Nanotechnology – CASA Conference-2012

Merging Technologies

- The merging of:
  - Biotechnology
  - Nanotechnology
  - Clean technology
  - Information technology

Definition: Nanotechnology

- A wide range of technologies that measure, manipulate or incorporate materials and/or features with at least one dimension between approximately 1-100 nanometers
- De-coupling nanotechnology to nanotechnologies
- (Health Canada Definition as well)

Photo: NRC-CNRC

Source: ANSI Document E2456-06:Terminology for Nanotechnology

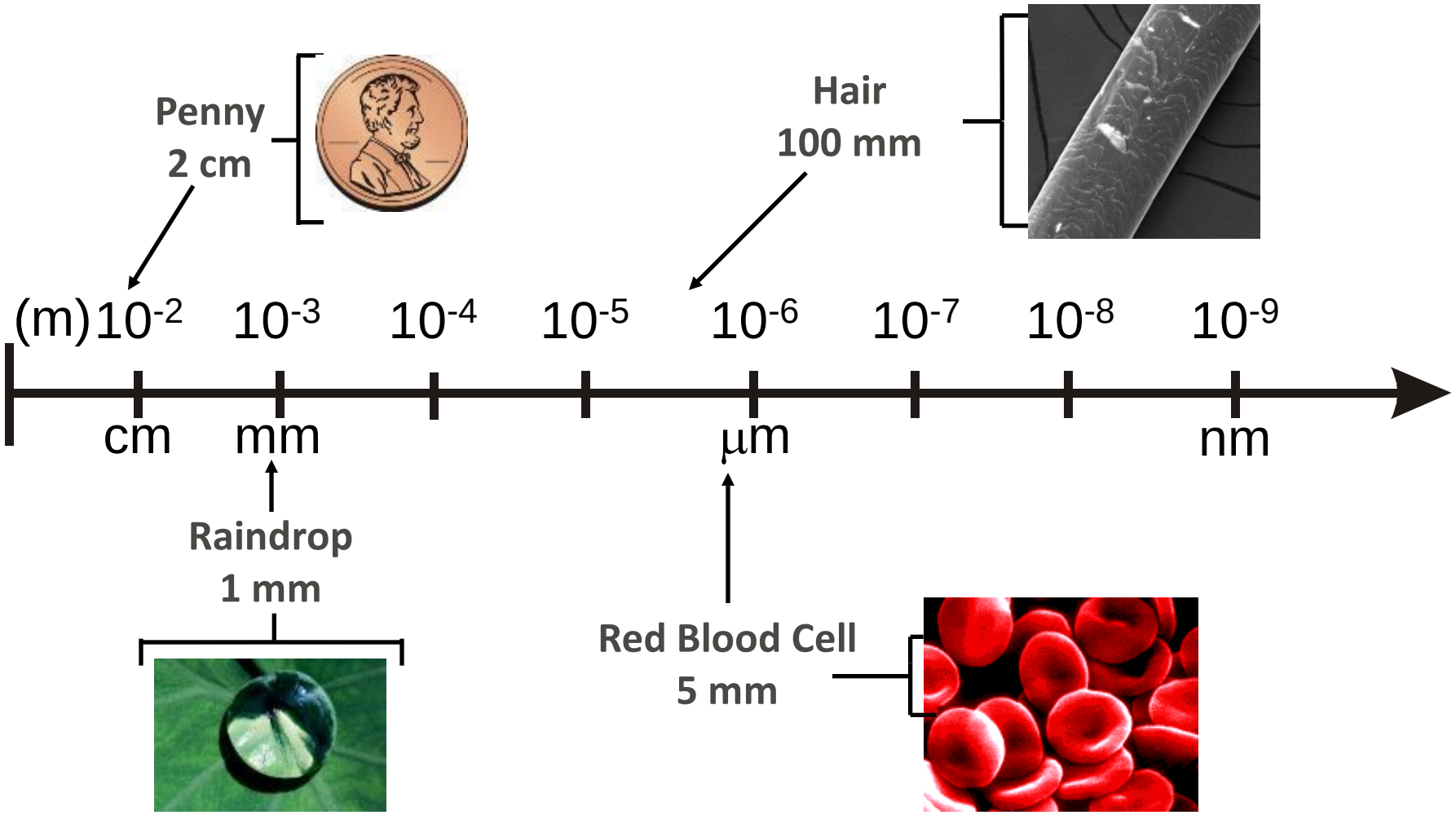
SI Units

- Centi 1 hundredth
- Milli 1 thousandth
- Micro 1 millionth
- Nano 1 billionth
- Pico 1 trillionth (quantum Mechanics)
- Femto 1 quadrillionth

Nanotechnology

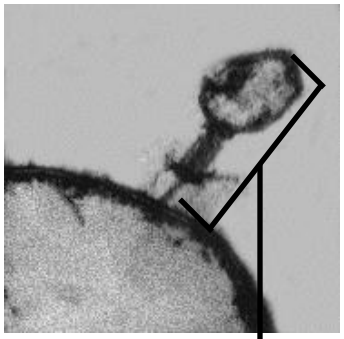
- Nanotechnology is concerned with nanomaterials and nanosystems whose structures and components exhibit novel and significantly improved physical, chemical, and biological properties
- These enable the exploitation of novel phenomena and processes which arise due to the Critical Feature Dimensions at nano-scale sizes

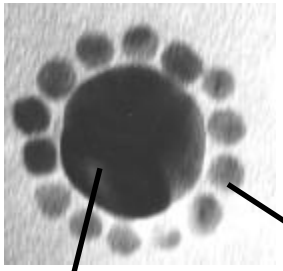
The Scale of Things NIST



Now Entering The NANO-ZONE (NIST)

Bacteriophage
60-70 nm

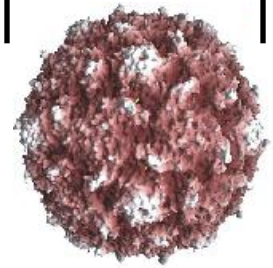




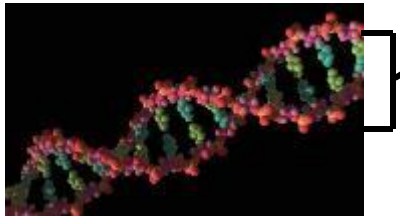
Gold Particles
13 nm and 50 nm

100 80 60 40 20 1

(nm)



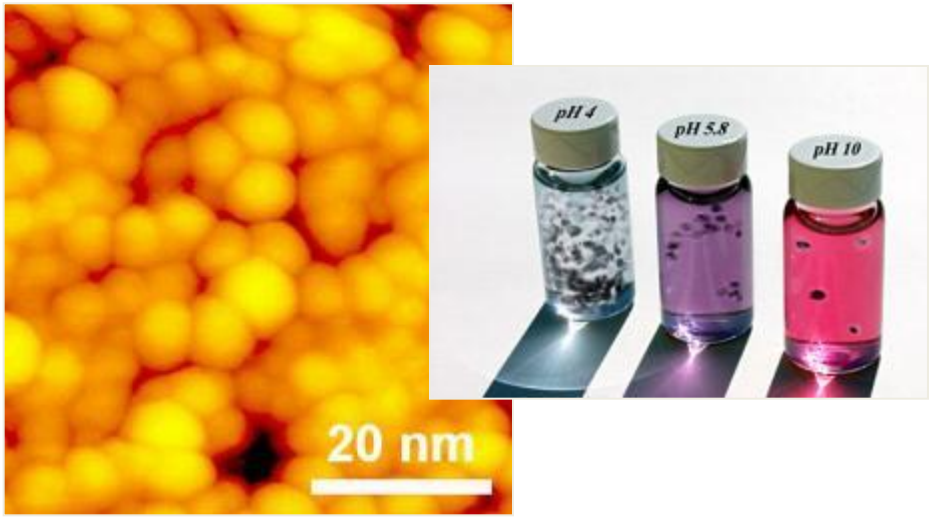
Flu Virus
100 nm



DNA
Diameter = 2 nm

Nanomaterials have dimensions in the range 1 nm to 100 nm

Nano versus Macro



Nano

Macro

Nanomaterials in Nature NIST

Smoke in fire

Sea spray

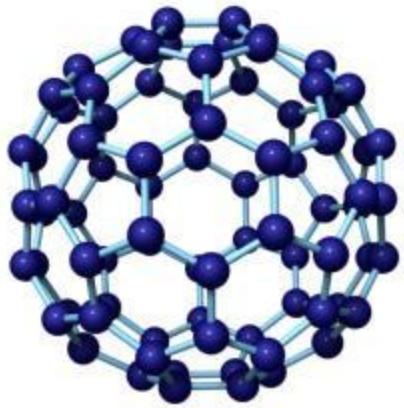
Abalone shell

Volcanic eruption

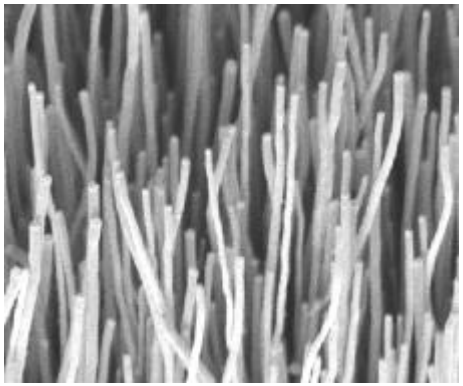
Sources: Incidental versus Engineered Nanoparticles

Welding Fumes

Diesel Exhaust Particulate



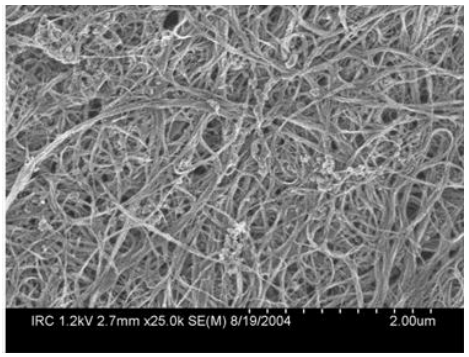
Fullerenes

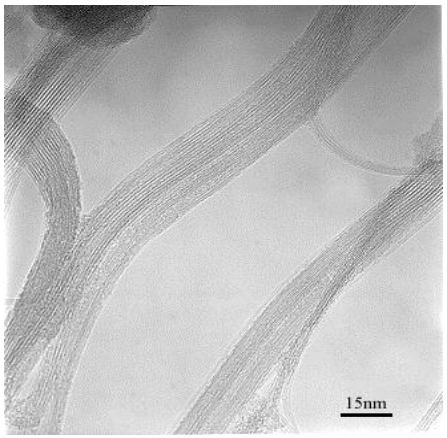


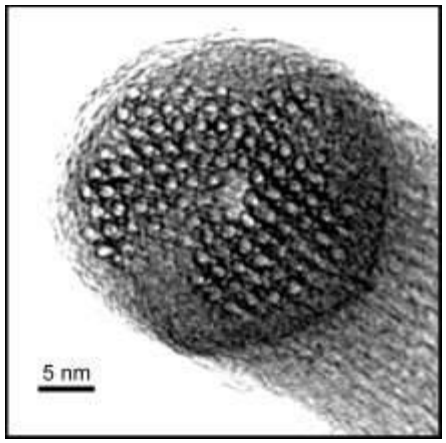
Carbon Nanofibre

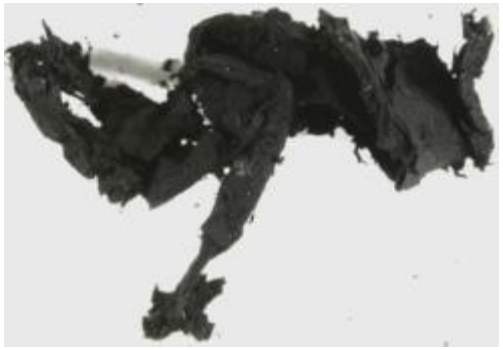
Source: GE

Current Sources in Development: Single-Walled Carbon Nanotubes





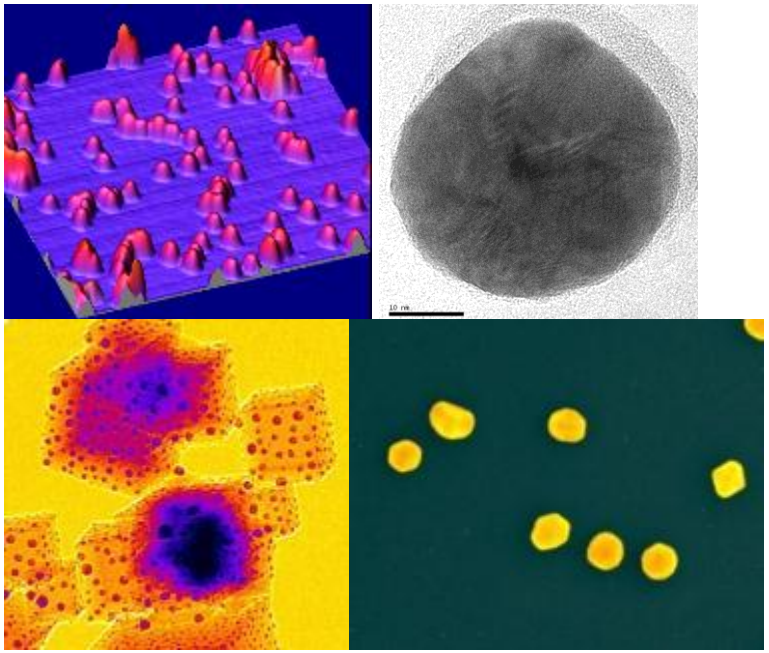




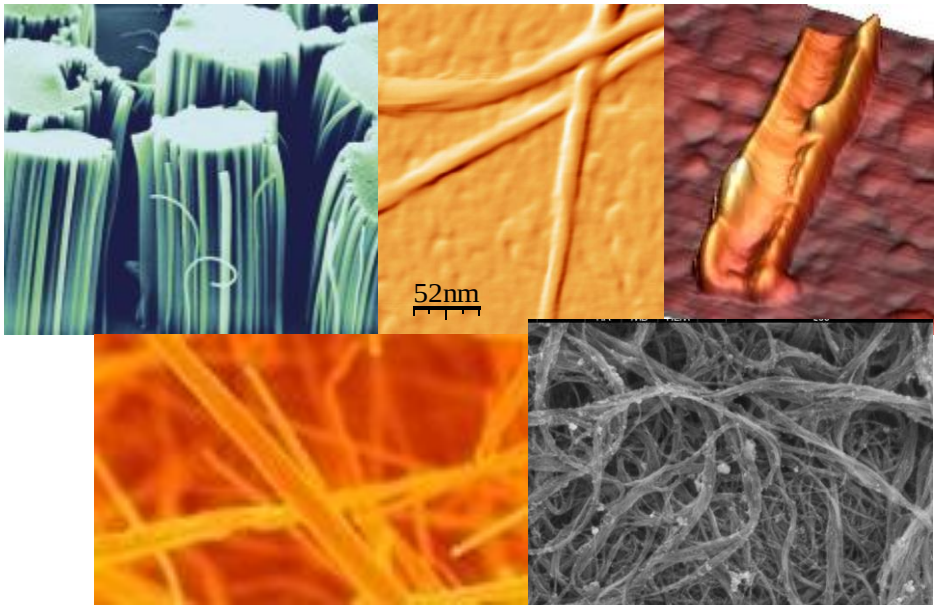
Source: NRC-CNRC

Manmade “Engineered” Nanomaterials NIST

nanoparticles

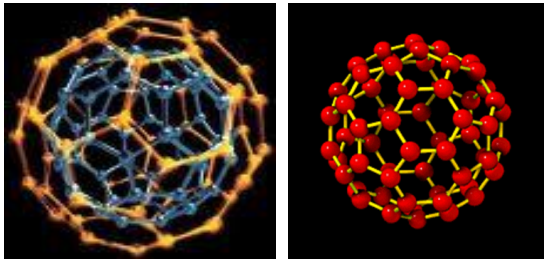


nanotubes

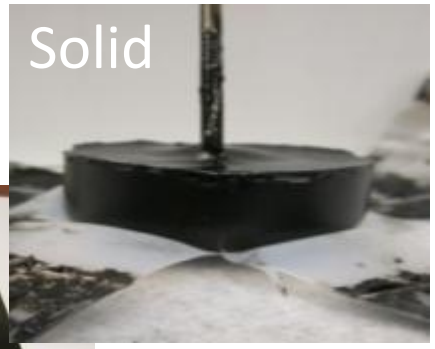


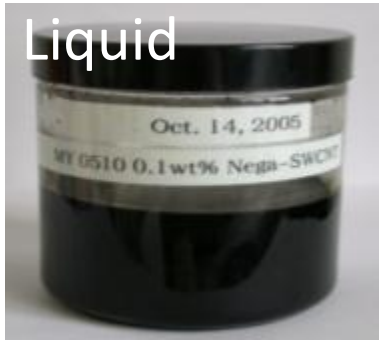
nanowires

Buckyballs



Current Sources in Development: SWCNT Composites

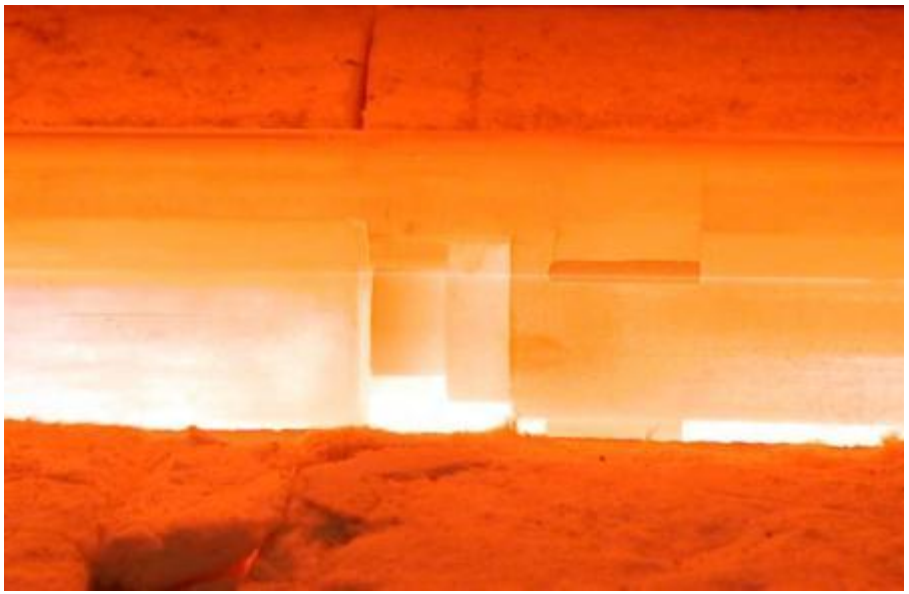




Source: NRC-CNRC

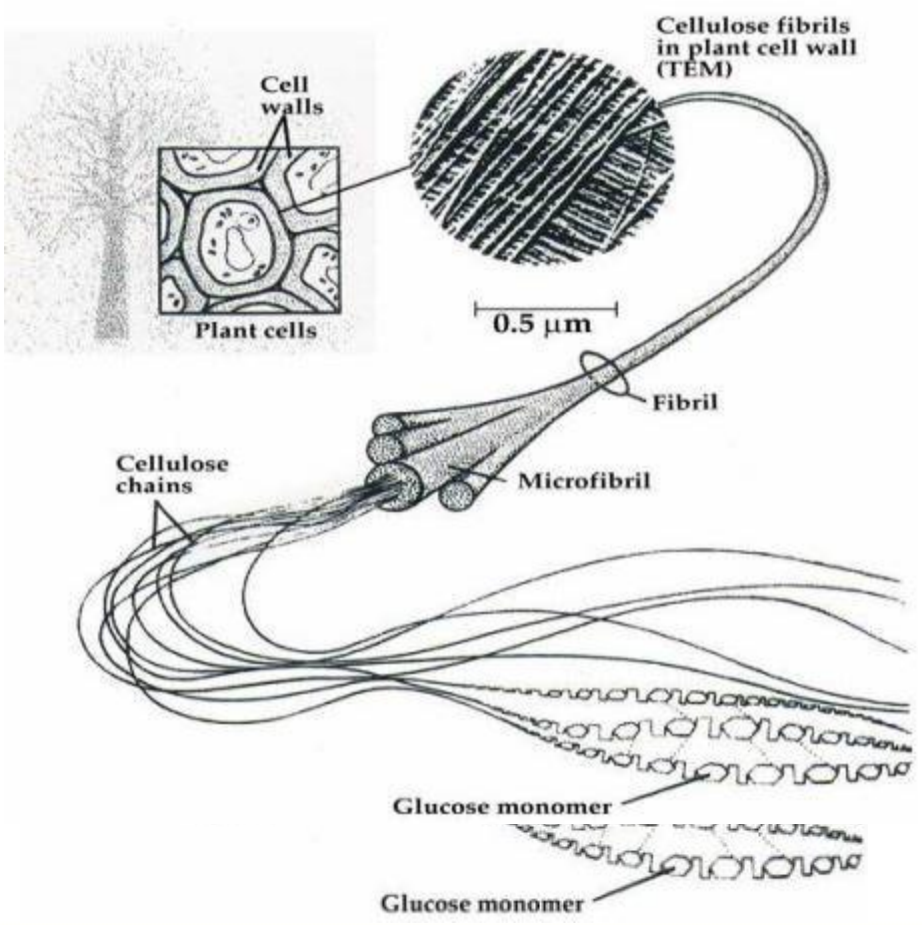
Carbon Nanotubes are Produced

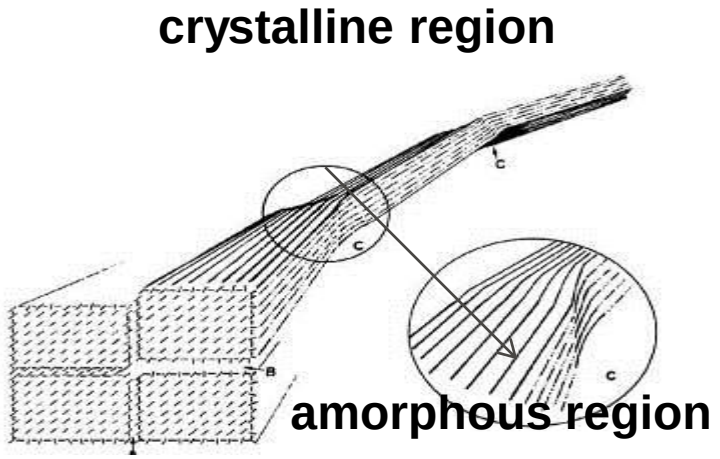
Laser Synthesis

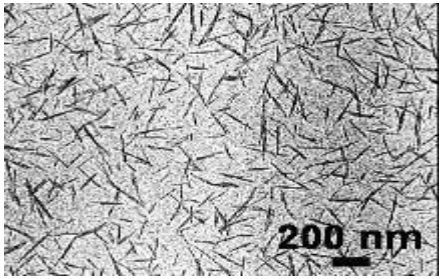


Source: NRC-CNRC

Origin of Forest Sector Nanotechnology Domtar/FPInnovations







1%

5%

NCC

7%

NCC

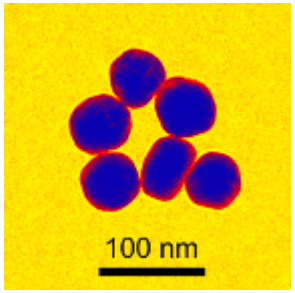
100%

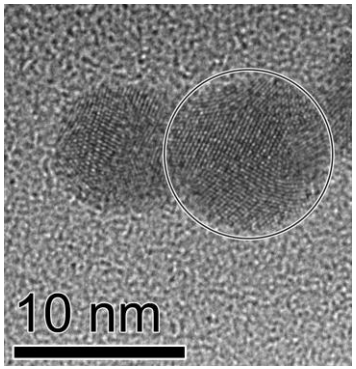
Domtar/FPInnovationa

Health & Safety ONTARIO

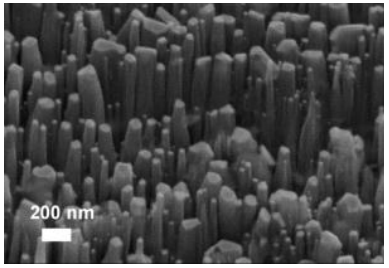
Important Properties of Nanomaterials NIST

Dimensions

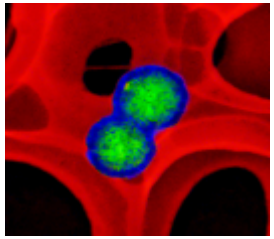


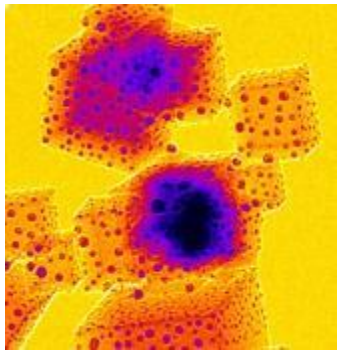


Surface Activity

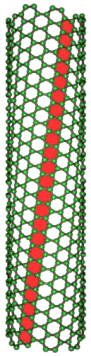


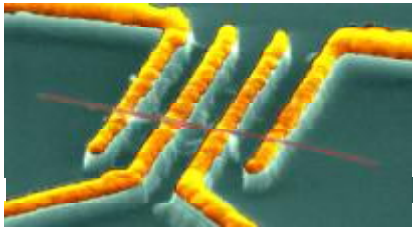
Morphology



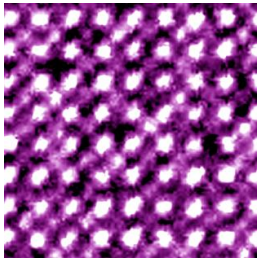


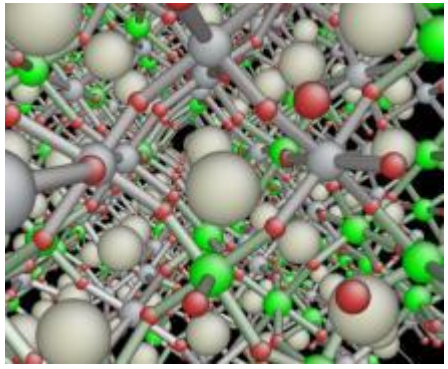
Electrical Properties



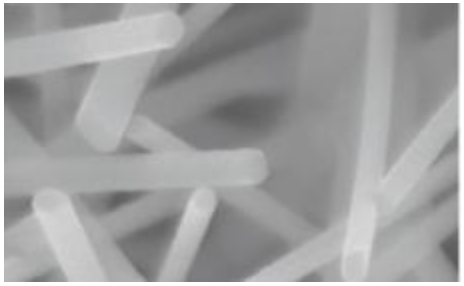


Structure



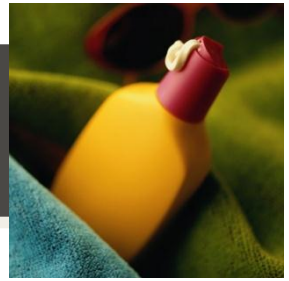


Mechanical Properties

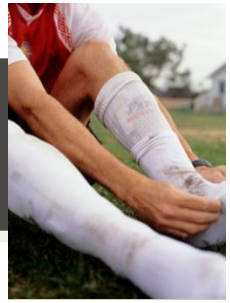


Current Promises of Nanotechnology

I wish my sunscreen wasn't so unsightly



*I **wish*** my socks didn't smell so much!



I wish my tennis racquet was lighter and stronger

I wish I could keep leftovers for longer

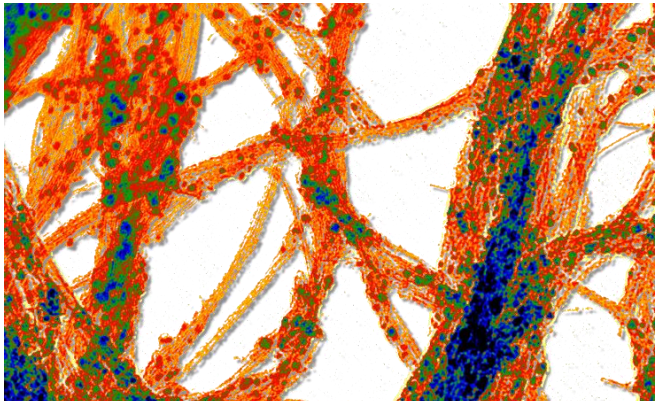
I wish red wine would run off pants without staining

I wish I could get more songs on my MP3 player

Source: Woodrow Wilson

Current Promises of Nanotechnology

Materials

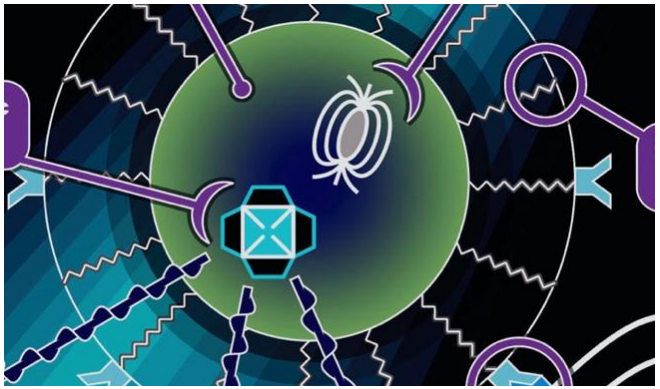


Light as plastic, strong as steel

Water

Clean water any time, any place

Medicine



Smart drugs that kill the disease, not the person

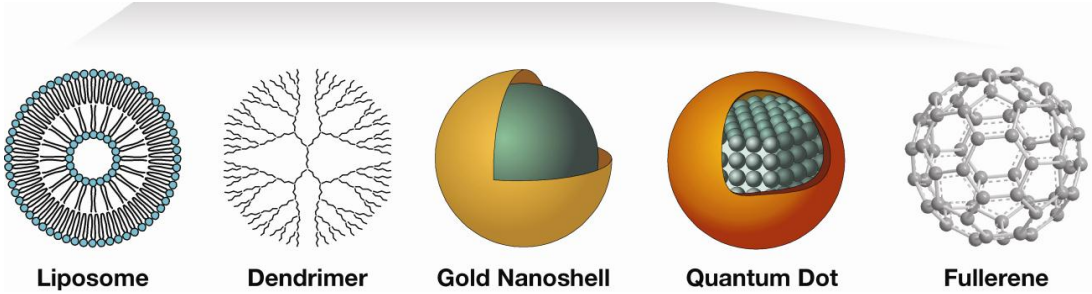
Energy

Converts light to energy – anywhere

Source: Woodrow Wilson

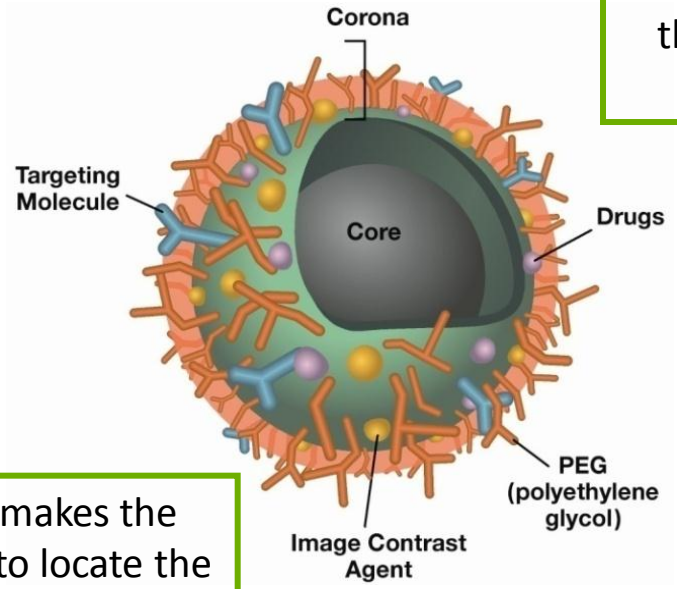
Cancer Nanotechnology NIST

Some types of nanoparticles being developed for early detection and treatment of many types of cancer

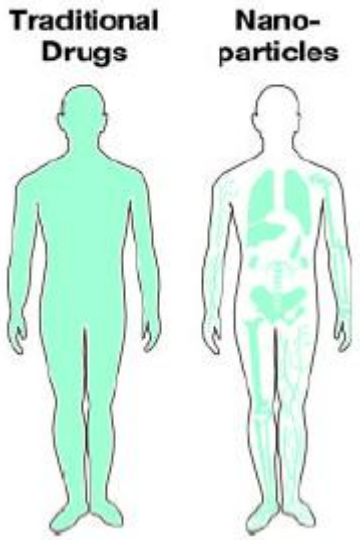


Nanoparticles are injected into the body

Surface "coating" to target tumor cells in a specific organ



Surface "coating" of a drug to treat the tumor locally without whole-body effects of chemotherapy



Surface "coating" that makes the nanoparticles "light up" to locate the tumor for treatment

Nano Materials in Architecture and Design

1. Self-cleaning: Lotus – Effect
2. Self-cleaning: TiO2
3. Easy-to-clean: hydrophobic
4. Air-purifying
5. Anti-fogging
6. Fragrance capsules
7. Thermal insulations: Aerogel

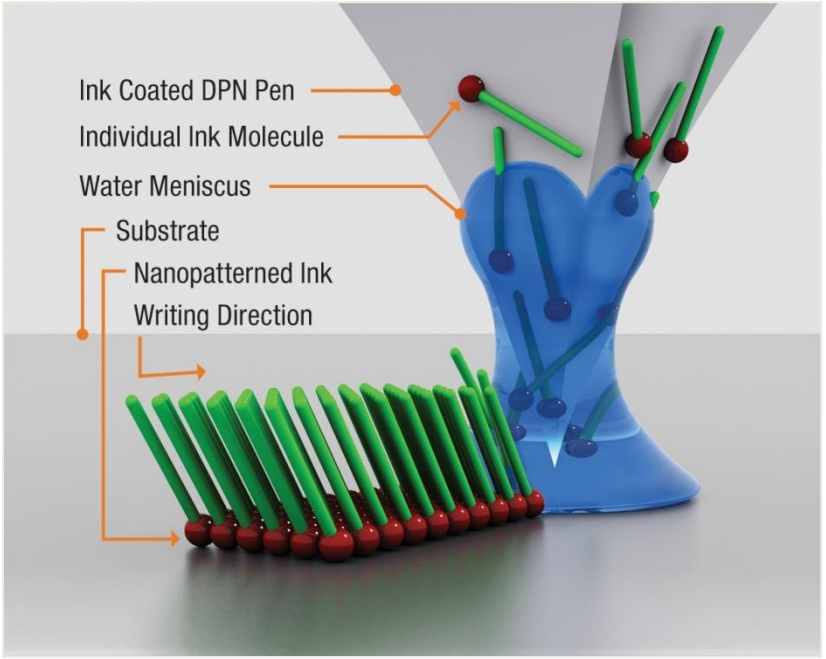
Nano Materials

8. Temperature regulation: PCMs
9. UV Protection
10. Solar protection: darkening
11. Fire-proof: silicic nanoparticle
12. Anti-graffiti: hydrophobic
13. Anti-reflection
14. Antibacterial
15. Anti-fingerprint

- Nano in the Food and Agriculture Industry
  - More efficient food production, seed treatment (Precision farming – monitoring environmental variables and apply target action.
  - More hygienic food processing (surface treatment)
  - Preservation of food
  - Improved taste, flavours, nutrient value, uptake in body
  - Longer shelf-life
  - Lighter, stronger, more functional packaging
  - Smart labels, sensors, crop sensors, pathogen toxin pesticide detection, authenticity and traceability
  - Water treatment
  - Pesticides, soil treatment, agrichemical delivery (smart delivery)

The DPN® Process

- Dip Pen Nanolithography® is NanoInk's patented process for deposition of nanoscale materials onto a substrate
- The vehicle for deposition can include pyramidal scanning probe microscope tips, hollow tips, and even tips on thermally actuated cantilevers

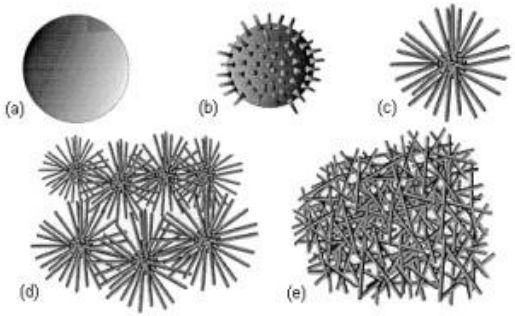


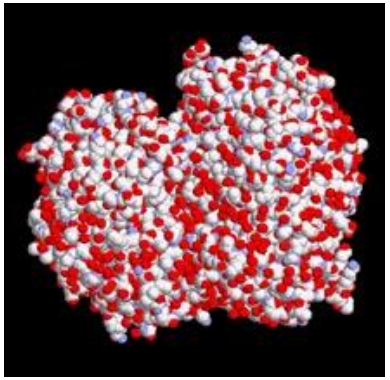
Source: NanoInk Inc.

Park Systems: Atomic Force Microscope

Health Effects

1. Physical dimensions of particles – affect penetration and durability
2. Chemical reactivity of surface (must account for surface components – transition metals and coatings), and release of free radicals
3. Surface area presented to target organ (dose)
4. Solubility (if it may disperse before causing a reaction)

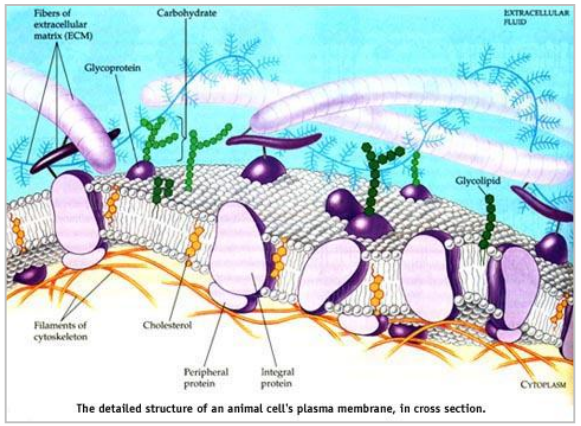




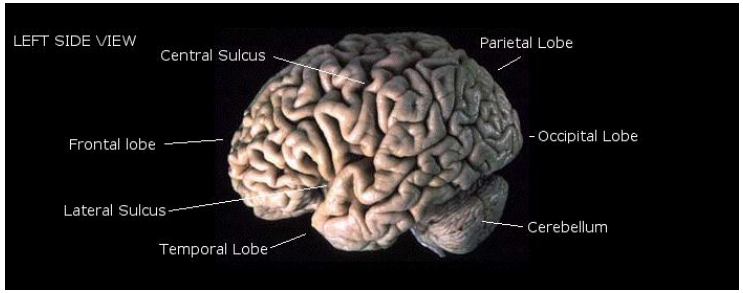
Source: GE

Health Effects

- Evidence suggests that because of their small size, nanoparticles are able to cross cell membranes and interact with sub-cellular structures (NIOSH, 2006)
- Evidence that nanoparticles can cross the blood brain barrier via the olfactory nerves



The detailed structure of an animal cell's plasma membrane, in cross section.

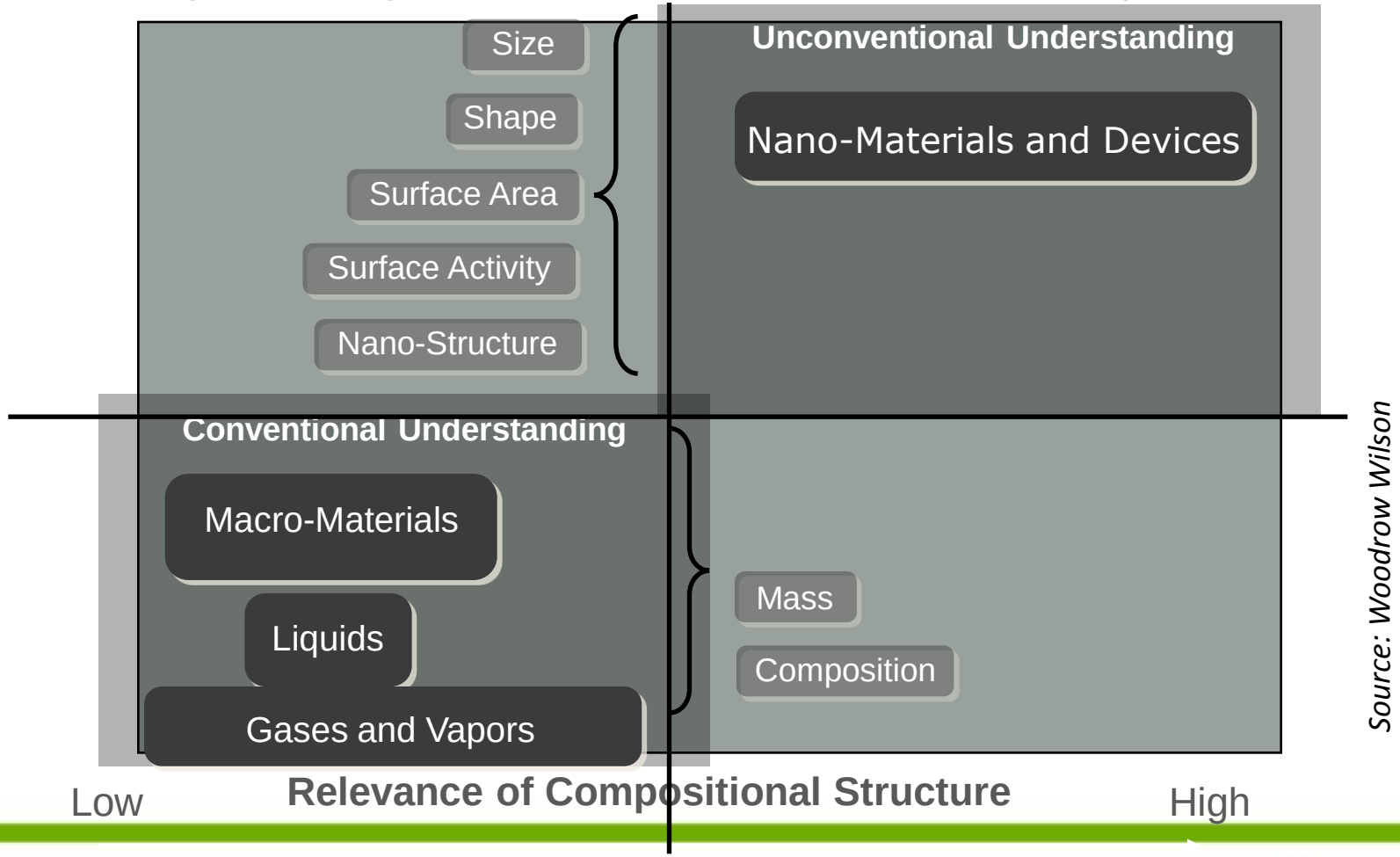


Source: GE

Behaviour of Nanomaterials

A thought experiment

The potential significance of structure on nanomaterial impact



Source: Woodrow Wilson

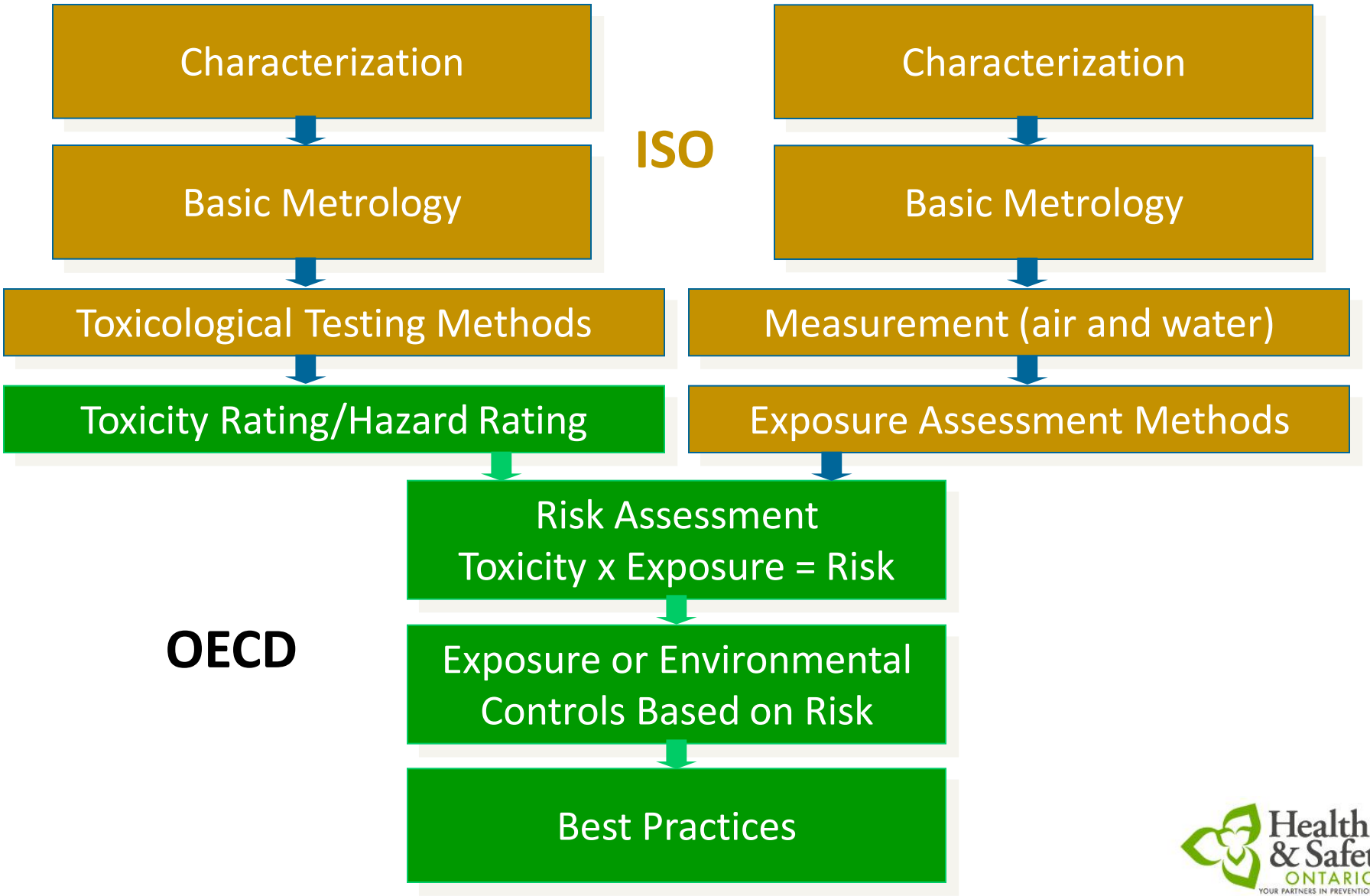
Measurement

What parameters should we be measuring?

- Mass
- Number
- Surface area
- Solubility
- Shape
- Surface chemistry
- Electrical mobility
- Density

Photo: Park Systems

NANO TC 229 WG 3 119-2007



Health & Safety ONTARIO
YOUR PARTNERS IN PREVENTION

- CAN/CSA-Z12885:12 National Standard of Canada
- Nanotechnologies- Exposure control program for engineered nanomaterials in occupational setting
- Built on CSA Z1000, OECD Guideline for measuring nano particle emission, NIOSH, etc.

Metrics for Nanoparticles

- Number
- Surface Area
- Lung deposited surface area
- Size distribution and concentration
- Chemistry
- Morphology
- Bio-activity

Size distribution and number concentration can also be measured for nanoparticle aggregates by Optical Particle Counters. These measurements are good for quick survey

Differential Mobility Analysis

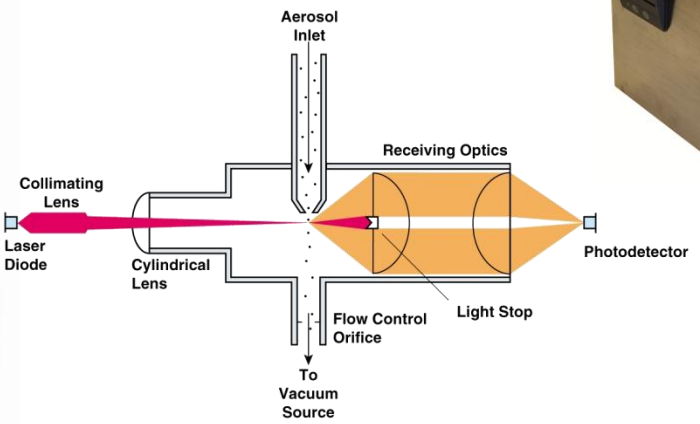


Figure 2
Flow Through an Optical Particle Counter

Source: TSI

JOEL: TEM ARM200F

Evaluation

- No Health-Based or Risk-based recommended OELs derived for specific NM
- NIOSH advised recommended Exposure Limits (RELs) for TiO2 and draft for MWCNT
- May be some company based i.e Bay-tubes MWCNT
- Nano Reference Values (NRV) IVAM UvA Netherlands
- 'Precautionary Principle' – global terms
  - No information, no risk assessment – take all precautions reasonable – err on the side of caution

Overview of Control Strategies

Lab Hood

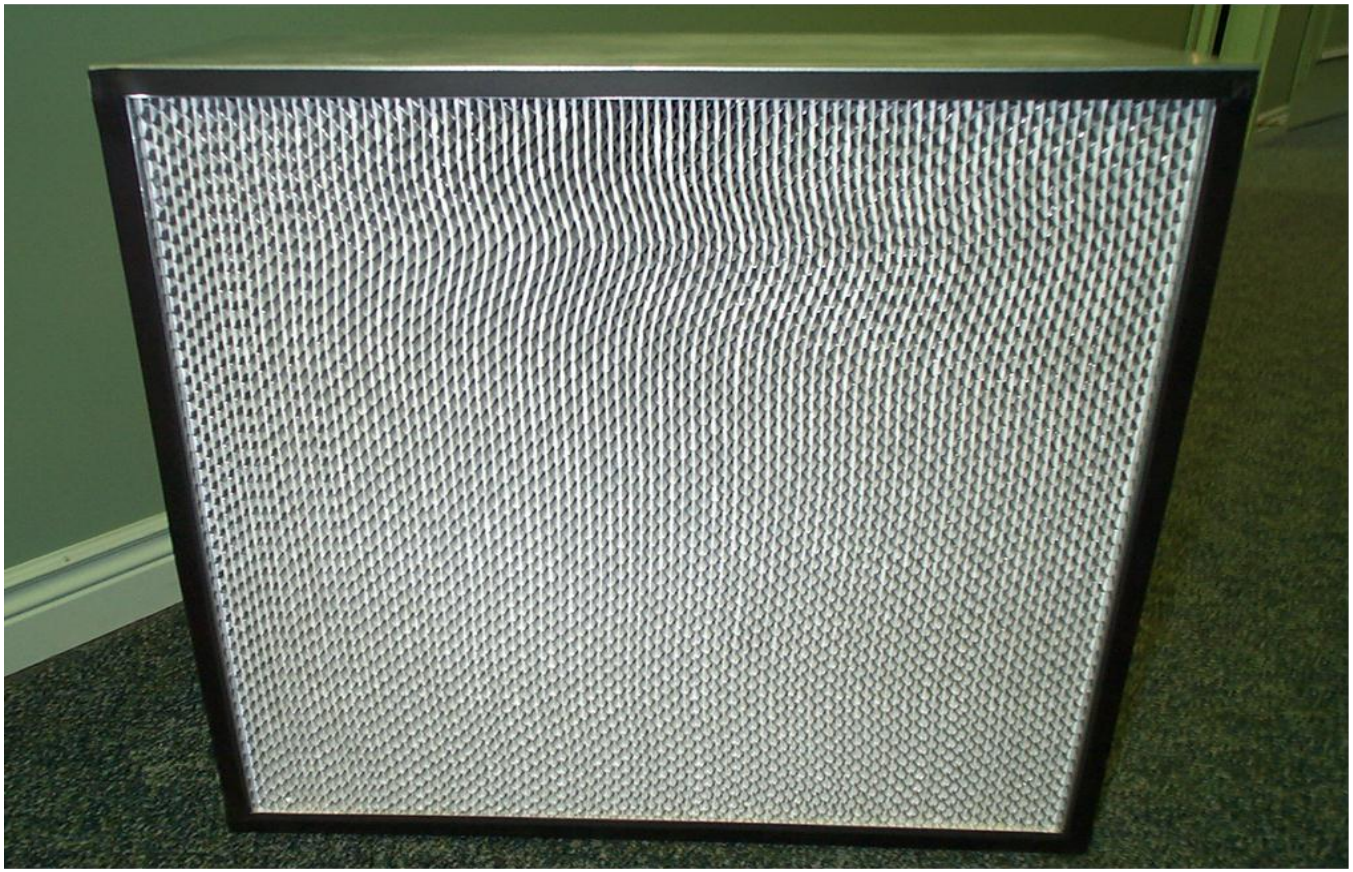
Local Ventilation connected to Hepa Filter

Respirator

Glove Box

Source: GE

HEPA Filter



Source: HEPA Filter Service

Clean Room with HEPA Filters

Source: HEPA Filter Service

•(Ontario's Long-term Report on the Economy, 2010)

For all your health and safety solutions, contact:

Workplace Safety & Prevention Services

1 877 494 WSPS (9777)

www.wsps.ca