Battelle
The Business of Innovation

Nanoparticle Air Monitoring Workshop

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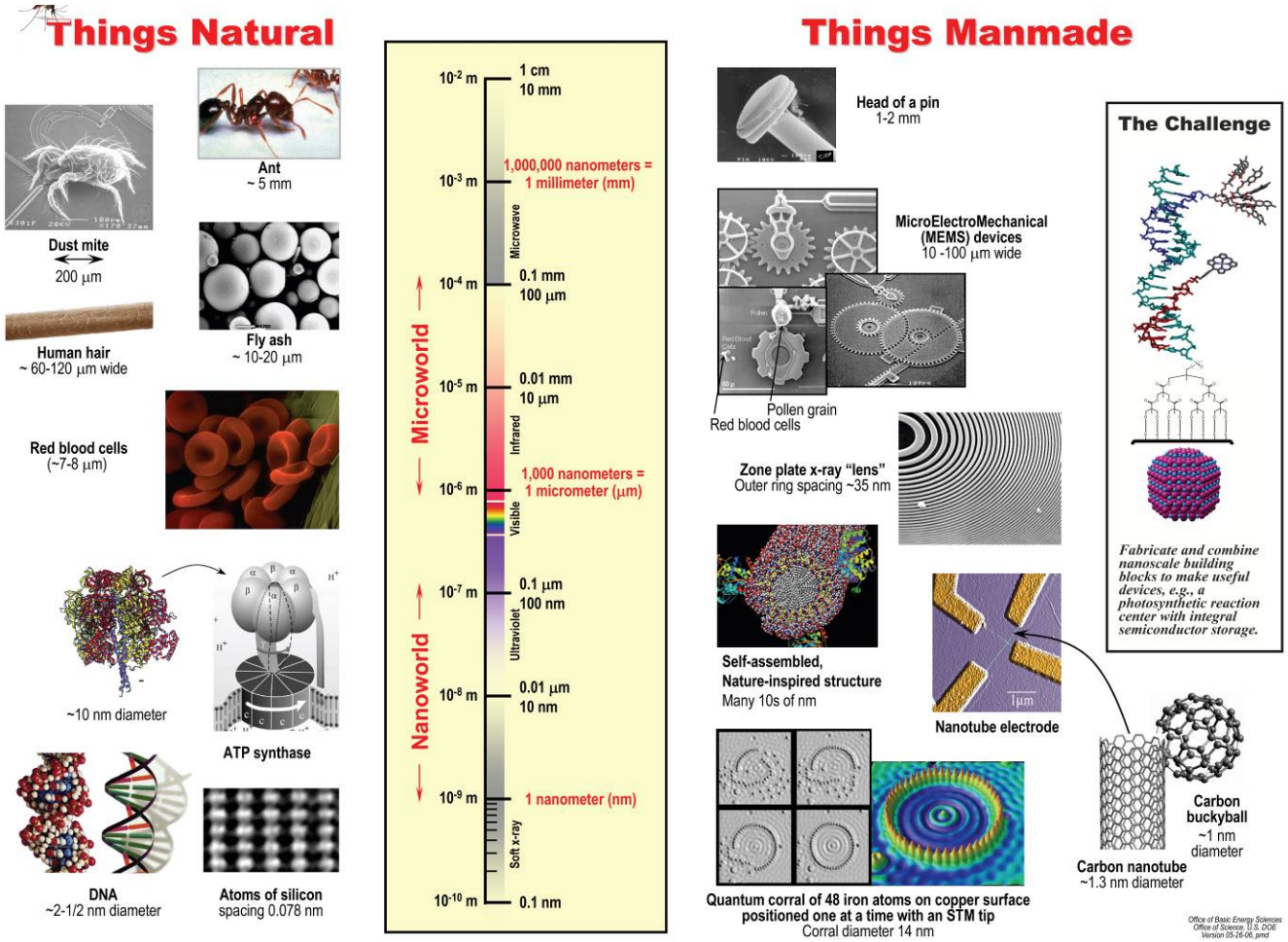
Nanomaterials – Natural and Manmade



(1) The creation of materials, devices and systems that (2) exploit novel properties by (3) controlling matter on the nanometer length scale (1-100 nm)

Nanomaterials - *Definitions*

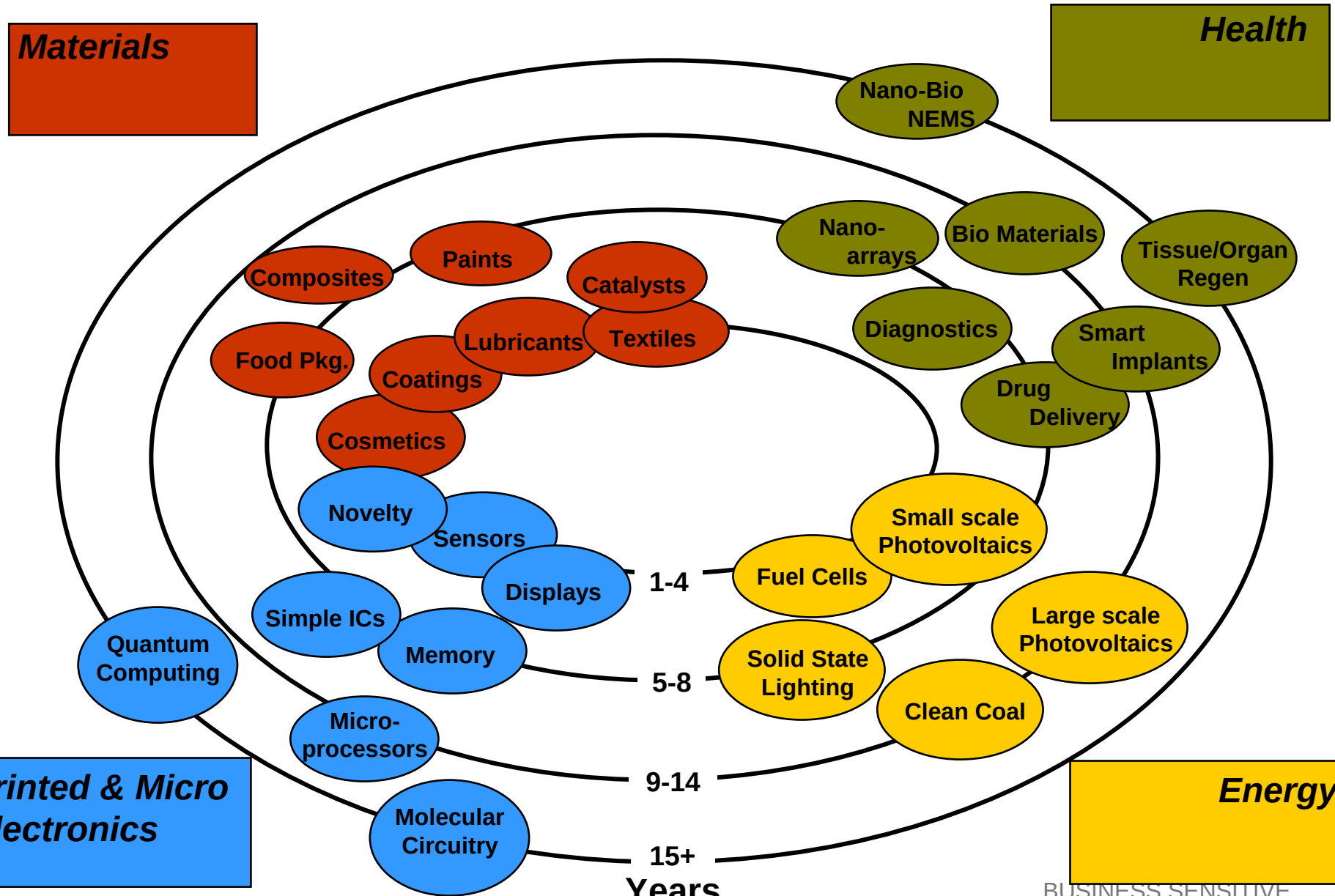
- Native nanomaterials
  - Materials whose particles are nano-sized, *i.e.*, < 100 nm in any of their dimensions (*e.g.*, components of diesel exhaust; carbon nanotubes)
- Engineered nanomaterials
  - Materials that have nano-sized particles incorporated into them to create unique physical and chemical properties (*e.g.*, polymer composites impregnated with carbon nanotubes to increase their electrical conductivity)

Nanotechnology: Estimated Economic Impact

- **A new world of products: ~ $1 trillion / year in 2010-2015**
  - **Materials** beyond chemistry: **$340B/y** in 10 years for materials and processing
  - **Electronics in 10-15 years**: **$300B/y** for semiconductor industry, > integrated circuits
  - **Pharmaceuticals in 10-15 years**: about half of production will depend on nanotechnology, affecting about **$180 B/y**
  - **Chemical plants in 10-15 years**: nanostructured catalysts in petroleum and chemical processing, about **$100B/y**
  - **Aerospace** (about **$70B/y in 10 years)**
  - **Tools** (measurement, simulations) ~ **$22 B/y** in 10y
- **Would require worldwide ~** 2 million nanotech workers
- **Improved healthcare**: extend life-span, its quality, human physical capabilities (~ **$31B** in tools for healthcare in 10 years)
- **Sustainability**: agriculture, water, energy **(~$45B/y** in 10 years), materials, environment; ex: lighting energy reduction ~ 10% or **$100B/y**
- **Knowledge base**: better comprehension of nature, life

Source: M.C. Roco, NSF

Nano Applications



Nano-based Products Emerging for Mainstream Consumers

Nanotex Materials

Nano-care™ treated fiber surface with ~ 200 nm "whiskers"

Water Proof – Stain Proof

smith&nephew

Antimicrobial Dressing

Nanowax: CERAX

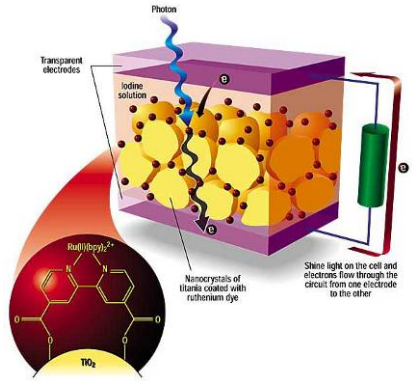
Self Cleaning Windows (photo catalytic coating)

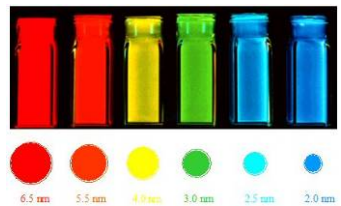
Nano-clay gas diffusion barrier

Nano Tin Oxide: Sunscreen

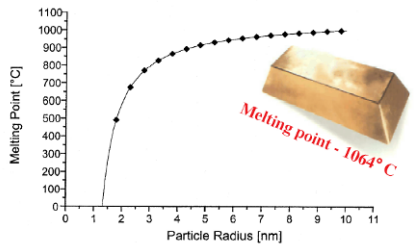
Nanoscale Phenomena

- Unique properties arise due to:
  - Size Effects
    - Tailored for specific length scale
  - Size-dependent Properties
    - Quantum Confinement
  - High Surface Area/Volume Ratio
    - Smaller particles are more reactive





Source: Vanderbilt University



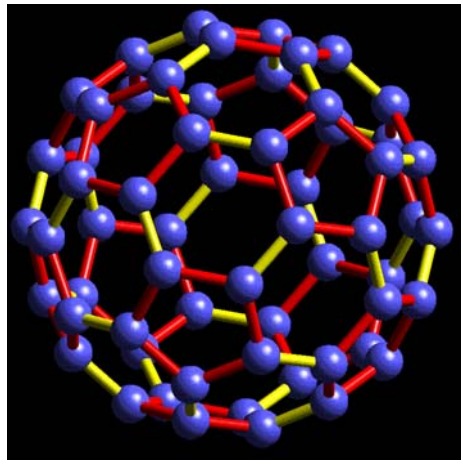
Source: NASA Ames

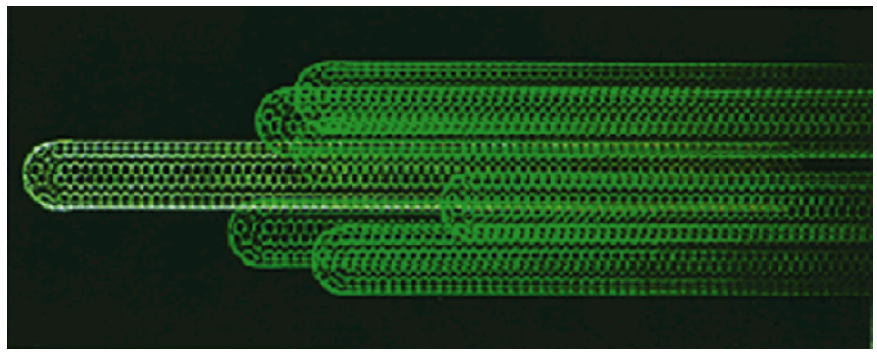
Environment, Safety, and Health (ES&H) Issues

- Health and Safety Concerns
  - Same properties that make nanoparticles interesting (they behave differently than the bulk material) could cause unknown health effects
- Smaller Size =
  - Potentially increased mobility in the environment and the body
  - Larger surface area and chemical reactivity
  - Larger importance of particle morphology & quantum effects
  - Increased ability to cross cell membranes

Nanoparticle Aerosol Generation

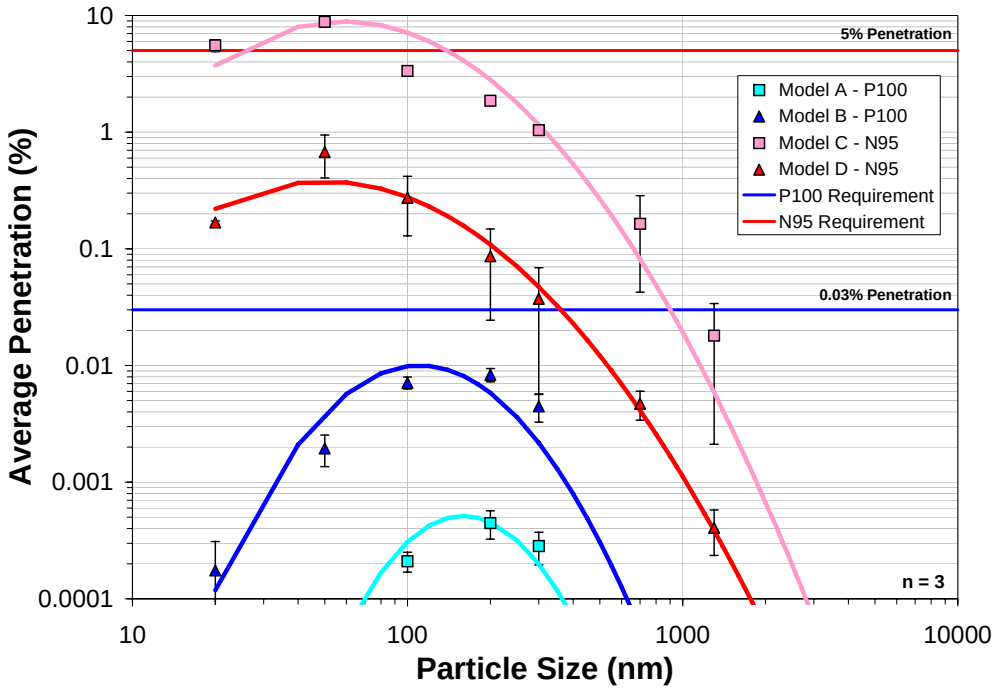
- Method of aerosol generation of nano-sized C_{60} fullerene has been developed and validated
  - High mass concentration of nanoparticles achieved
  - Stable and controllable generation over extended period of times
- Methods of aerosol generation of other nano-materials in development
  - Metal Nanoparticles
  - Single Walled Carbon Nanotubes



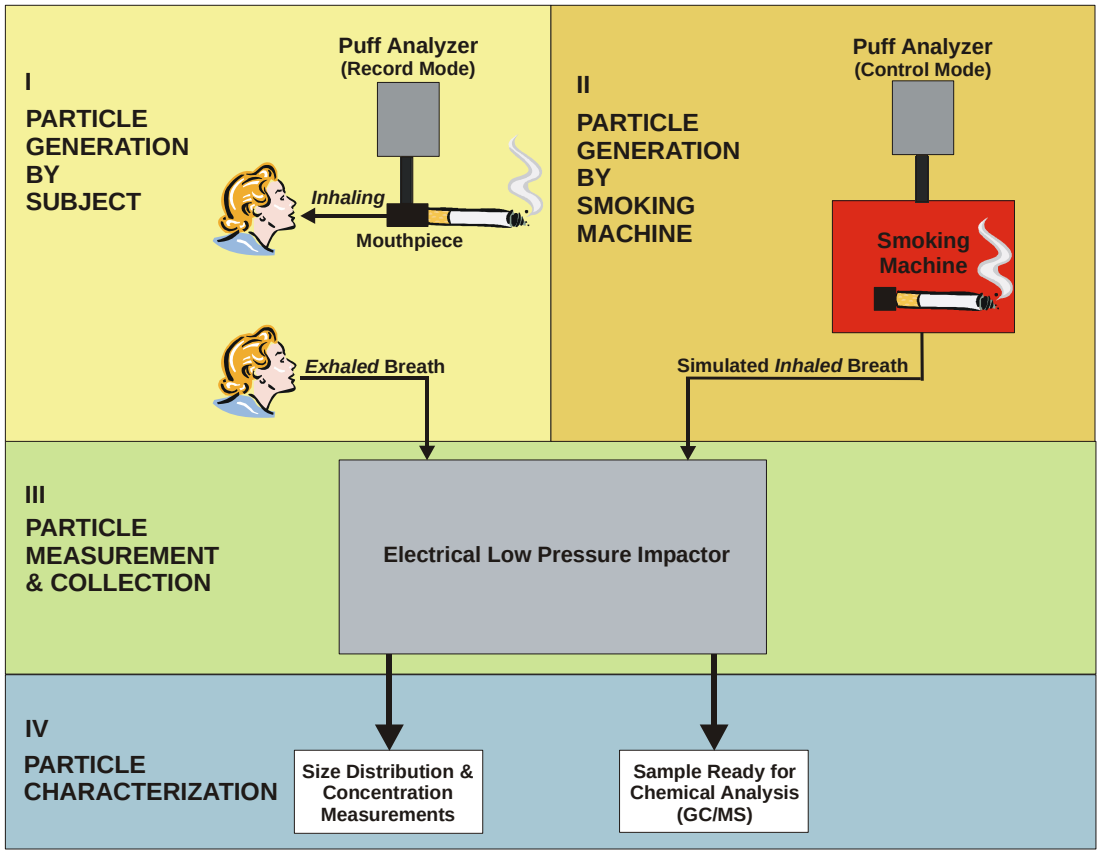


Industrial Health – Assessing Respirator Filters

Performance of NIOSH-Approved
Particulate Filters Against Nanoaerosol Challenge



Measuring Nanoparticles in Cigarette Smoke



Regulatory Environment

- ES&H effects of nanotechnology need to be defined; regulatory environment is lagging advances in technology
- Dec 2008 National Research Council report suggests ES&H research needs to be strengthened
- Jan 2009 Science and Technology Committee includes nanotechnology on agenda for 111th Congress
- Feb 2009 reauthorization of National Nanotechnology Initiative

Workshop Outcomes

- Improved understanding of needs for measuring nanoparticles in ambient air and emissions
- Increased knowledge of approaches to meet measurement needs, and possible gaps
- Information to feedback into organization planning
- Contacts for future discussion and collaboration