



Summary of Nanoscience and Nanotechnologies: Opportunities and Uncertainties

(Royal Society & Royal Academy of Engineering)

July 29, 2004

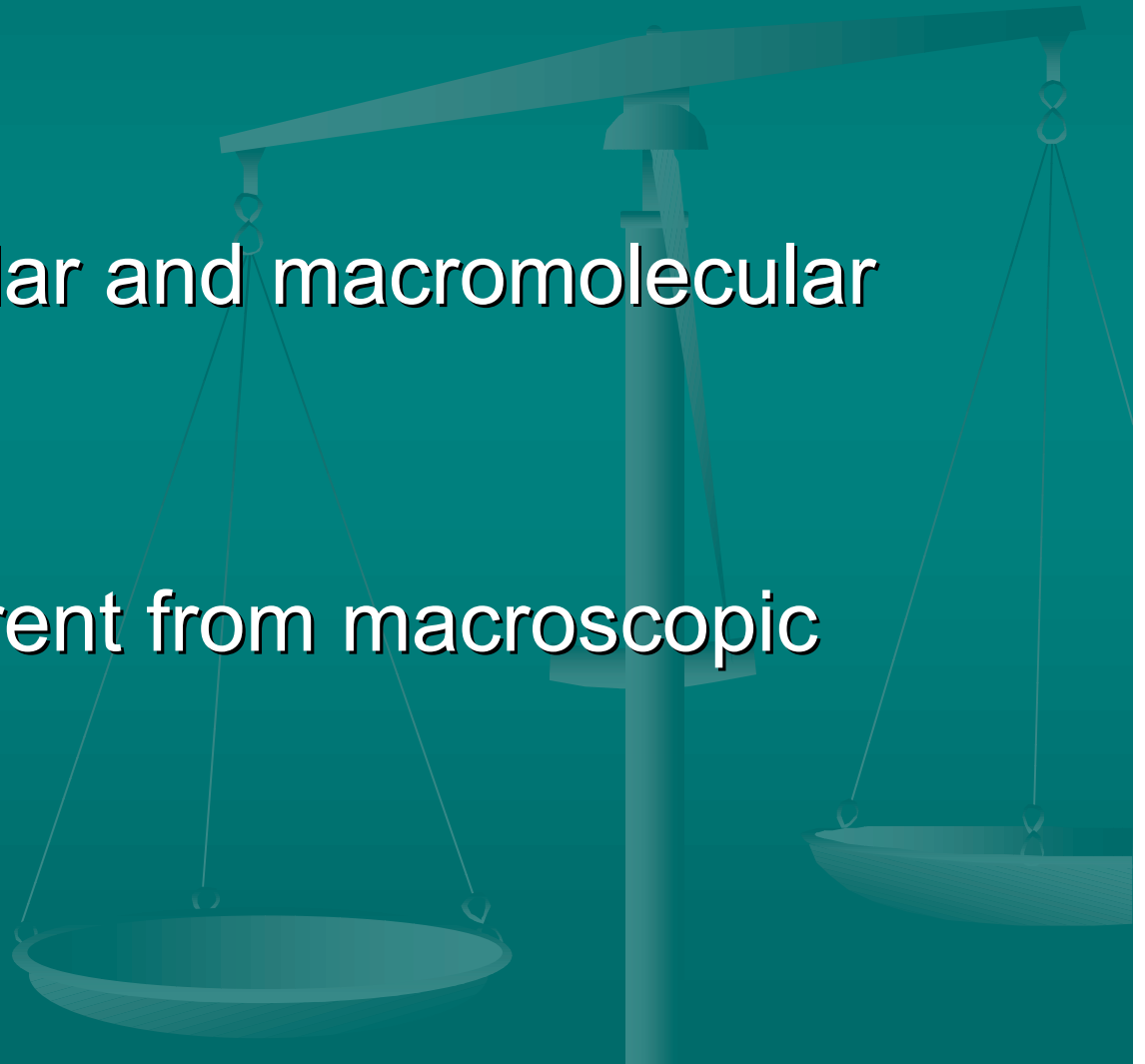
<http://www.nanotec.org.uk/finalReport.htm>

Akhlesh Lakhtakia

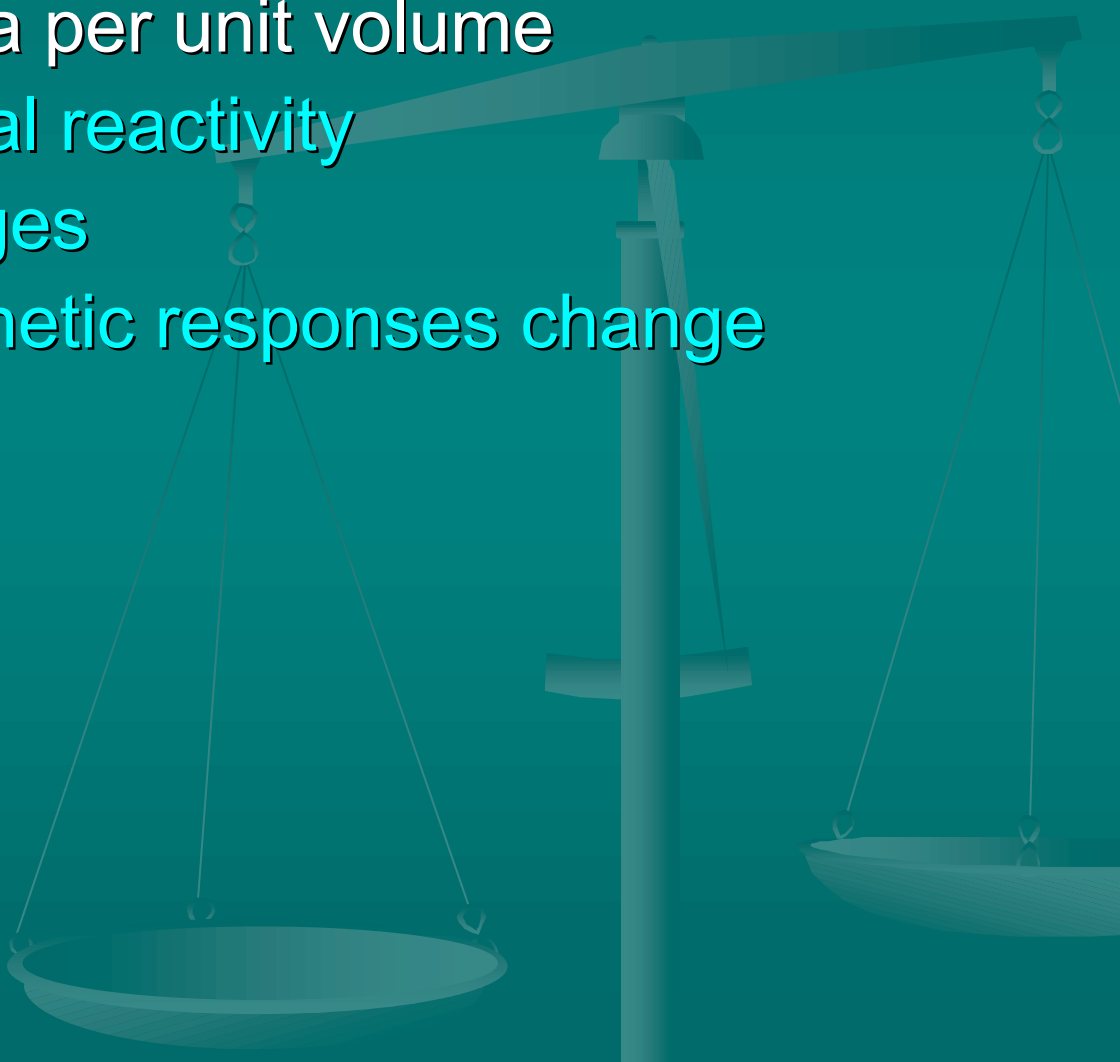
Pennsylvania State University & Imperial College London

Definition

- 0.2 to 100 nm
- Atomic, molecular and macromolecular phenomena
- Properties different from macroscopic length scales

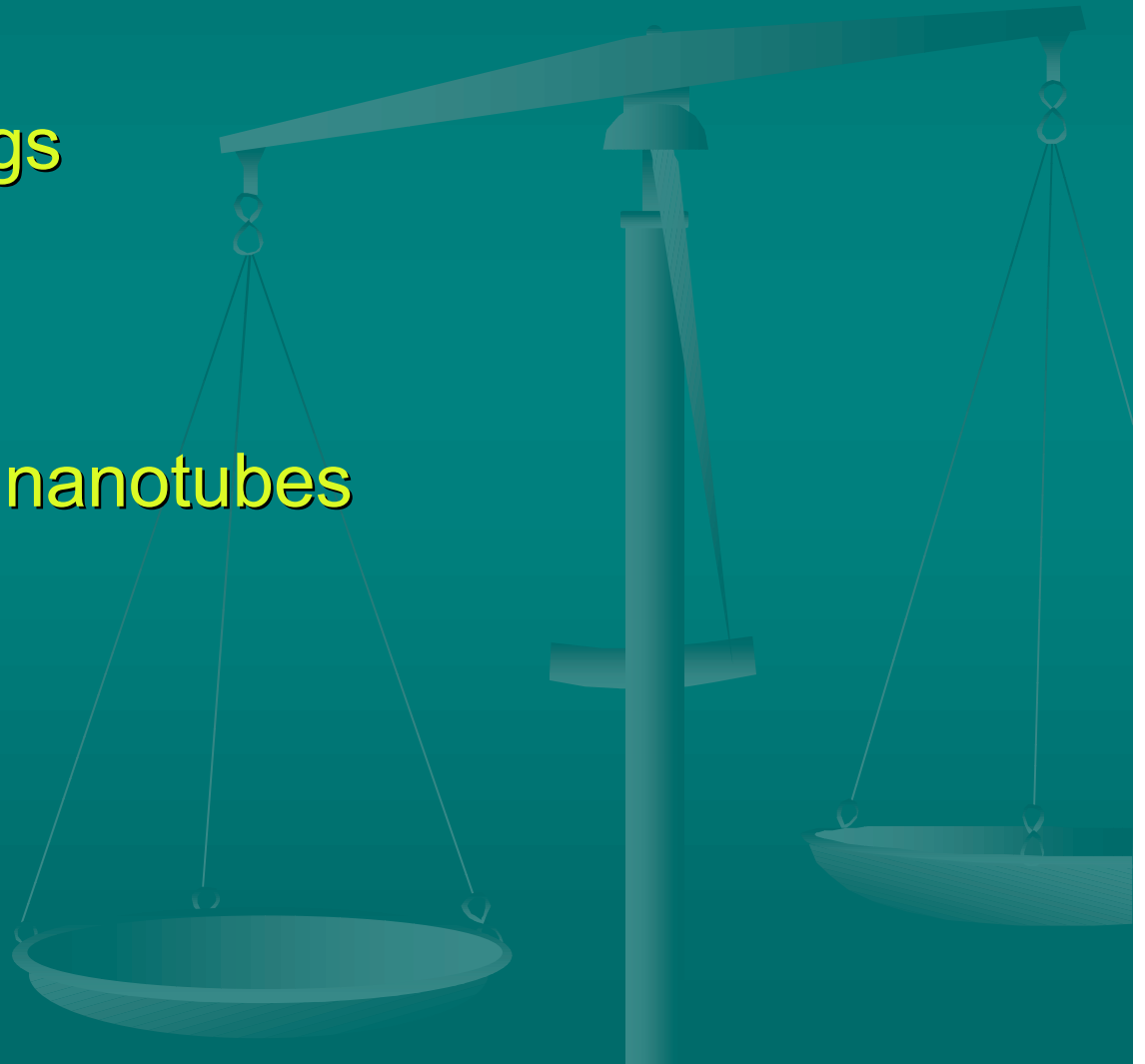


Significant Attributes

- Large surface area per unit volume
 - higher chemical reactivity
 - strength changes
 - electrical/magnetic responses change
 - Quantum effects
 - Multidisciplinary
 - Interdisciplinary
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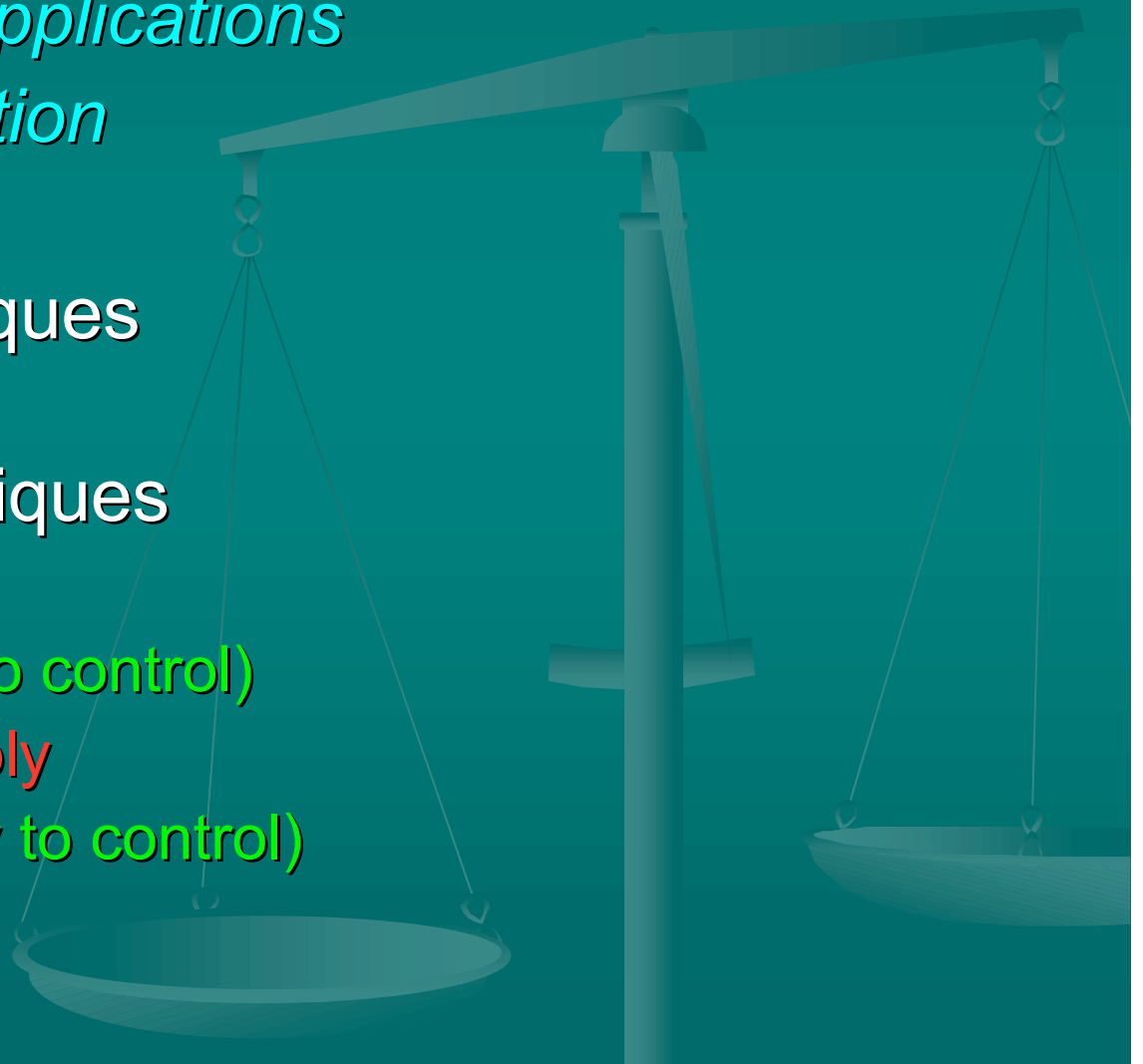
Dimensionality

- 1 D
 - Ultrathin coatings
- 2 D
 - Nanowires and nanotubes
- 3 D
 - Nanoparticles



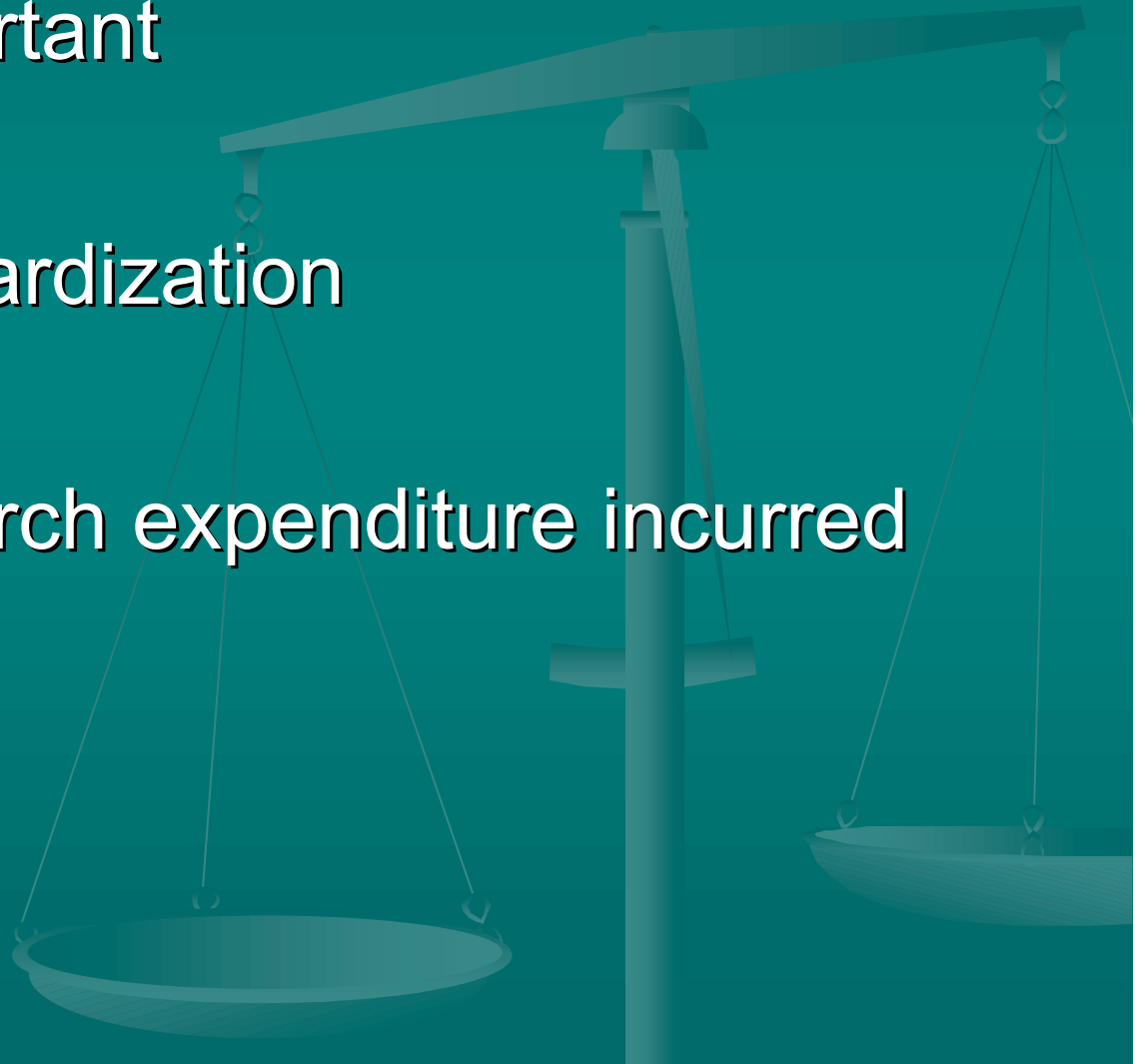
Nanomaterials

- *Lots of potential applications*
- *Unreliable production*
- “top-down” techniques
 - **Etching**
- “bottom-up” techniques
 - **Self-assembly**
(cheap, difficult to control)
 - **Positional assembly**
(expensive, easy to control)



Metrology

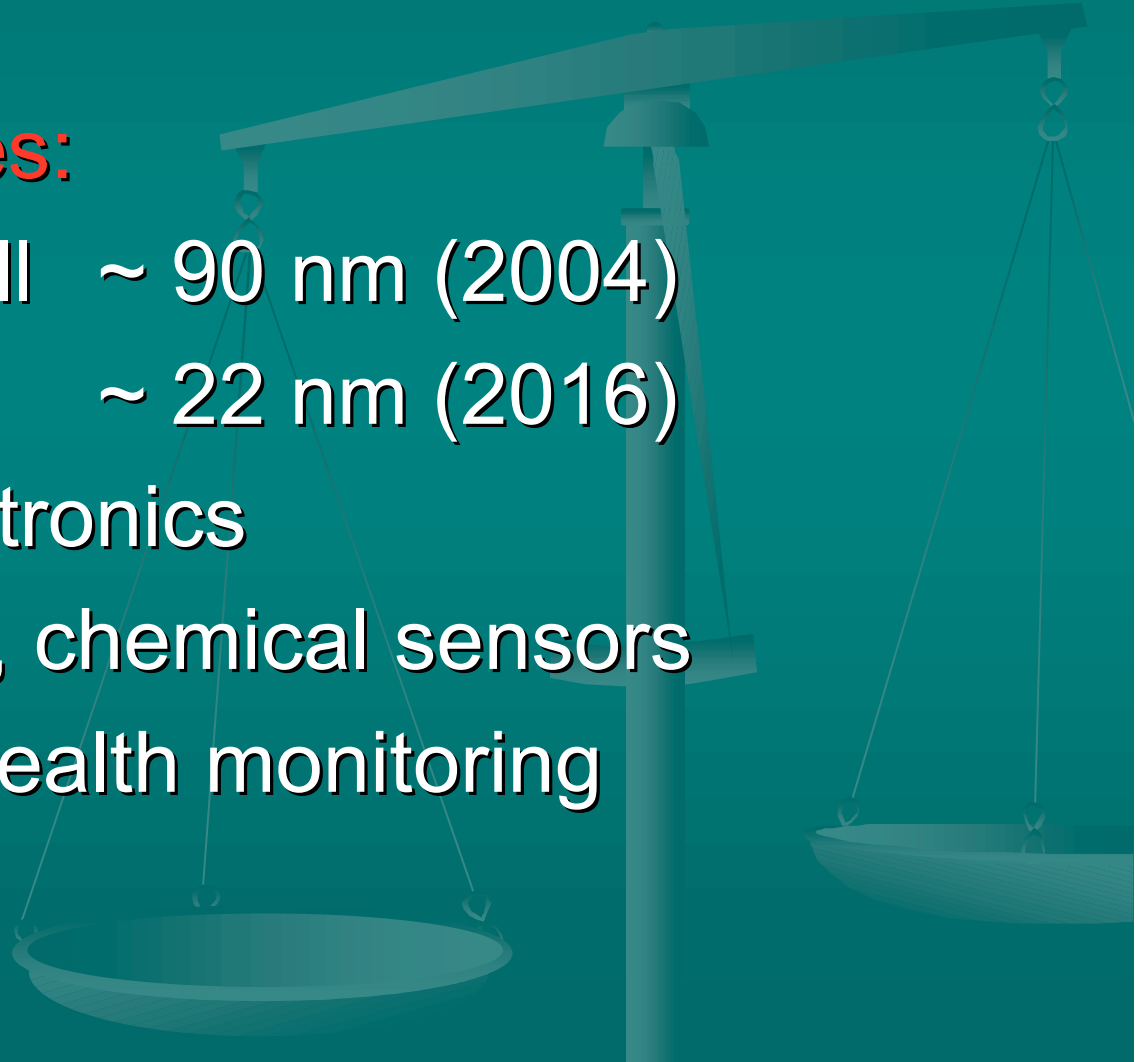
- Extremely important
- Requires standardization
- Very little research expenditure incurred so far



Integrated Electronics and Optoelectronics

Many opportunities:

- memory cell ~ 90 nm (2004)
~ 22 nm (2016)
- plastic electronics
- biosensors, chemical sensors
- structural health monitoring



Bionanotechnology and Nanomedicine

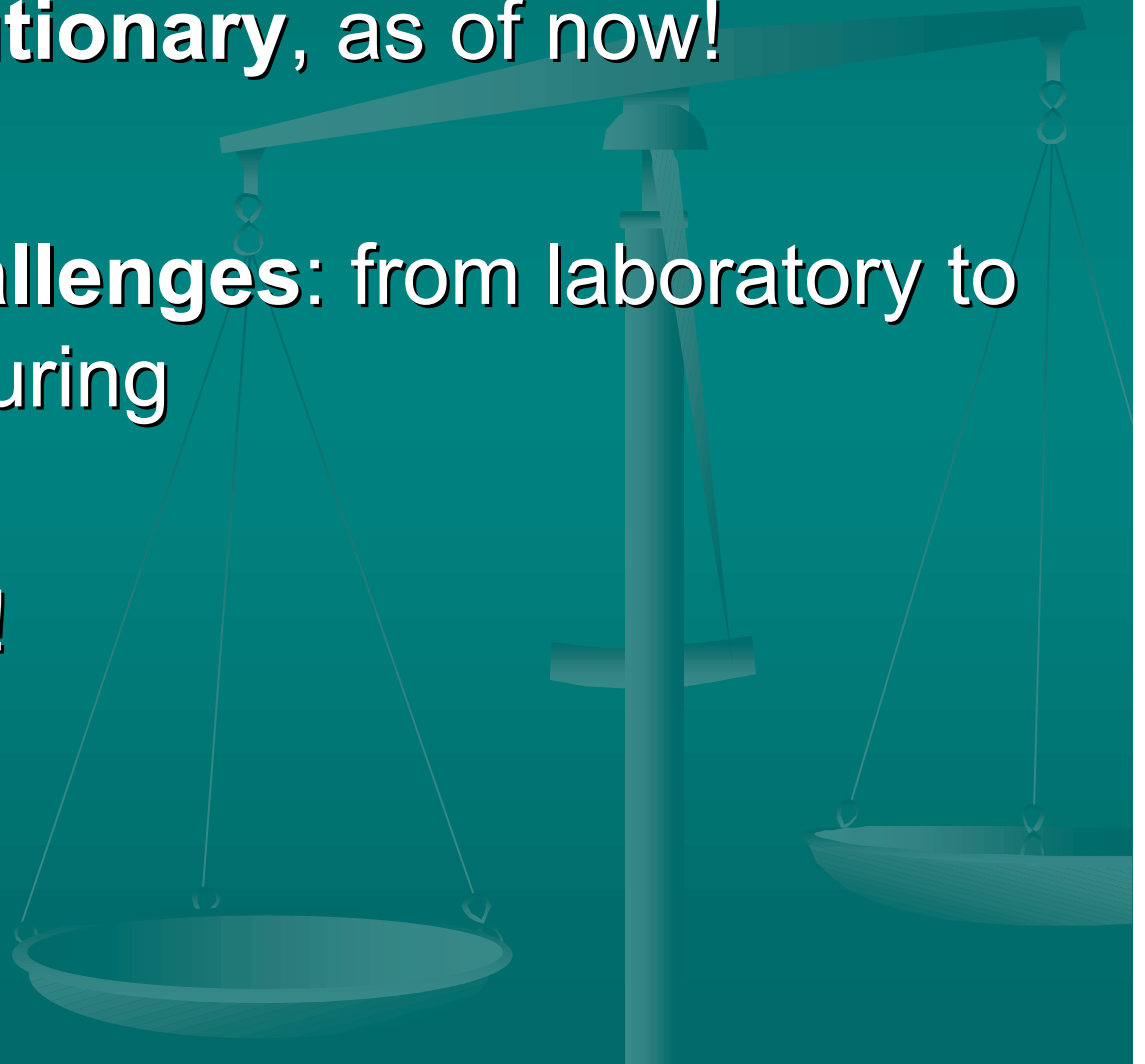
Many opportunities:

- targeted drug delivery
- *in vivo* molecular imaging
- antimicrobial agents
- tissues and scaffolds
- “smart” health monitoring



Industrial Applications

- **Nothing revolutionary, as of now!**
- **Significant challenges:** from laboratory to mass manufacturing
- **Lots of hopes!!**



Desirable Features for Industrial Application

- Cost-effectiveness
- Waste reduction
- Lifecycle (cradle-to-grave) environmental auditing

“Grey-goo” scenario appears unrealistic!



Health Impacts

Nanoparticles may be more toxic than larger particles of the same substance

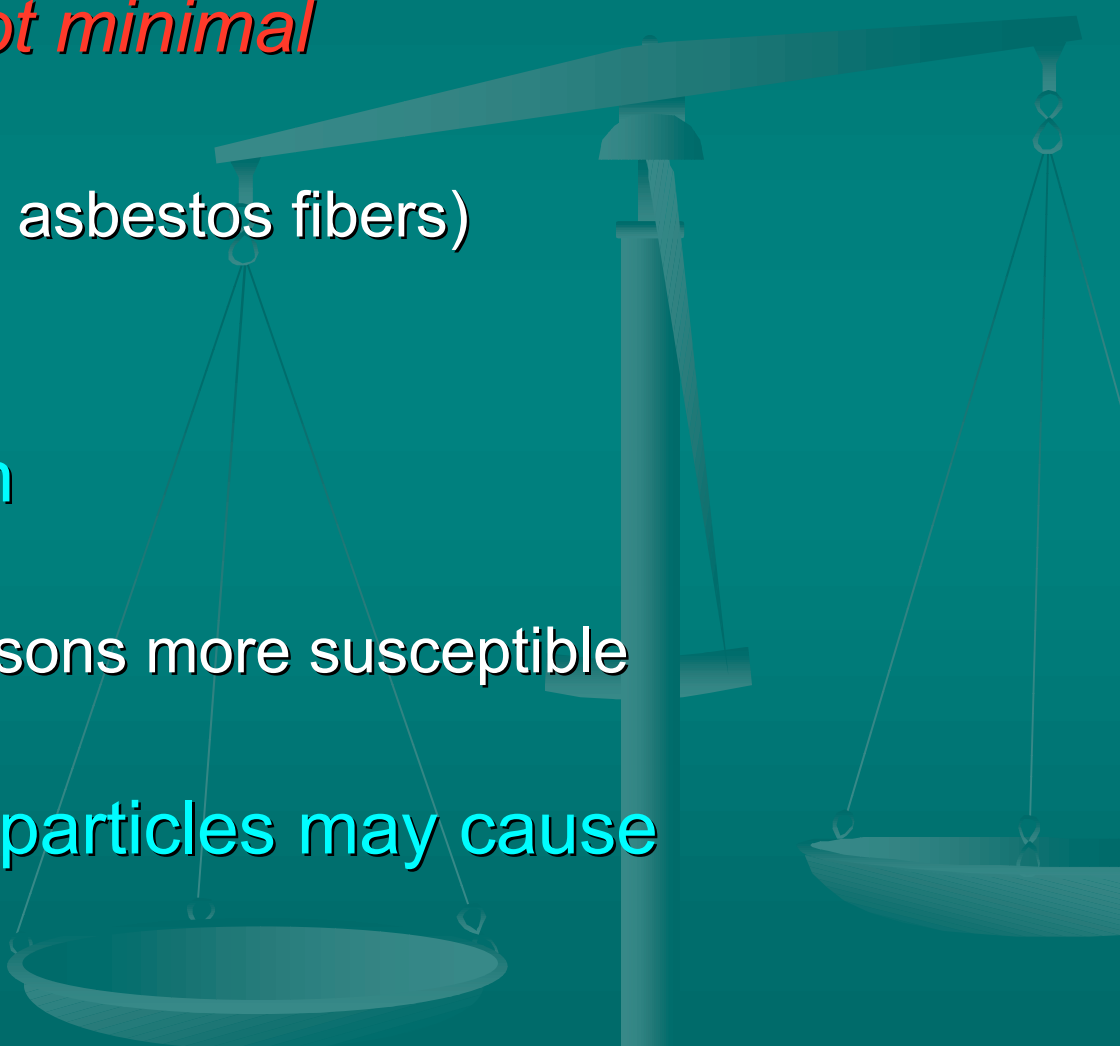
- High surface area
- Enhanced chemical reactivity
- Easier penetration of cells

Only a few chemicals are being manufactured in nanoparticulate form, and that too in small quantities


Risk to general public is minimal

Health Impacts

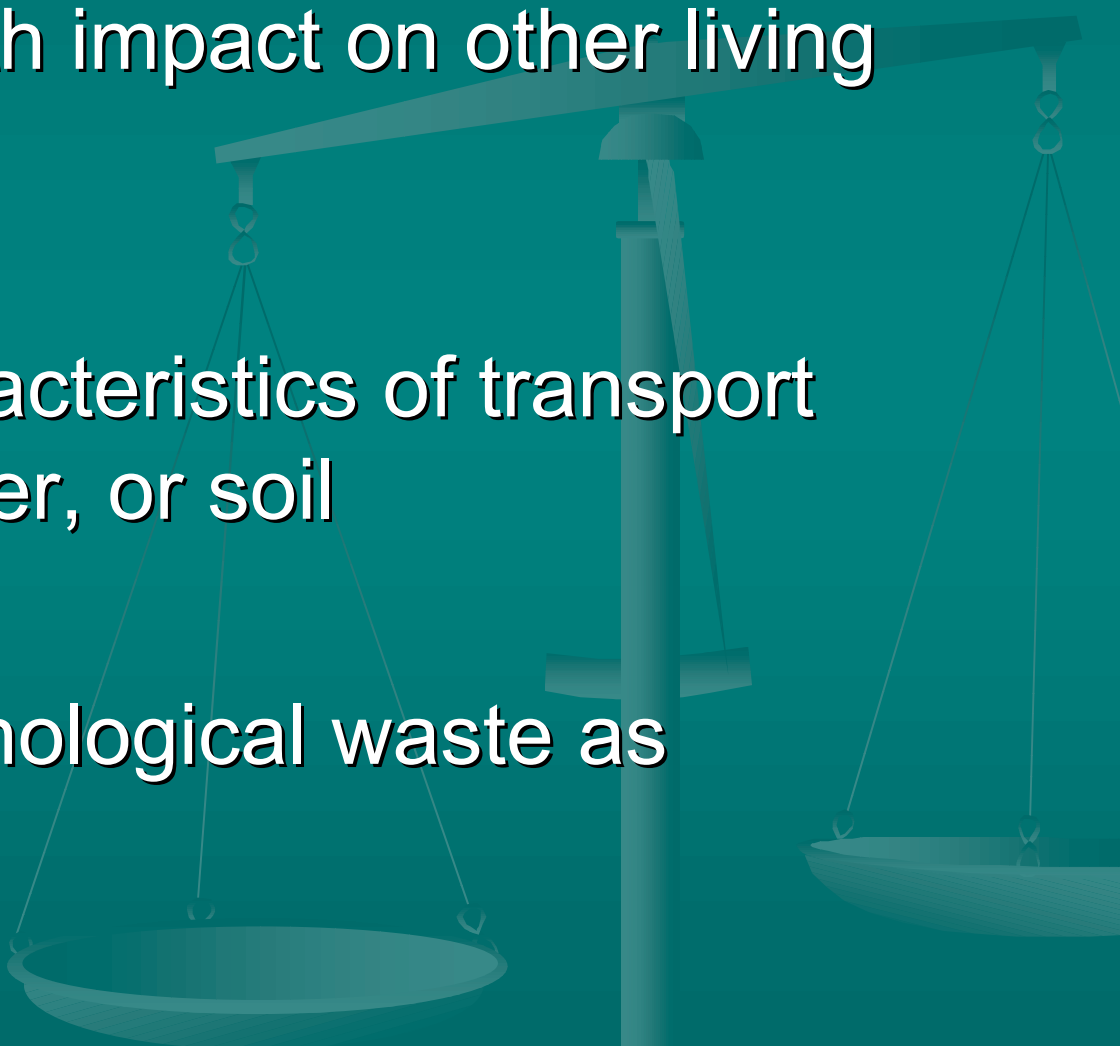
Risk to workers is not minimal

- Inhalation
 - Physical risk (e.g., asbestos fibers)
 - Chemical risk
 - Penetration of skin
 - Cell damage
 - Skin-diseased persons more susceptible
 - Combustible nanoparticles may cause explosions
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Health Recommendations

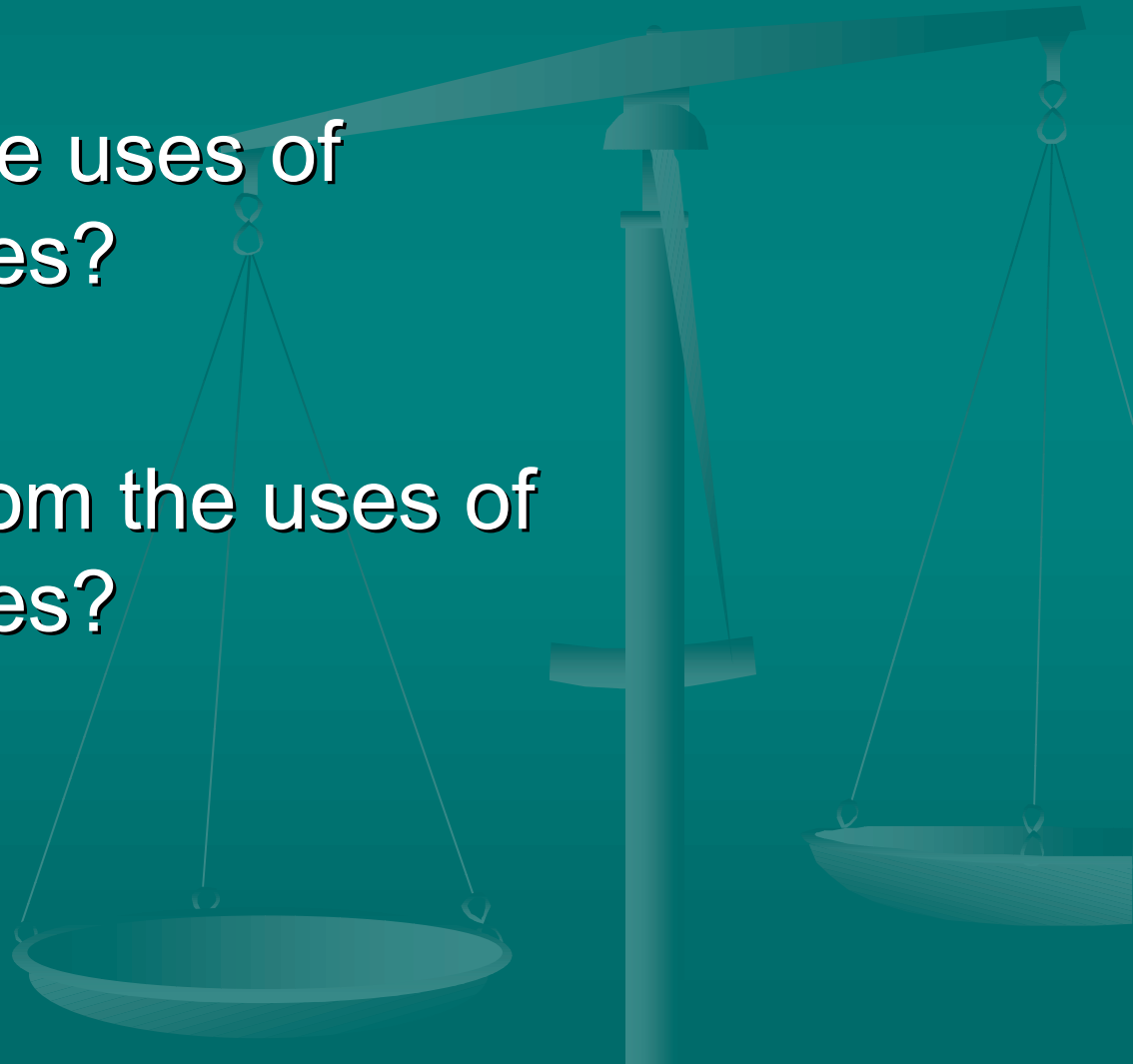
- *Restrict human exposure in workplaces*
 - *Require toxicological data for all nanomaterials*
 - *Enhance collaboration between toxicologists and targeted-drug-delivery researchers.*
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Health Recommendations


- Determine health impact on other living beings
 - Determine characteristics of transport through air, water, or soil
 - Treat nanotechnological waste as hazardous
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Socioethical Impacts

- Who **controls** the uses of nanotechnologies?
- Who **benefits** from the uses of nanotechnologies?



Convergence of Nano, Bio, and Information Technologies

- New forms of surveillance and sensing
 - Invasion of privacy
 - Regulation of governmental and private data-collection agencies
 - Radical human enhancement
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The Time Machine, Brave New World, 1984, Gattaca

Convergence of Nano, Bio, and Information Technologies

- **Nanodivides**

- Rich and poor in the same country
- Rich and poor countries



Regulatory Climate

Regulatory bodies must commence scrutiny

Private watchdog groups must emerge



Need for Public Dialog

John/Jane Q. Public

- is poorly informed
- trusts the “experts”
- is optimistic, if somewhat informed

“Constructive and proactive debate” must commence “now”

