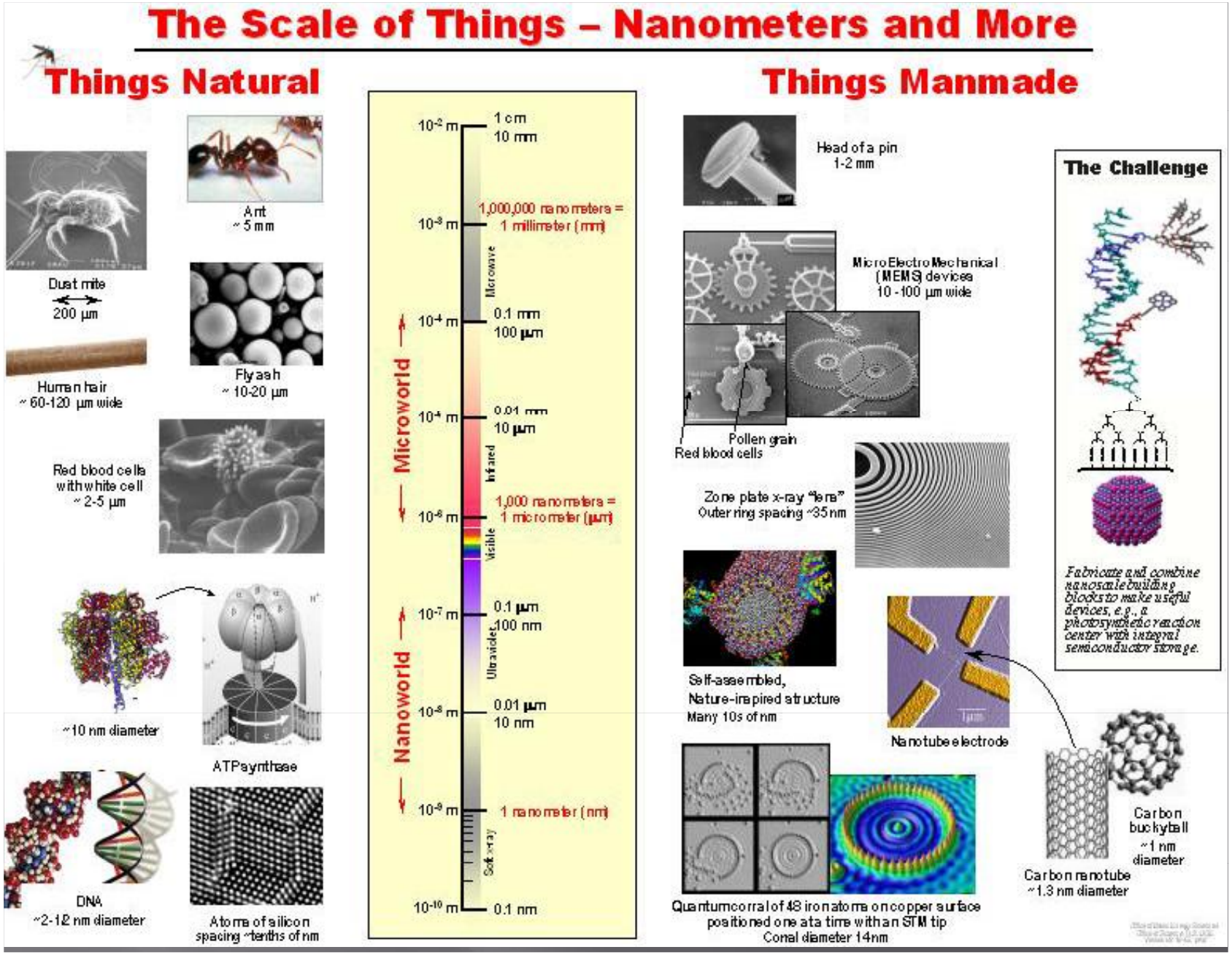
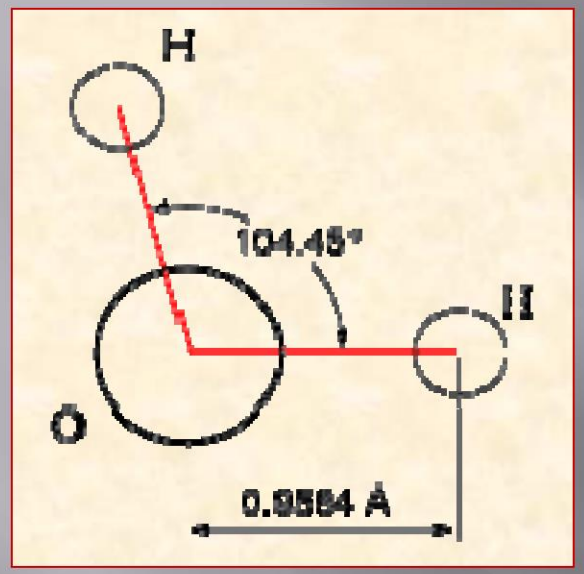


http://www.nano.gov/html/facts/The_scale_of_things.html

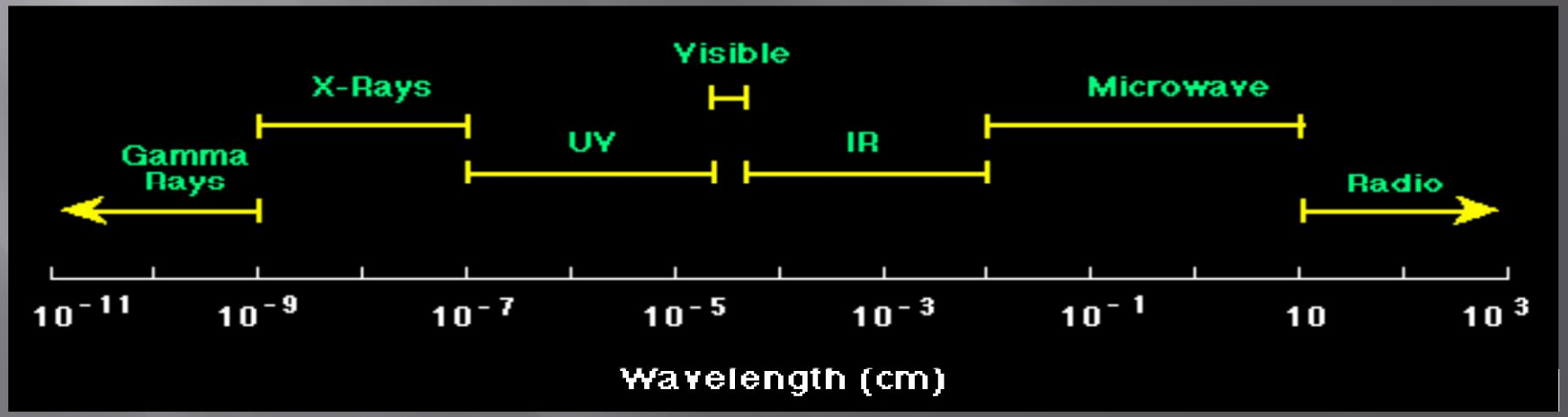
Scale of things



C-C bond – 1.5 angstroms

C-H bond – 1.1 angstroms

Ethanol: CH_3-CH_2OH

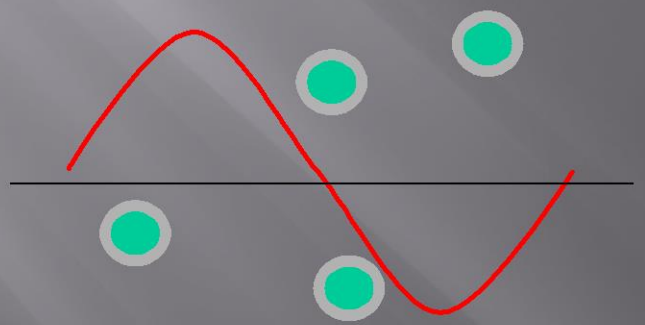


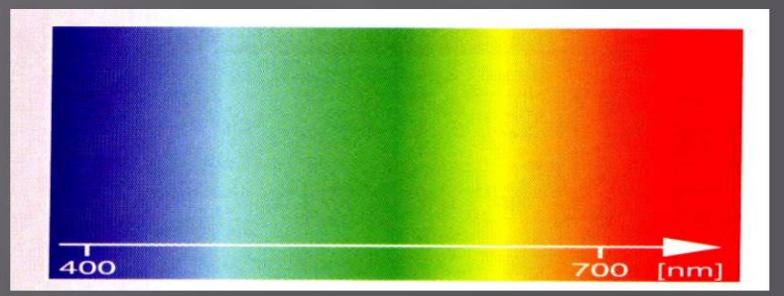
10^{-4} 10^{-2} 10^{0} 10^{2} 10^{4} 10^{6} 10^{8} 10^{10}

Nanometer

Nanocomposites: Optical Clarity

- Size and refractive index of particles are important
- Nanoparticles are smaller than the wavelength of visible light; reduces chance of light scattering

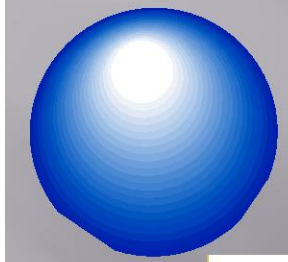




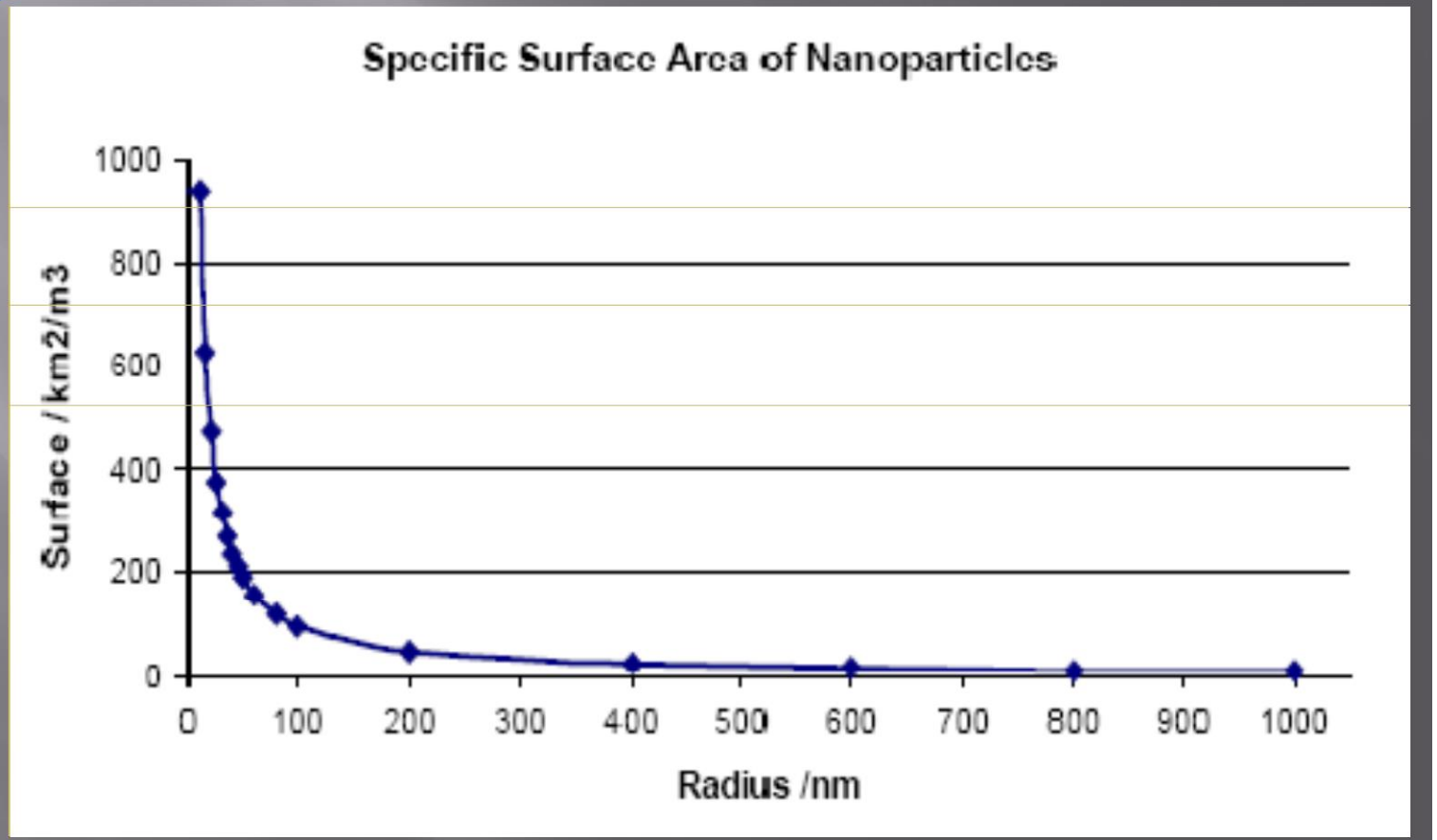
Nano-Scale & Conventional Polymeric Coatings

Polymer latex particle size	50 - 500 nm
Hiding grade TiO_2 particle size	200 - 250 nm
Polyurethane Dispersion particle size	50 - 100 nm
Polymer molecular size in solution	2 - 100 nm

Nanomaterials: Surface Area Dependence on Size



$$A = 4\pi r^2$$



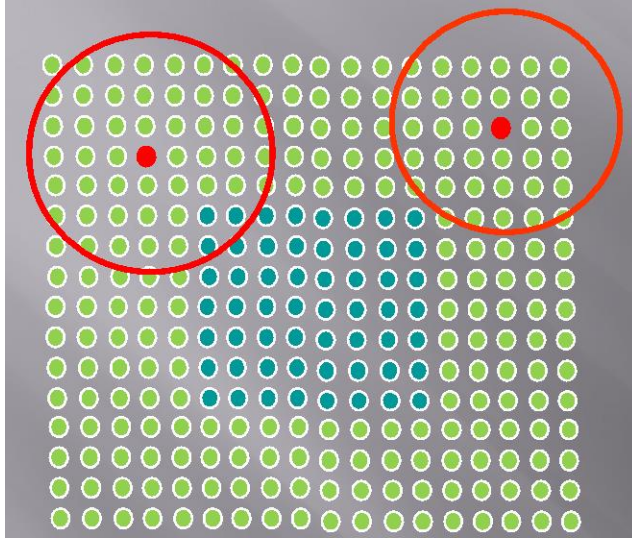
Surface Area

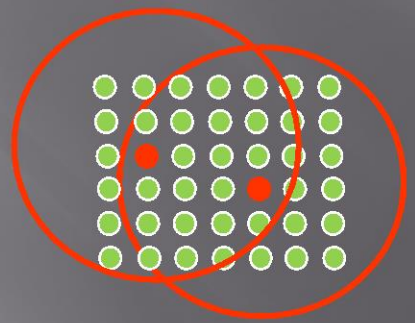
Volume = $4/3*\pi*r^3$ Surface area = $4*\pi*r^2$

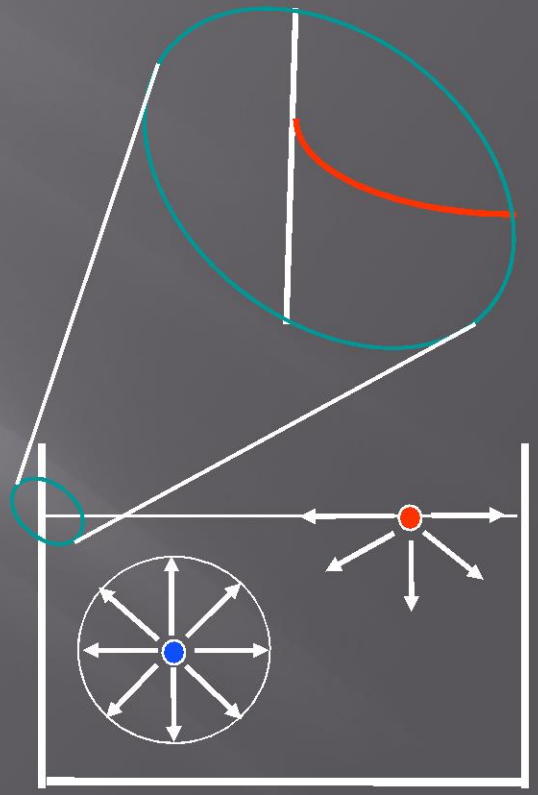
- 1 gram of TiO_2 → Volume = 0.25 cm^3

Particle diameter (nm)	Particles per gram	Surface area per gram (m^2)	Surface Area / Volume
200	6×10^{13}	7.5	1.8×10^{12}
20	6×10^{16}	75	1.8×10^{16}
2	6×10^{19}	750	1.8×10^{20}

Bulk Vs Surface Properties



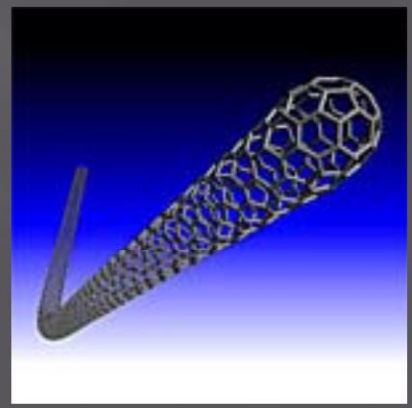




Bulk properties are not scalable to nanoscale

Surface Material Content

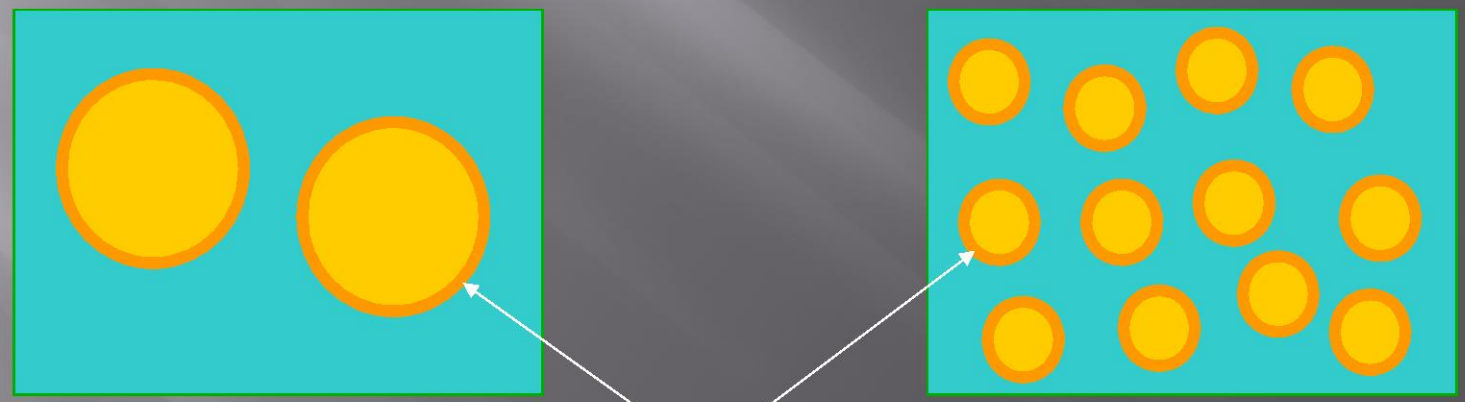
- A particle of 10nm diameter has 20% surface atoms
- A particle of 2nm diameter has 80% surface atoms
- A particle of 1nm diameter has 100% surface atoms
  - Single wall Carbon nanotube



A capped single-wall carbon nanotube with a slight bend.
http://www.thomas-swan.co.uk/pages/nano_images.html

Interfacial Material Content

Particle Diameter (nm)	300	250	200	150	100	50
Interfacial Volume Fraction	0.03	0.04	0.05	0.06	0.10	0.22



Dispersed particle volume fraction is 0.3 in all cases