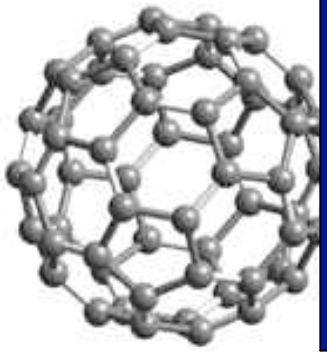
Nanotechnology, Society, & the Engineer

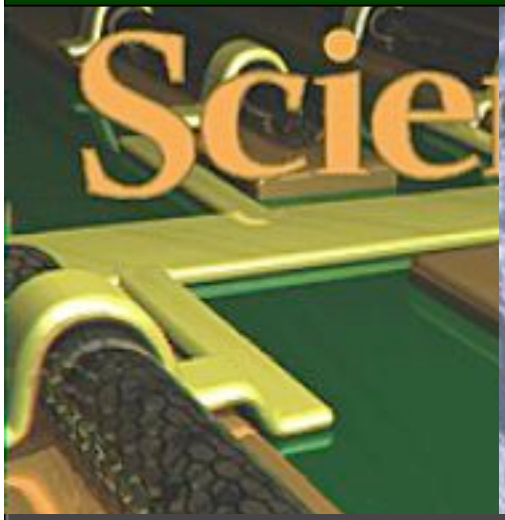


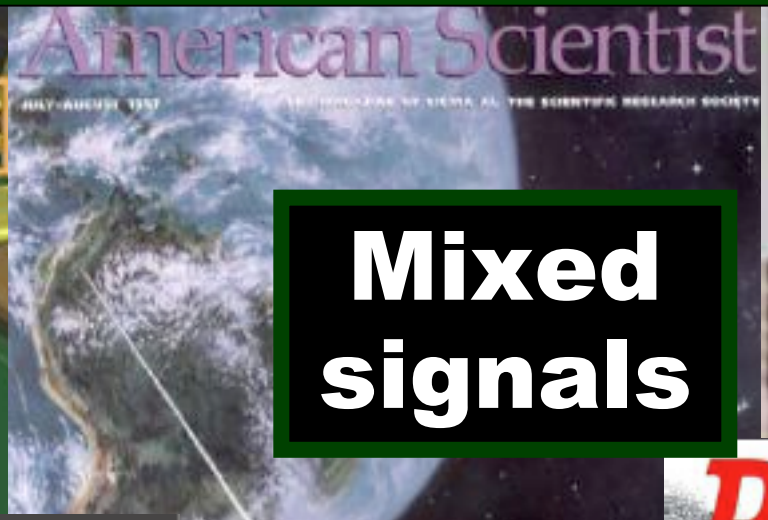
Guest Lecture
Introduction to Engineering 160
November 17 & 18, 2004
University of Wisconsin, Madison

Outline for Today

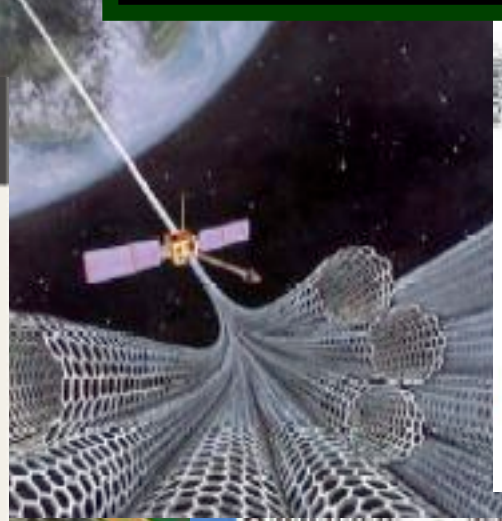
- **Introduction to Nano** [Charlie Tahan]
- **Group Discussions & Reports**
- **Societal Implications** [Ricky Leung]
- **Wrap-up and Survey**

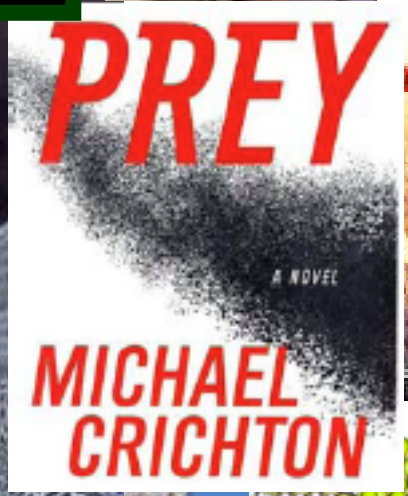
Nanotechnology

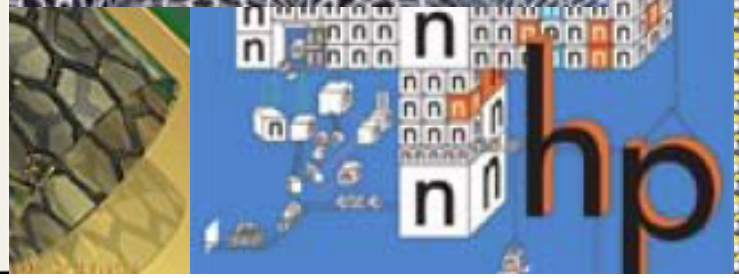


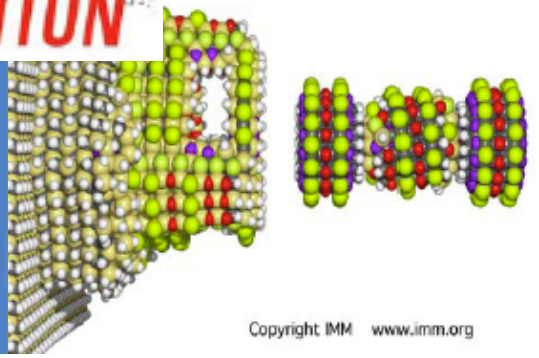


Mixed signals







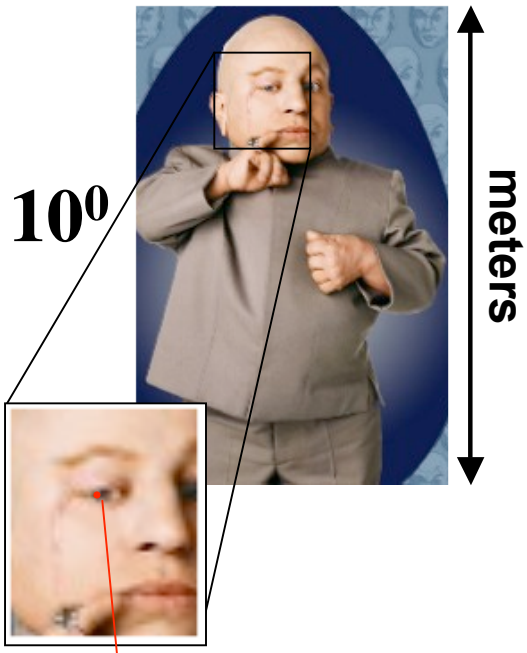


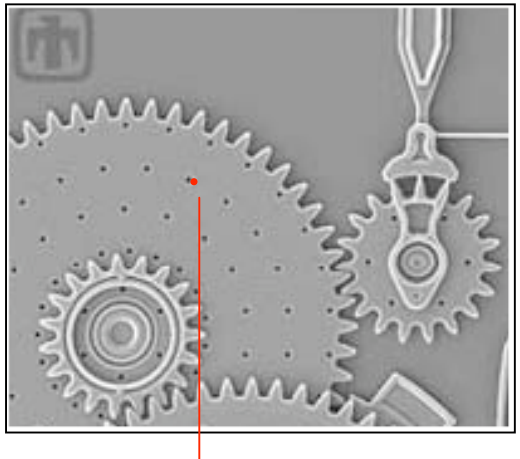
Nanotechnology

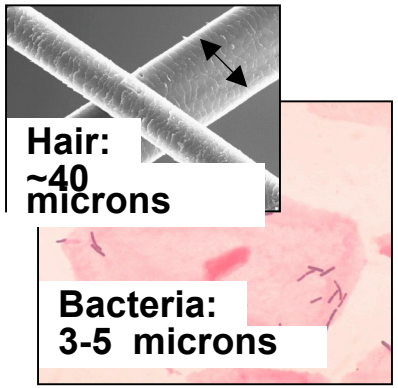
kilometer	km	1000	$1X10^{3}$
meter	m	1	$1X10^{0}$
millimeter	mm	1/1000	$1X10^{-3}$
micrometer	μm	1/1000000	$1X10^{-6}$
nanometer	nm	1/1000000000	**$1X10^{-9}$**
angstrom	Å	1/10000000000	$1X10^{-10}$

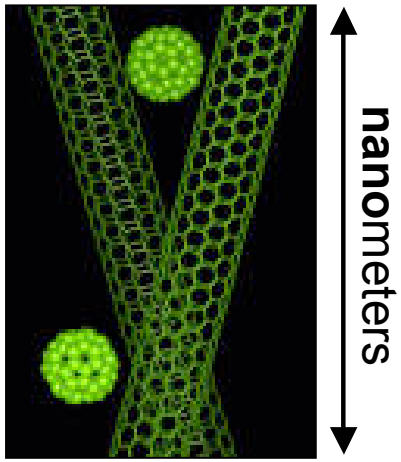
A nanometer is one billionth of a meter

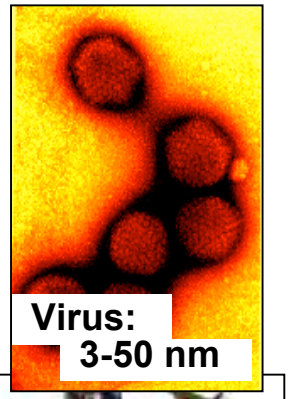
Size and Scale: Factors of 1000

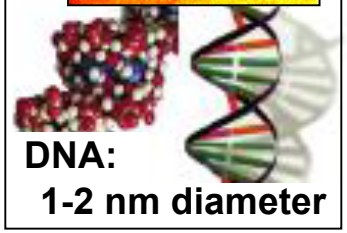










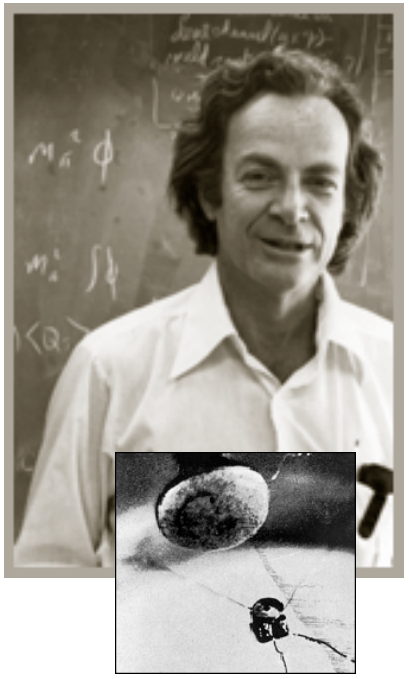


1 nm = 10 Hydrogen atoms:

Defining Nanotechnology

Federal Gov.'s def:

Nanotechnology is the creation of functional materials, devices, and systems through control of matter on the nanometer length scale, exploiting novel phenomena and properties (physical, chemical, biological) present only at that length scale.



History

c. 1960

Feynman:

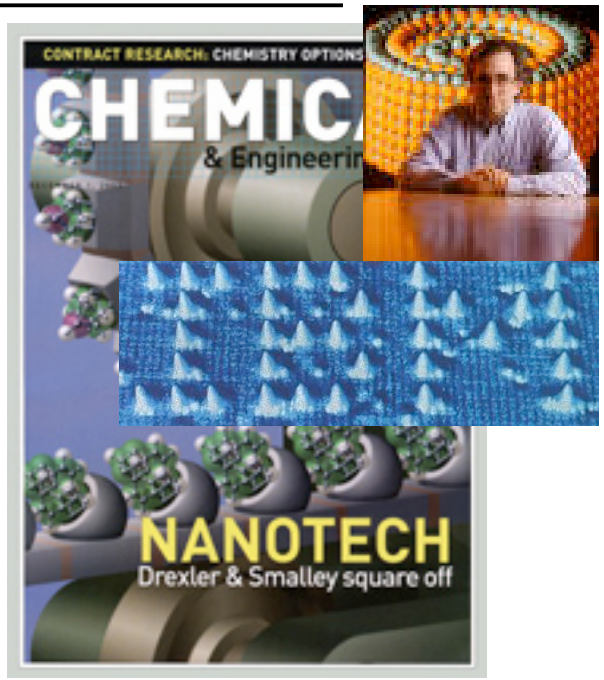
- **miniaturization**
- **info. storage**
- **precision chemistry**
- **tiny machines making tinier machines**

c. 1980s

- **"nanotech" popularized**
- **idea of molecular self-assemblars**

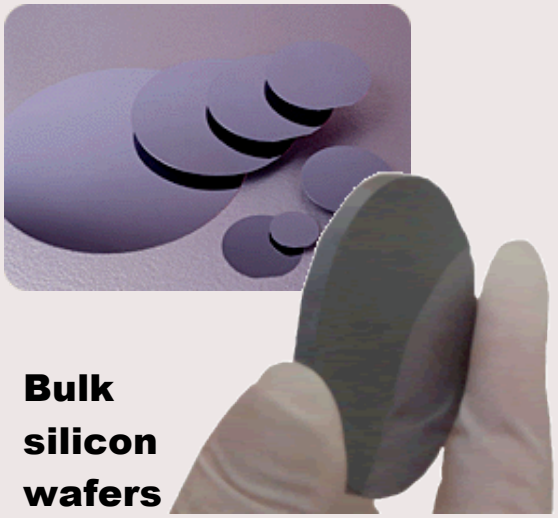
c. 1990

- **science and technology started to catch up**



New properties at nanoscale

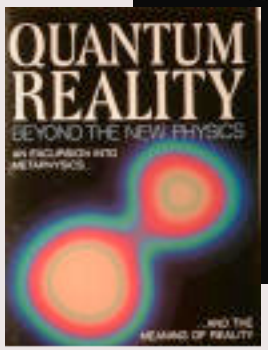
The amazing shrinking silicon crystal...



Bulk silicon wafers for computer chips

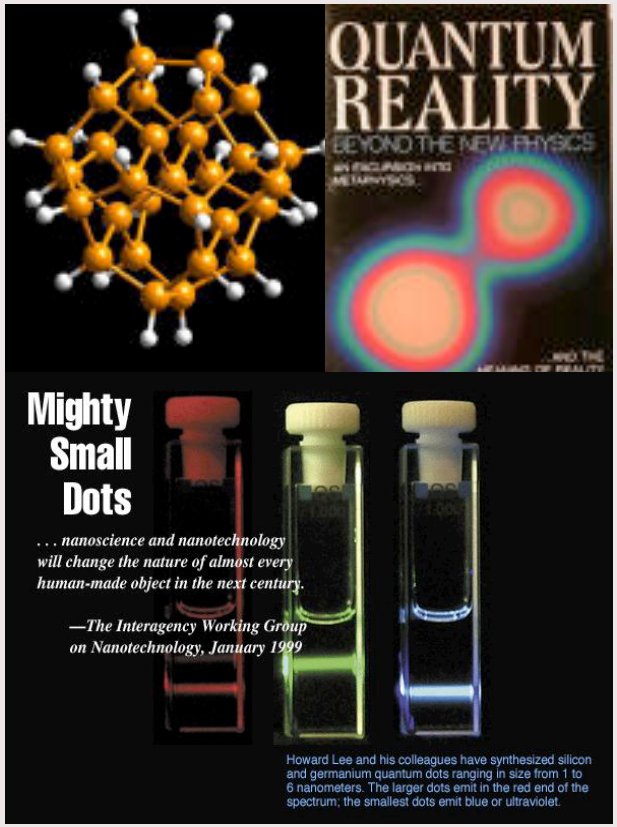
Silicon nanocrystal

< 100 nm



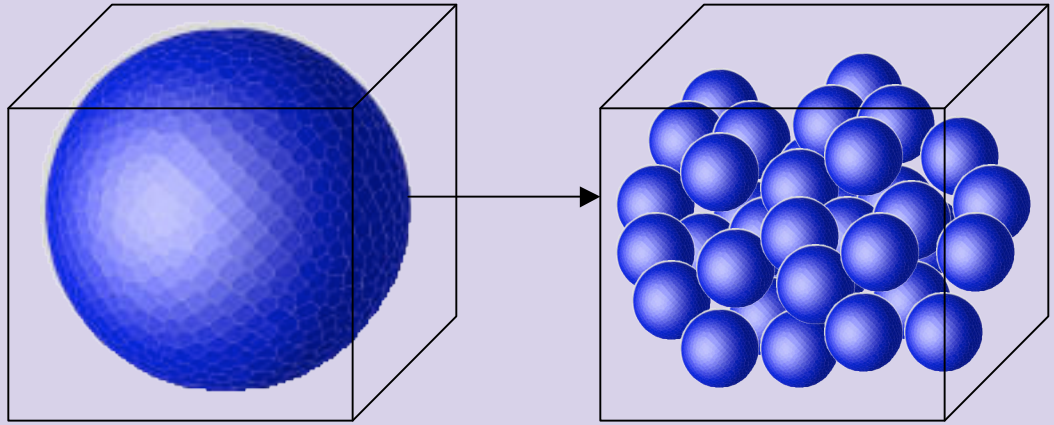
Quantum	Chemical	Biological

New properties at nanoscale



Completely different physical behavior than bulk.

Reactivity may depend on surface area.

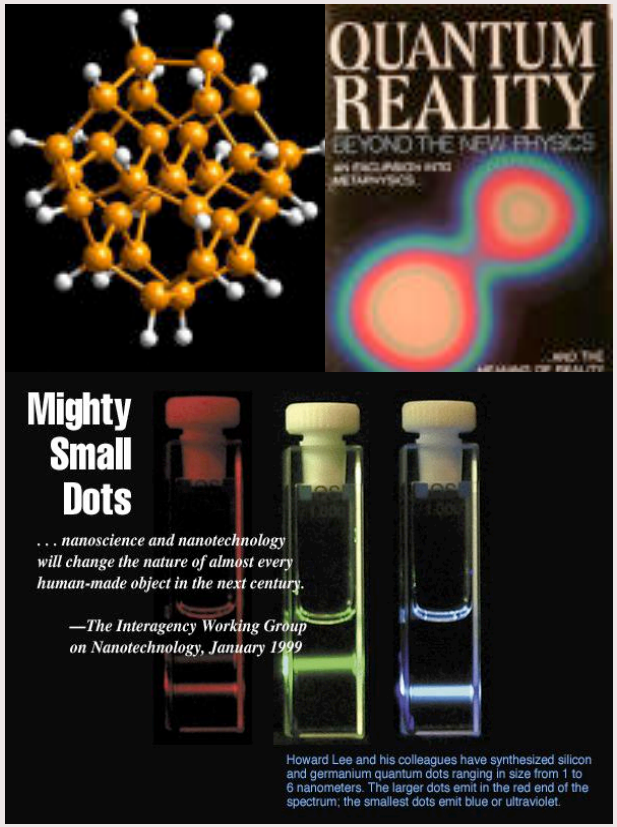


More, smaller particles = more surface area

"A catalyst of 10 nm nanoparticles is 100 times more reactive than the same amount of material in 1 micron particles."

Quantum | **Chemical** | **Biological**

New properties at nanoscale



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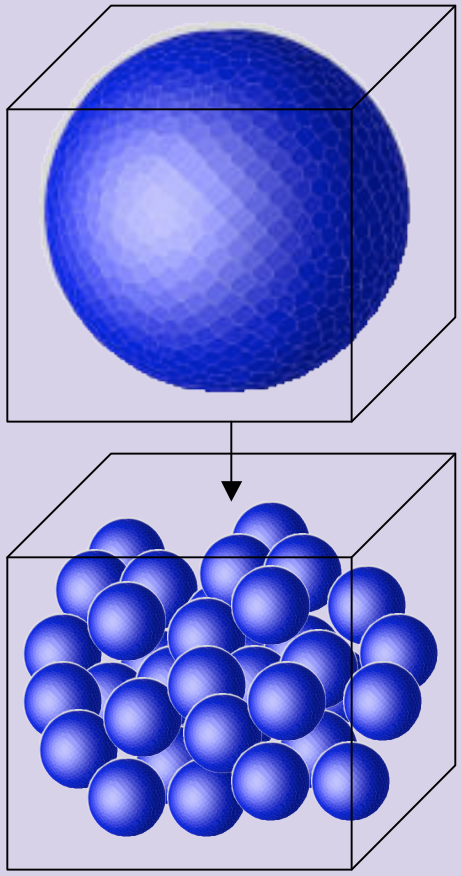
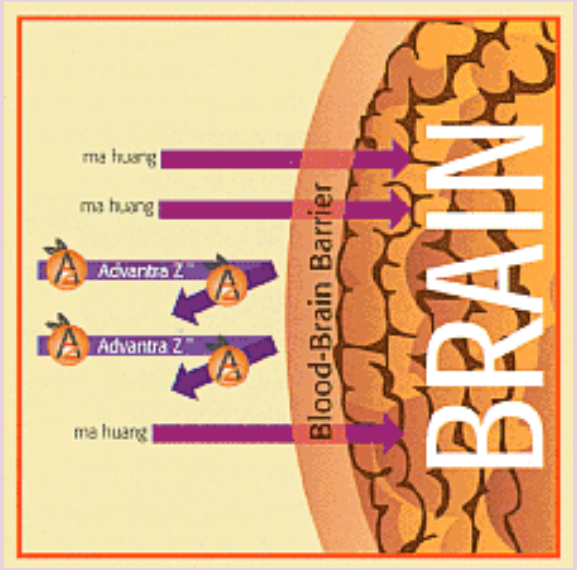
Quantum



More surface area per volume. More reactive.

Chemical



Nanoparticles can cross the blood brain barrier. Microparticles can't

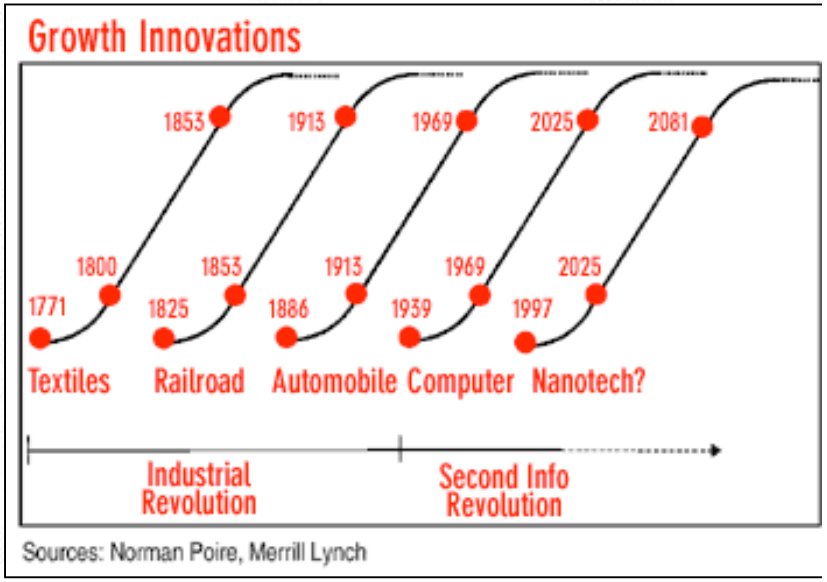
Biological

Nanotech -is- Interdisciplinary

Physics, Chemistry, Materials Science, Biology, Engineering, Informatics, … and even Humanities!

National Nanotechnology Initiative
(Budget authority, dollars in millions)

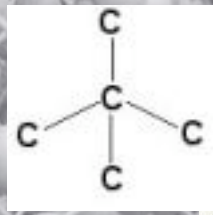
	2001 Actual	2005 Request	Dollar Change 2001 to 2005	% Change 2001 to 2005
National Science Foundation	150	305	155	103
Defense	125	276		
Energy	88	211		
National Institutes of Health	40	89		
Commerce (NIST)	33	53		
NASA	22	35		
Agriculture	0	5		
EPA	5	5		
Justice	1	2		
Homeland Security	0	1		
TOTAL	**464**	**982**		

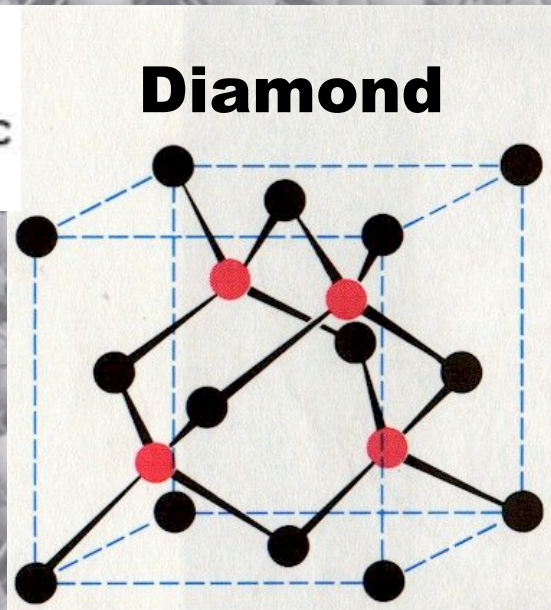


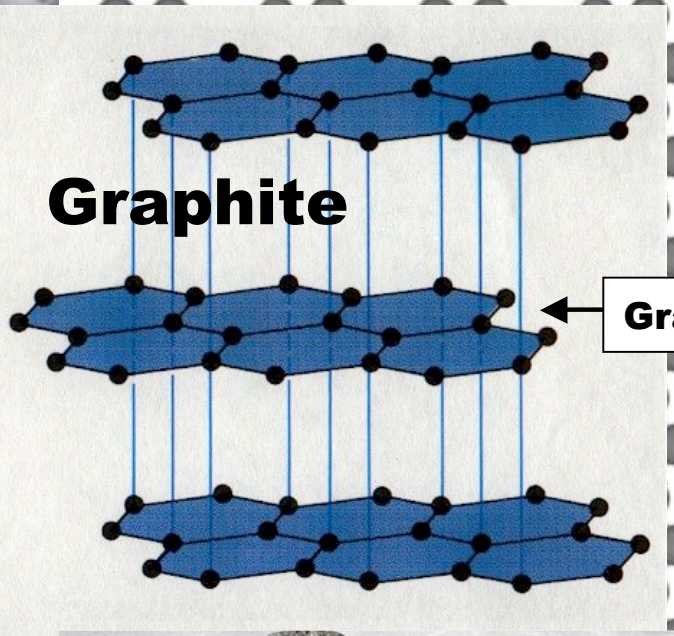
Sources: Norman Poire, Merrill Lynch

Example: Carbon in the macro

Allotropes of Carbon: different crystal structures with different properties.



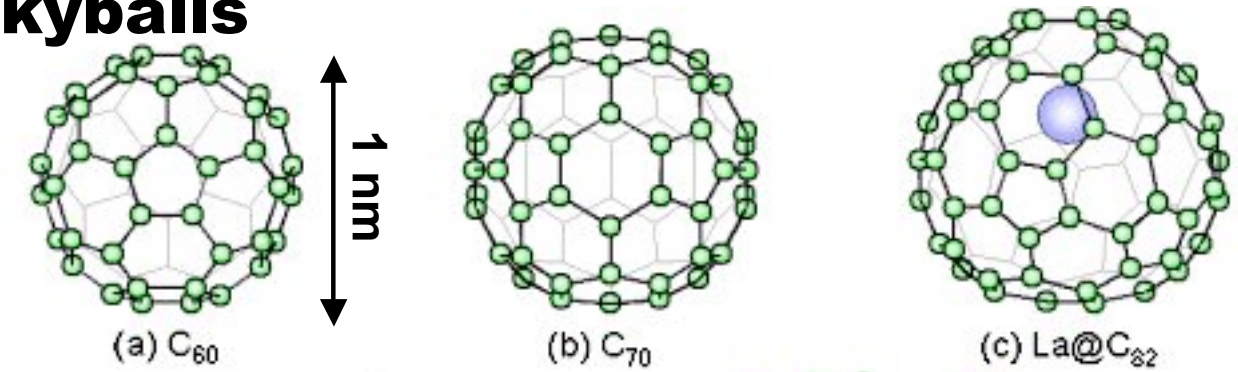




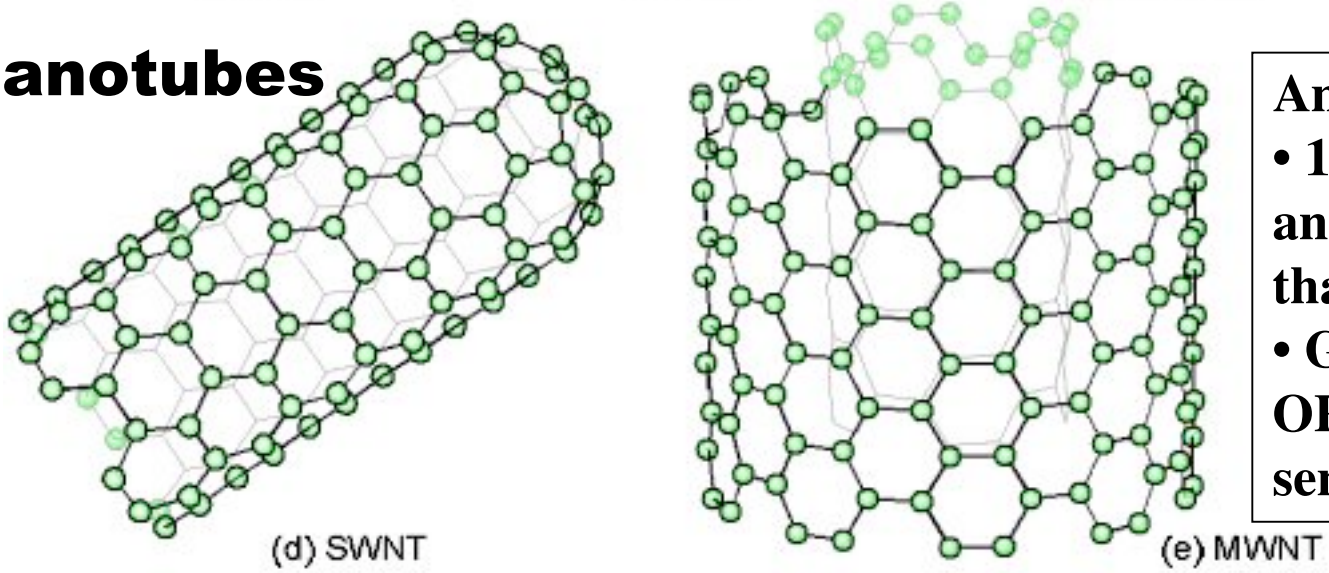
Example: Carbon in the nano

A new form of Carbon: buckminsterfullerenes

buckyballs



nanotubes



Amazing properties:

- **100 times stronger and 6 times lighter than steel**
- **Good conductores OR good semiconductors**

Nanotubes are useful

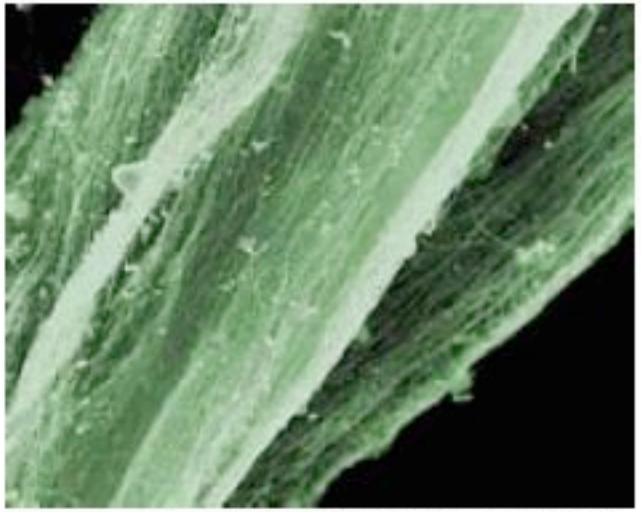
Move over, Spider-Man

CARBON WORLDS

Scientists Make Long Nanotubes

Troy - May 07, 2002

For the first time, researchers have created a simplified method for making long, continuous, hair-like strands of carbon nanotubes that are as much as eight inches in length.



brief communications

isselaer

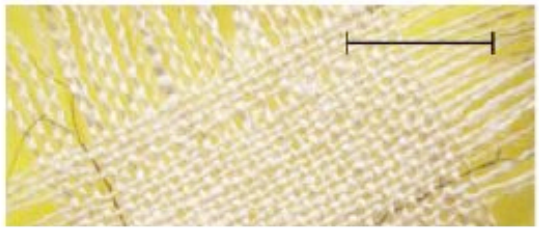
Super-tough carbon-nanotube fibres

These extraordinary composite fibres can be woven into electronic textiles.

The energy needed to rupture a fibre (its toughness) is five times higher for spider silk than for the same mass of steel wire, which has inspired efforts to produce spider silk commercially[1–3]. Here we spin 100-metre-long carbon-nanotube composite fibres that are tougher than any natural

process. This stage involves unwinding the fibres onto a series of godets that carry them through an acetone-washing bath and then through a drying path so that they can be wrapped onto a mandrel.

The resulting composite fibres are about 50 μm in diameter and contain around



that (CVD), grow ld of r-

Write Board Exercise:

How would you use super-strong nanotube thread?

Community Reports

Fishing Village

Las Vegas

Dairy Town

Rust Belt Town

Traveling Circus

Space Station

Retirement Community

State Prison

Deserted Island

Nano & Communities

Consider the top brainstorming idea for your client/customer.

- How might introduction of this technology affect your client/customer's community?

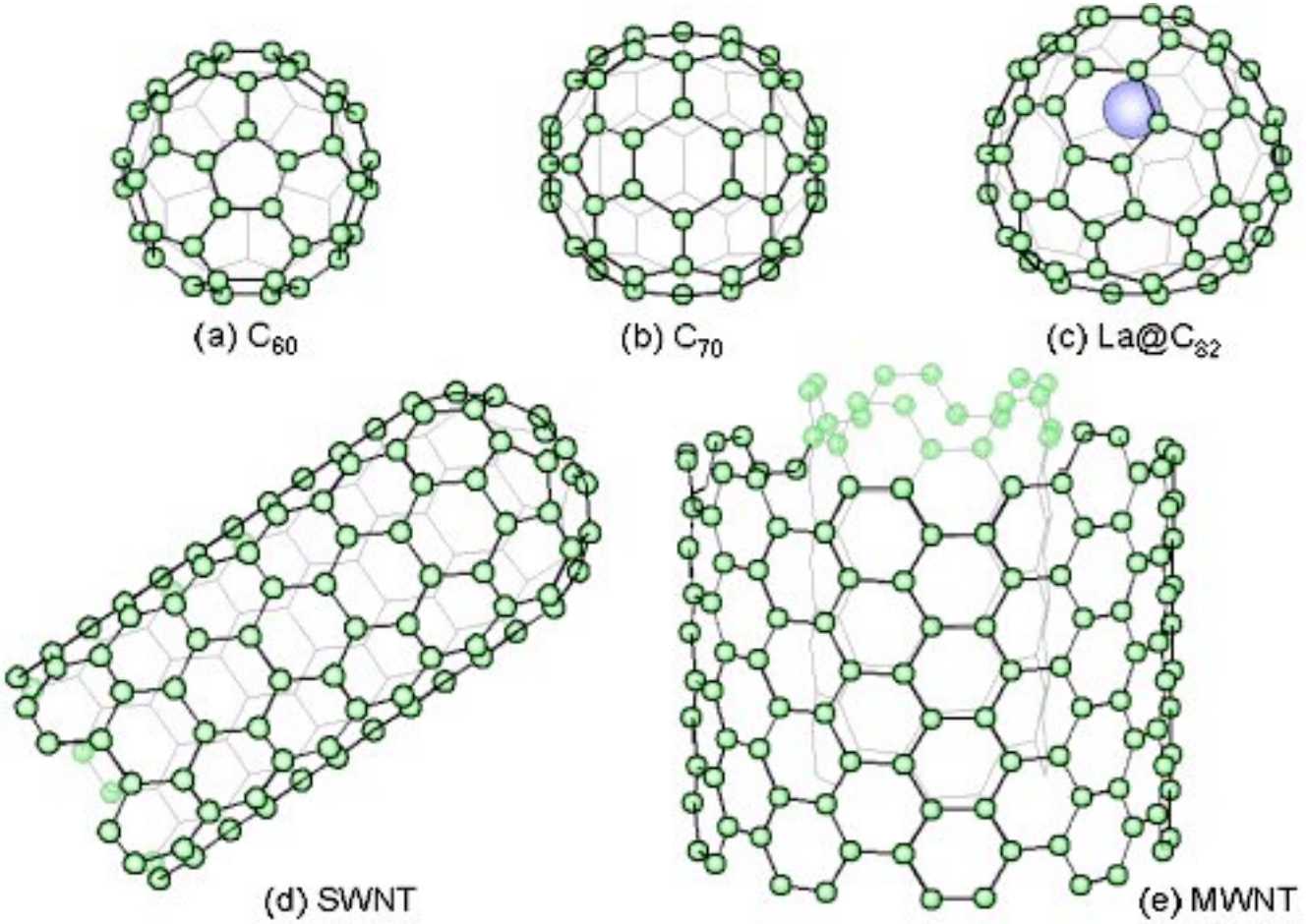
- What are the ramifications?

- Consider how it will change the community in 20 years?

Nanotechnology & the Environment: Enemies or Friends?

Ricky Leung

Carbon Nanotubes

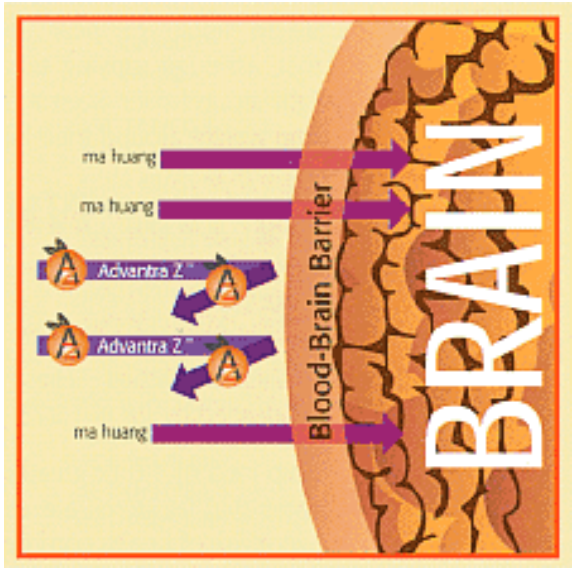


Potential Harms of Nanomaterials

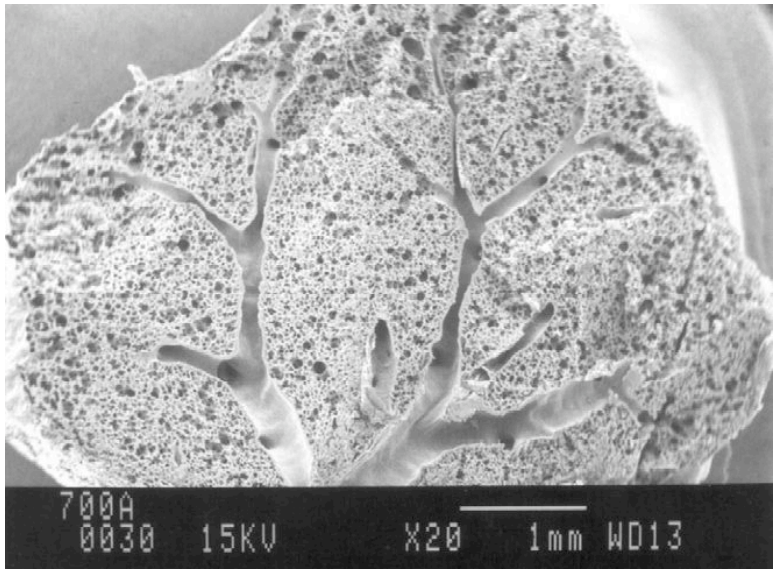
- Materials below 50 nanometers (size of a cold virus) tend to go into body (Colvin 2003)

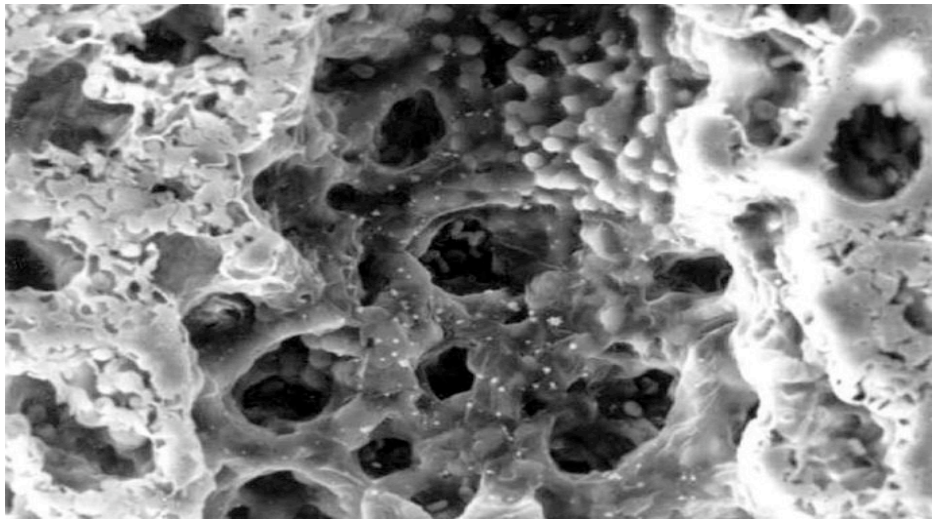
- Nanoparticles produce enhanced level of lung inflammation, fibrosis & tumor responses in lab animals (Donaldson et 2001; Oberdorster 2000)

- Other unknown effects



Deposition of inhaled carbonyl iron particles in rat's lung (Warheit 2004)





Caveats

- **Are Rats the same as Humans?**
- **Risk = Hazard + Exposure (Assessment)**
- **Other scientific factors e.g. surface coatings**

Can nanotechnology improve environment?

"It is a mistake for someone to say nanoparticles are safe, and it is a mistake to say nanoparticles are dangerous."

Vicki Colvin, Director,
The Center for Biological & Environmental Nanotechnology at Rice University

e.g. Nanocomposites & Nanosensors

Government Bodies

United States Department of Agriculture

UNITED STATES DEPARTMENT OF DEFENSE

National Institute of Standards and Technology

NIST

...working with industry to foster innovation, trade, security and jobs

FDA U.S. Food and Drug Administration

Department of Health and Human Services

Interagency meeting from government bodies

On Sep 15-16, 2003, the National Nanotechnology Coordinating Office (NNCO) organized an **"Interagency Research Meeting / Workshop - Nanotechnology and the Environment: Applications And Implications"**

Three central questions:

1. **How does your agency view its research agenda as it relates to the environment?**
2. **Can the research be applied to an environmental problem or possibly prevent an environmental problem?**
3. **Might the research cause an environmental problem?**

http://es.epa.gov/ncer/publications/nano/agenda.html

“If it were a perfect world, we wouldn’t think about this topic for 10 years. And then all the data would be there, and we would make a good decision. But the fact of the matter is that society will be forced to make a decision in the absence of data.”

Vicki Colvin, Director,
The Center for Biological & Environmental
Nanotechnology at Rice University

So, what is your decision?

What kinds of actions?

1. How about existing protocols?
   (E.g. Toxic Substances Control Act)

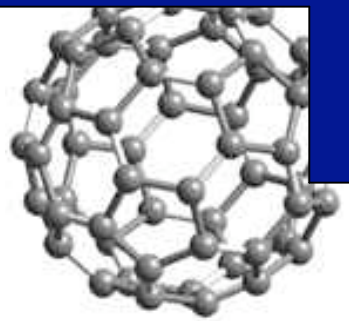
2. New legal category specific to nanosized substances?

3. Use a proportion of funds (e.g. from NNI) to investigate
   the social and environmental impact of nanotechnology?

4. Moratorium?

5. Other creative ideas?

Nanotechnology and Society



A course being offered next spring: **Science and Technology Studies 201**

What is nanotechnology and why are scientists, businesses, and governments around the world so excited about it?
What happens when nanotechnology leaves the laboratory and enters society?
How will nanotechnologies change our future?
Take our class and find out.

STS 201: Nanotechnology and Society, 2 sections being offered:

#84375	T, R	9:30-10:45 am	by Ricky Leung
#84405	M, W, F	9:55-10:45 am	by Charlie Tahan