Nanoparticles:

Effects on Health

Environmental Toxins

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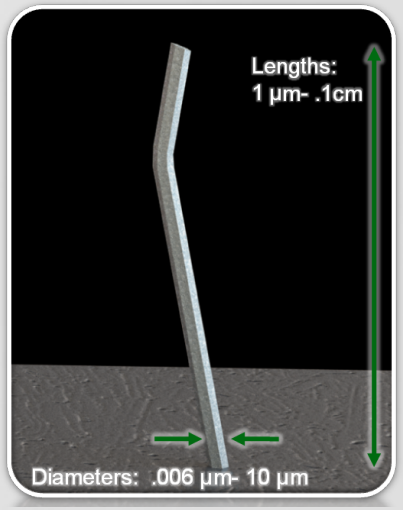
What are Nanoparticles?

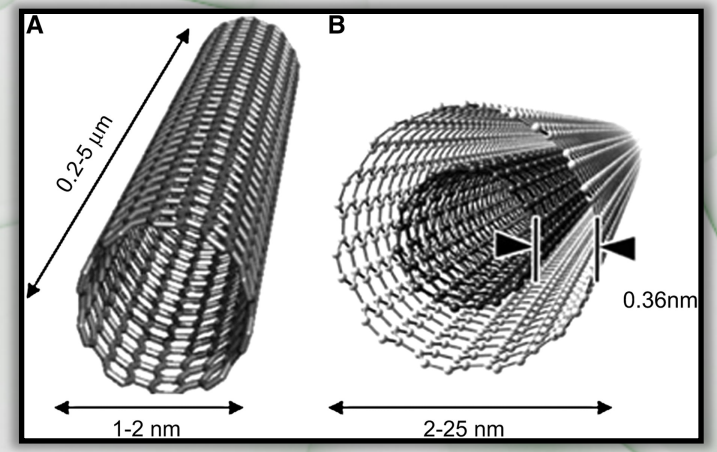
- Particles having at least one dimension less than 100nm (.001 µm = .001 micron = 1 nm)

- Common nanoparticles and materials:
  - -Carbon nanotubes
  - -Graphene
  - -Quantum dots (semiconductors)
  - -Engineered organics (immunofluorescence)
  - -Whiskers

Particle	Particle Size (microns)
dot (.)	615
Beach Sand	100 - 10000
Mist	70 - 350
Human Hair	40 - 300
Red Blood Cells	5 - 10
Face Powder	0.1 - 30
Liquid Droplets	0.5 - 5
Sea Salt	0.035 - 0.5
Bacteria	0.3 - 60
Tobacco Smoke	0.01 - 4
Viruses	0.005 - 0.3
Sugars	0.0008 - 0.005
Oxygen	0.0005



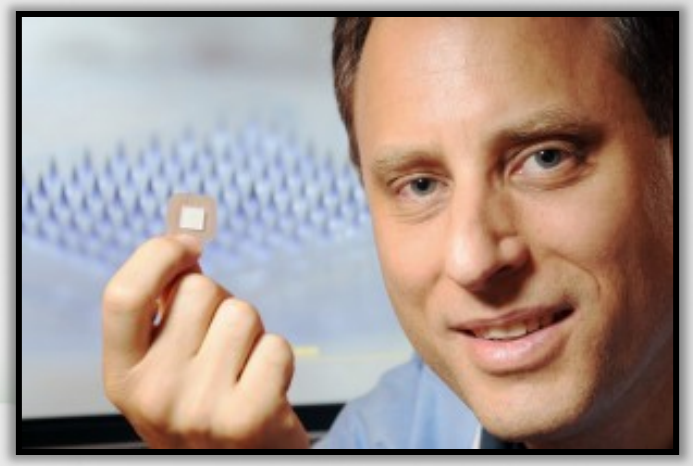
Tin Whisker



Carbon Nanotube

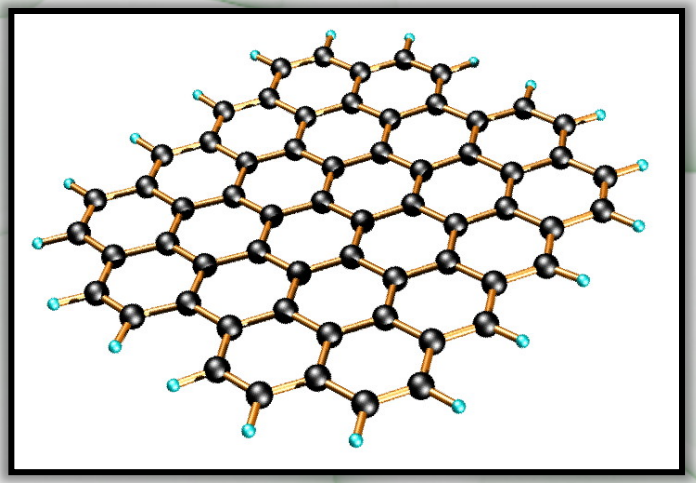
Benefits of Nanotechnology

- Drug Delivery Systems
  - Vaccines
  - DNA manipulation
  - Cancer and disease detection



- Nanowires
  - Nanocircuits, diodes, transistors, etc.
  - Energy storage and production

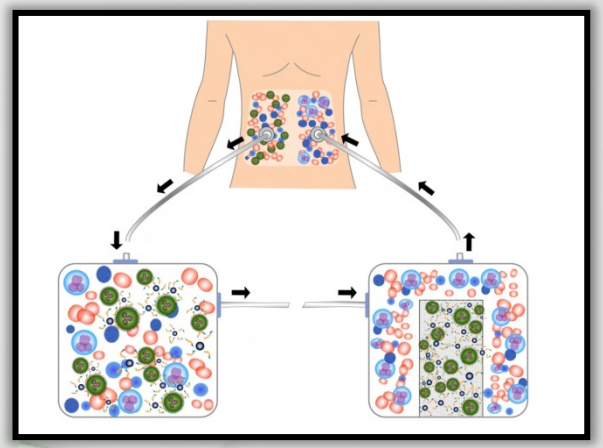
- Nanotubes and graphene
  - Excellent thermal management
  - Strength filaments

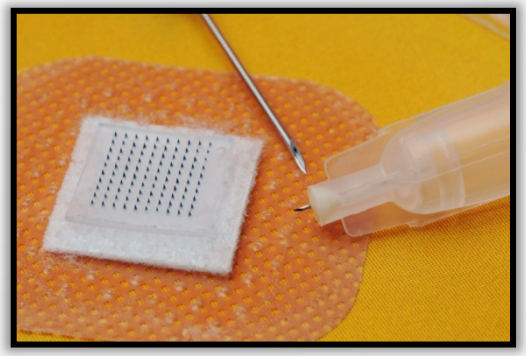


- Nanobiology
  - Plant manipulation
  - Clean water production

Properties of Airborne Nanoparticles

- High specific surface (Gibbs free energy)
- High reactivity with other particles
- Ability to remain isolated or to agglomerate

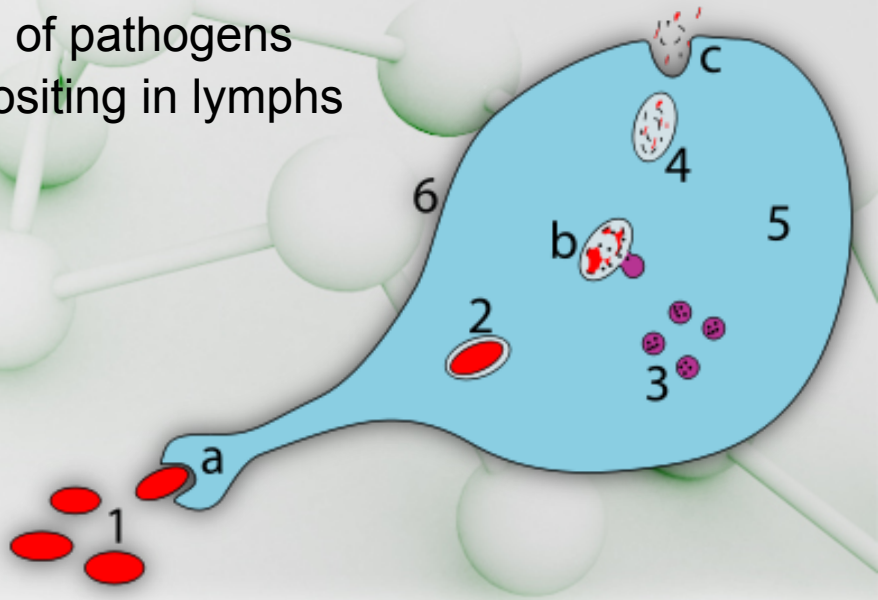




- Can penetrate cell walls and DNA
- Can enter bloodstream and deposit in organs
- Can enter sensory axons of nervous system (brain)
- Traditional Dose-Response is not sufficient

Expulsion Methods from the Pulmonary System

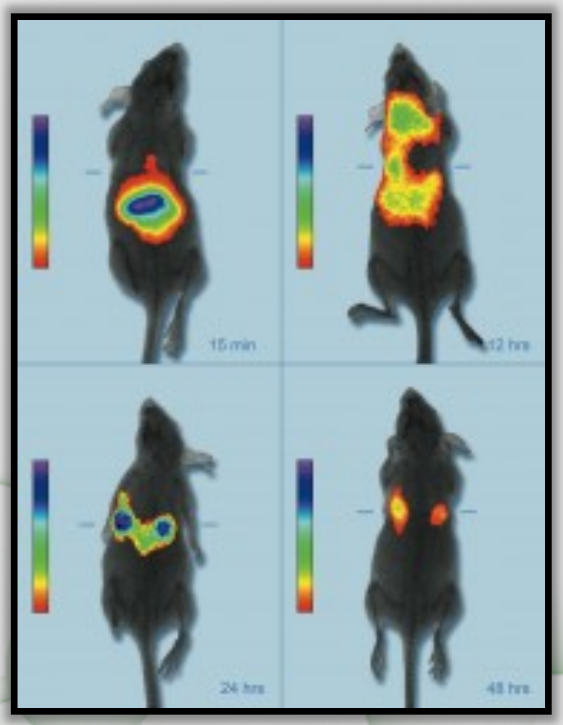
- Particles enter bloodstream and organs
- Particles enter sensory axons of nervous system
- Mucociliary escalator- chemical flush into digestive tract through strings of cells
  -24 hours or less
- Alveolar macrophage- enzyme deterioration of pathogens
  -Large undissolved clusters can form, depositing in lymphs
  -Up to 700 DAYS for nanoparticles



Observed Toxic Effects of Nanoparticles

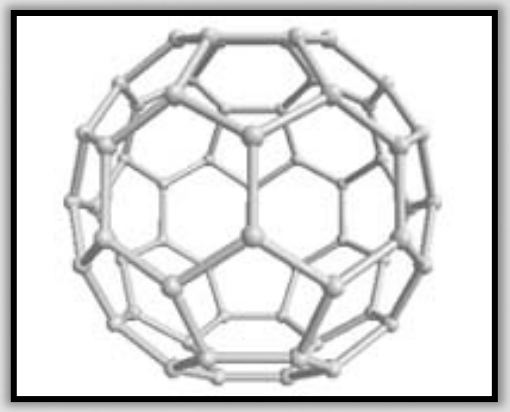
- Pulmonary effects
  - -Exasperation of pre-existing bronchial problems
  - -Lung cancer
  - -Asthma
  - -Welder's disease

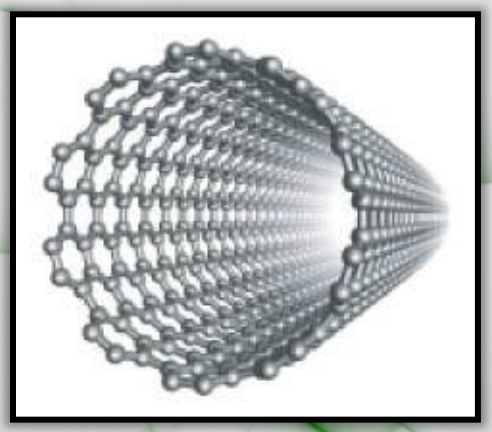
- Other effects:
  - -Cardiac rhythm changes
  - -Arterial diameter expansion
  - -Plasma viscosity
  - -High concentration in lymphs



Toxicity of Carbon Nanotubes

- Little inherent chemical toxicity
- Toxicity increases with agglomeration (like asbestos)
- Highly reactive, bonds with more toxic elements
- Formulation of pulmonary granulomas, similar to Beryllium
- Lung cancers, similar to asbestos
- FORM FACTOR!
  -Shape and Size are as toxic as chemistry





Discussion

- Significant work remains in characterizing NP behavior
- Some carcinogenic results will take years to evaluate as cancer data comes out
- Traditional micro-particle modeling is insufficient in terms of dose-response
- Nanoparticles gain their toxicity once airborne; control the dust, control the devil (toxins)
- Thoughts??

References

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Questions?