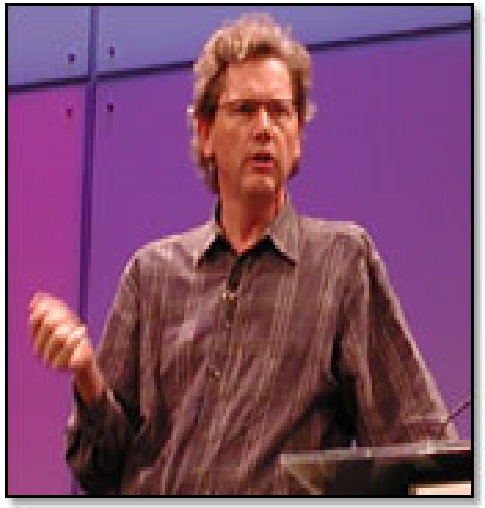
Admiral David E. Jeremiah, USN (Ret)
Former Vice Chairman, Joint Chiefs of Staff
November 9, 1995

"Even with all its unknowns, even with all its perils and risks, who'd say no to nano?"

Ed Regis, author of *Nano, the emerging science of nanotechnology: remaking the world – molecule by molecule*, 1995, p.308

Social Responsibility, ethics…
Need Understanding & Responsibility

"Our most powerful 21st-century technologies : robotics, genetic engineering and nanotech are threatening to make humans an endangered species."



Bill Joy

http://www.wired.com/wired/archive/8.04/joy.html

"If everyone has this technology, then if it *can* be abused, it *will* be abused. And if it can destroy the biosphere, that's threat enough for me."

K. Eric Drexler

For the next step

Size Down to Nano

Political Investment

Ability to Control

Keep In Mind !!

The Fundamental Problems Of Nanotechnology

Nano Physics

Nano Fabrication

Nano Application