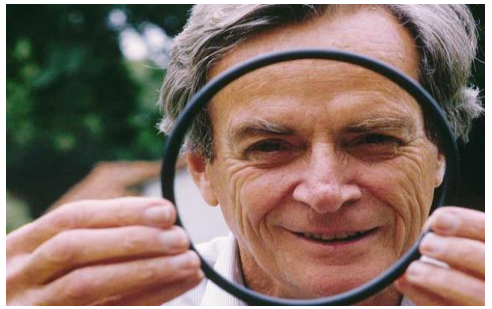
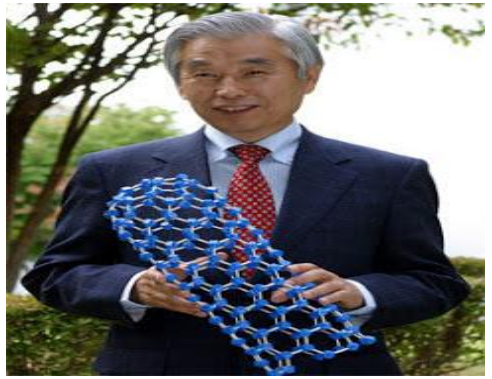

P. D. Patel Institute of APPLIED SCIENCES
CHARUSAT
CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY
“There’s plenty of room at the bottom”
- Richard P Feynman (29 December 1959)
Annual meeting of the American Physical Society

History of nanoscience:

- The concept of nanotechnology was first coined by Richard Feynman in 1959 in his lecture “There’s plenty of room at the bottom”
- The term Nanotechnology was first used in 1974 by Norio Taniguchi to refer to a precise and accurate tolerances required for machining and finishing.
- In 1981 K. E. Drexler (now at the Foresight Nanotech Institute for Molecular Manufacturing), talked about molecular manipulation and molecular engineering.
- In 1986, Drexler published a book “Engines of Creation, which finally popularized the term Nanotechnology.
- In 1985 researchers reported the discovery of the “buckyball”, a round molecule consisting of 60 carbon atoms.
- This led in turn to the 1991 discovery of a related molecular shape known as the “carbon nanotube” by Sumio Iijima at NEC Fundamental Research Laboratories in Tsukuba, Japan





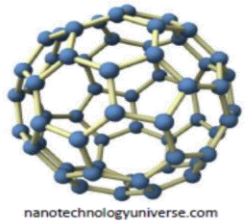
What is nanomaterial?

- ‘nano’ is to a Greek prefix meaning dwarf or something very small and depicts one billionth (10^{-9}) of a unit

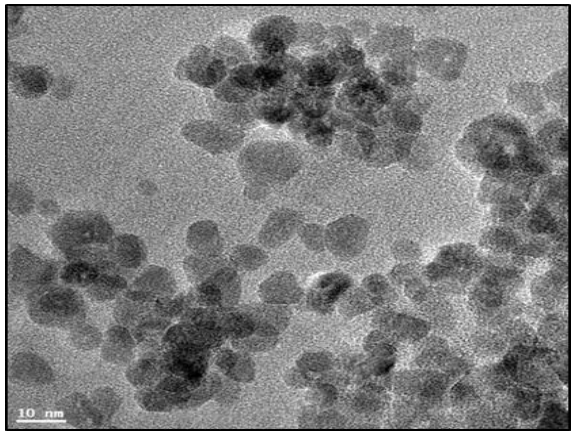
NASA defined nanomaterial this way……

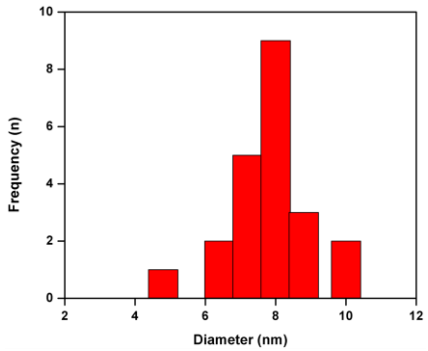
- . . . . . .the creation of functional materials, devices and systems through control of matter on the nanometer length scale (1–100 nm), and exploitation of novel phenomena and properties (physical, chemical, biological) at that length scale.

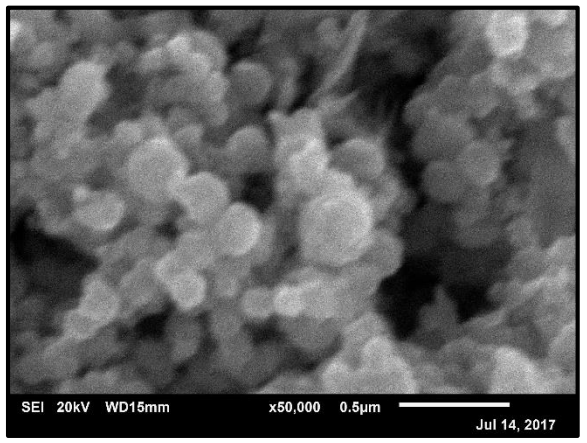
ratio earth / football = ratio football / fullerene

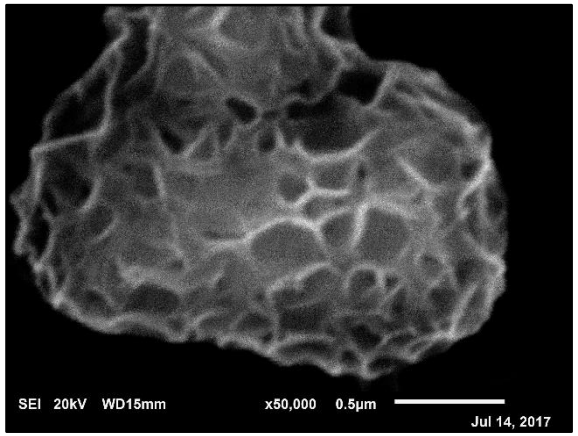


TEM **SEM**



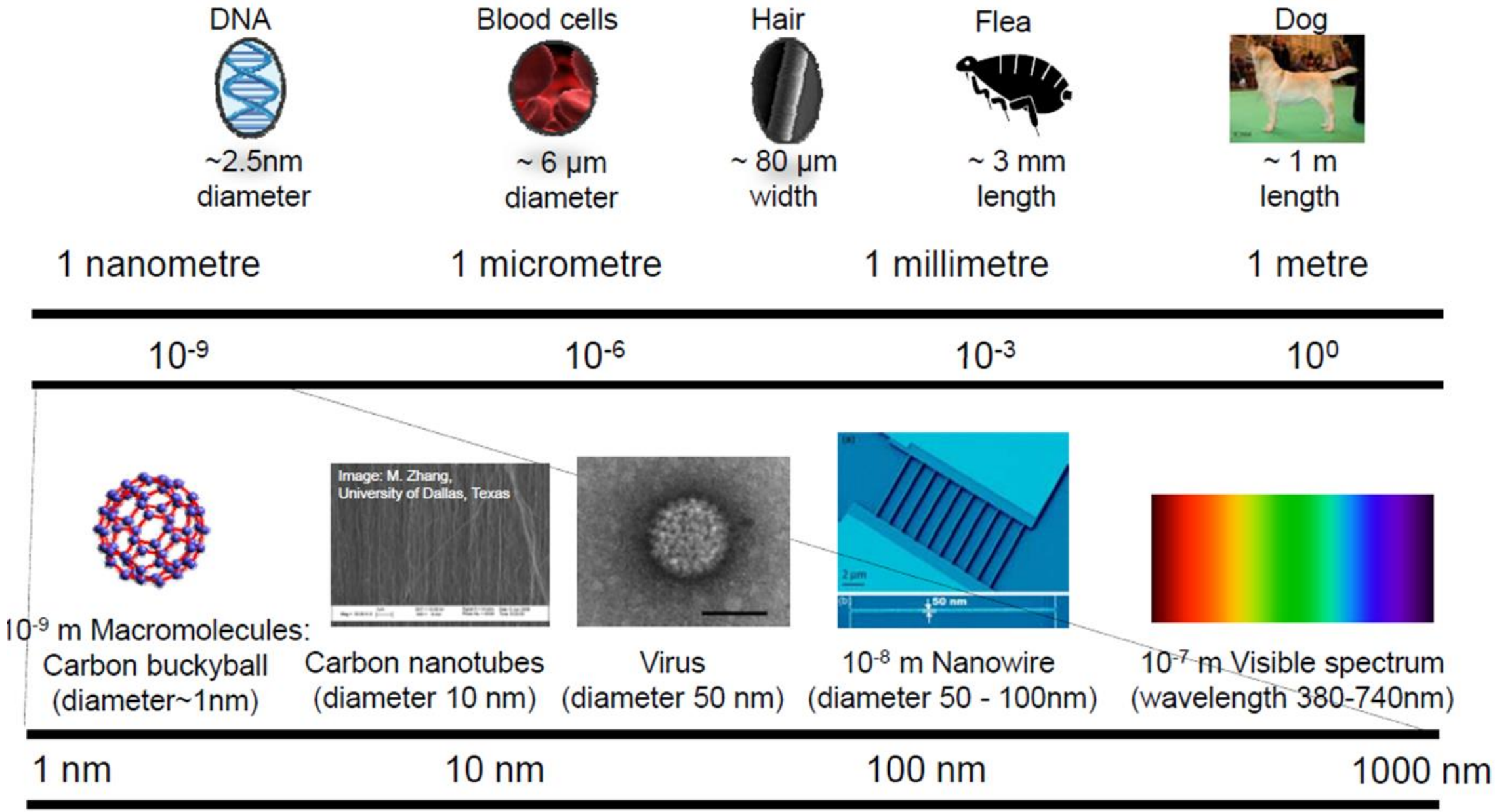






MoS_2-ZnO ZnO MoS_2-ZnO

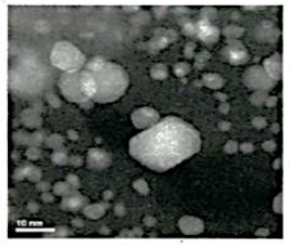
Size Comparison:



Size Comparison:

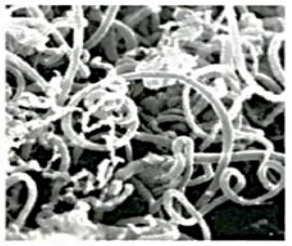
0-D
All dimensions (*x*,*y*,*z*) at nanoscale

Nanoparticles

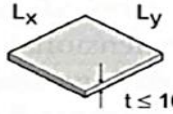


1-D
Two dimensions (*x*,*y*) at nanoscale, other dimension (*L*) is not

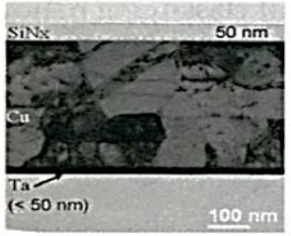
Nanowires, nanorods, and nanotubes



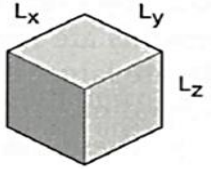
2-D
One dimension (t) at nanoscale, other two dimensions- (L_x, L_y) are not



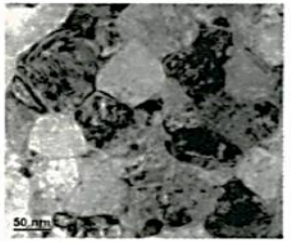
Nanocoatings and nanofilms

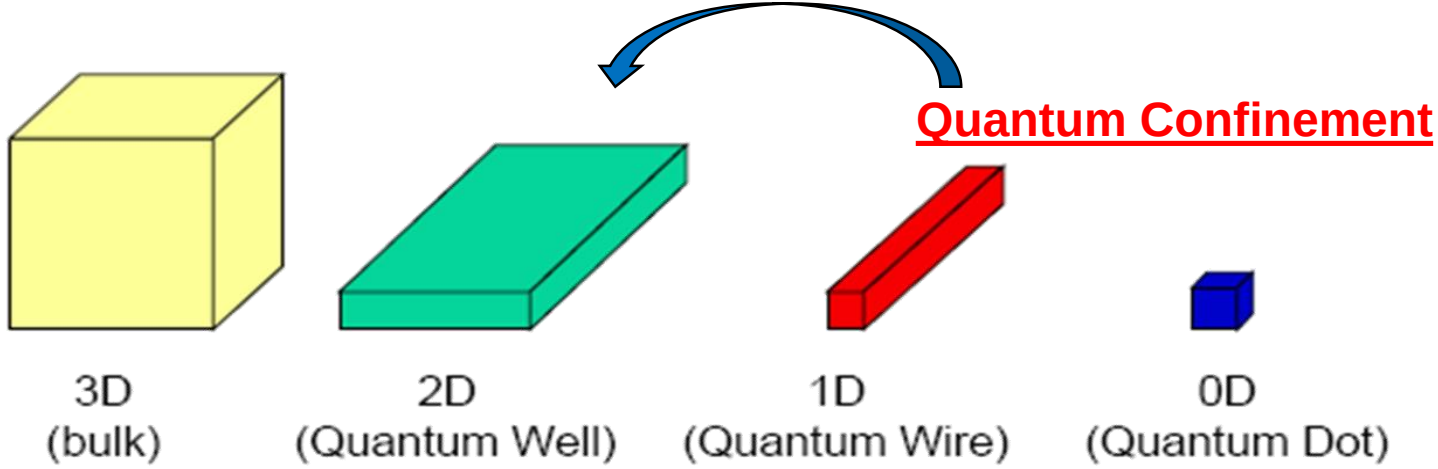


3-D
No bulk dimension at nanoscale



Nanocrystalline and nanocomposite materials

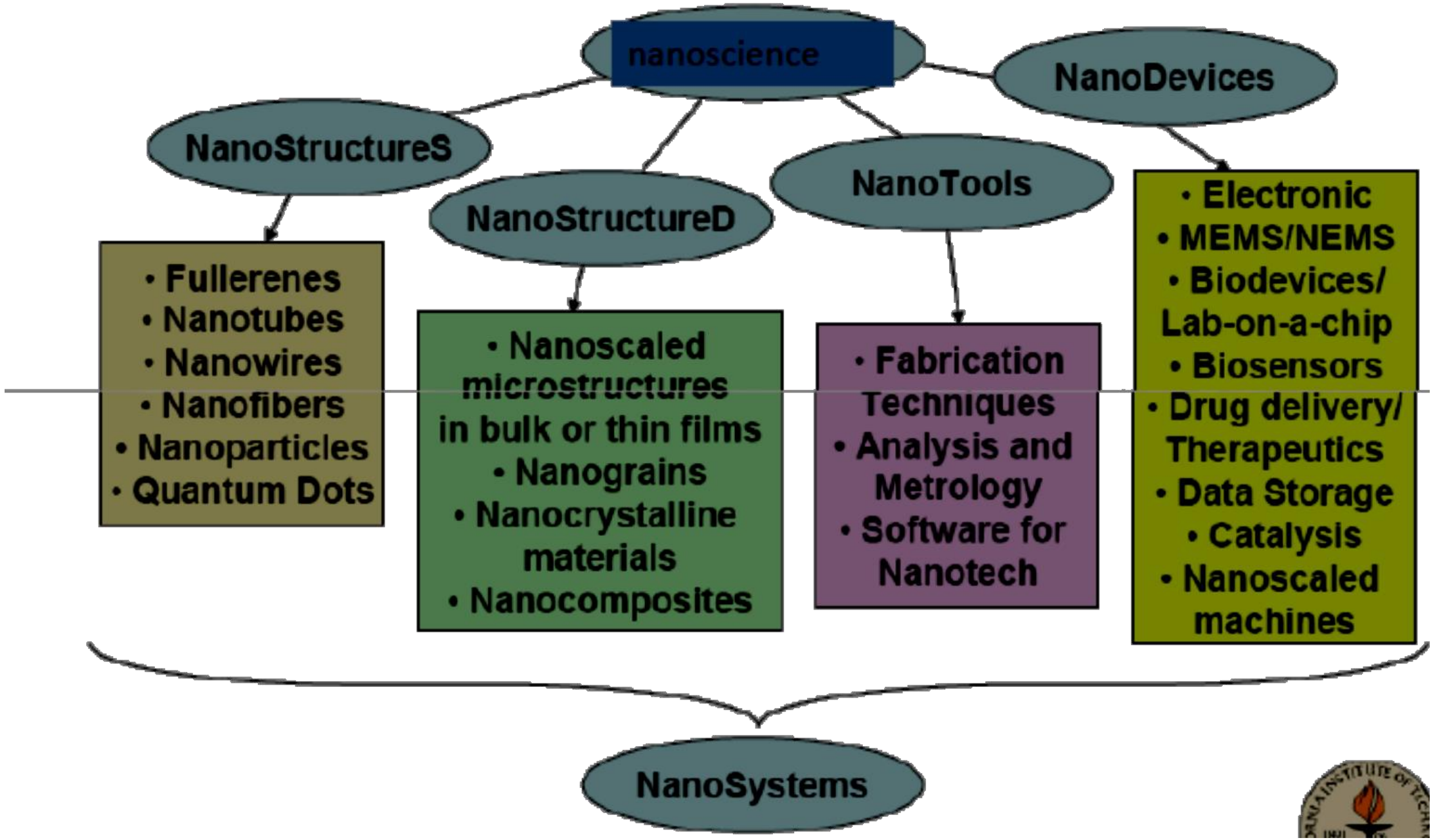




Quantum dots , Quantum wire and Quantum well

- **The extreme case of this process of size reduction in which all dimensions reach the low nanometer range is called a quantum dot (0D).**
- **If two dimensions are so reduced and one remains large, the resulting structure is referred to as a quantum wire (1D) .**
- **If one dimension is reduced to the Nano range while the other two dimensions remain large, then we obtain a structure known as quantum well (2D) .**
- **Properties like electrical conductivity, color, strength and weight change when the nanoscale level is reached: the same metal can become a semiconductor or an insulator at the nanoscale level.**

Different forms of nanoparticles:



Properties of nanoparticle:

Why "nano"

Nanomaterials have superior properties than the bulk substances :

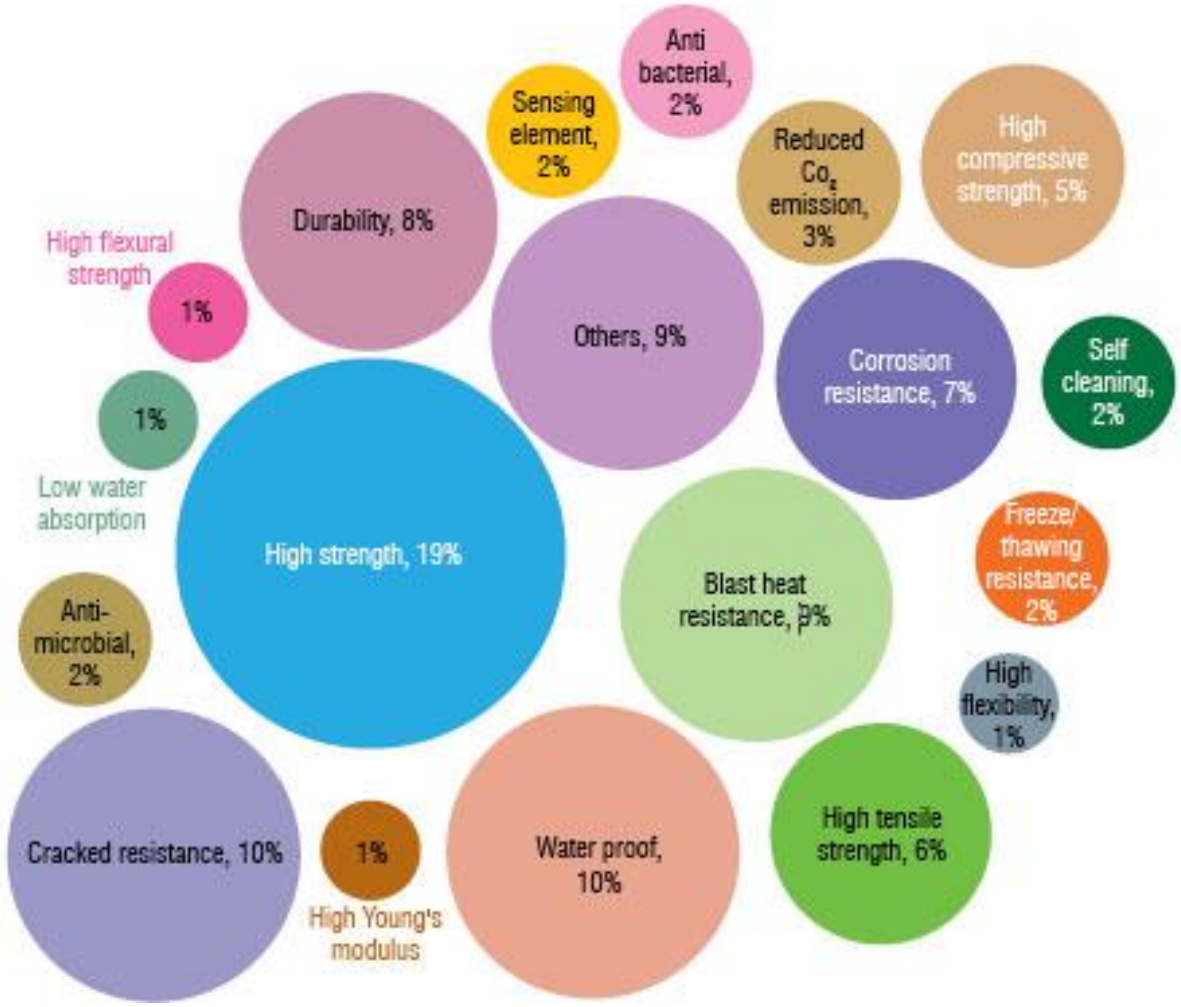
- Mechanical strength
- Thermal stability
- Catalytic activity
- Electrical conductivity
- Magnetic properties
- Optical properties
- .....

A wide range of applications:

Quantum electronics, nonlinear optics, photonics, sensing, information storage and processing, adsorbents, catalysis, solar cells, superplastic ceramics...

New fields:

Nanofabrication, nanodevices, nanobiology, and nanocatalysis

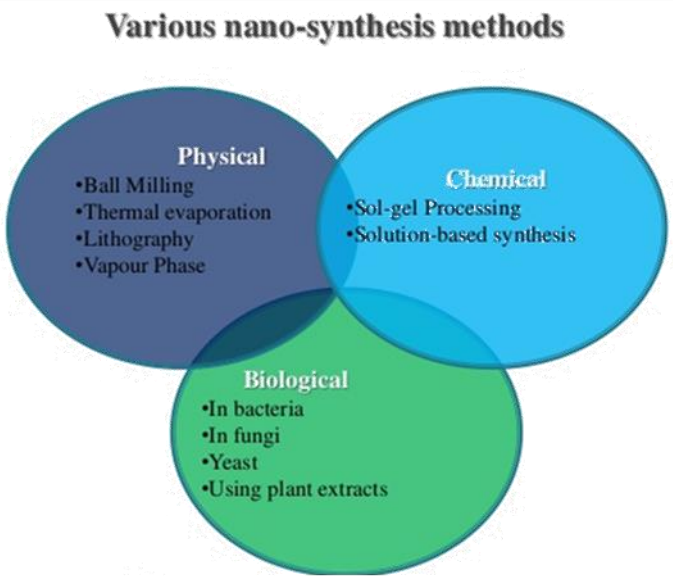


How to create nanomaterials?

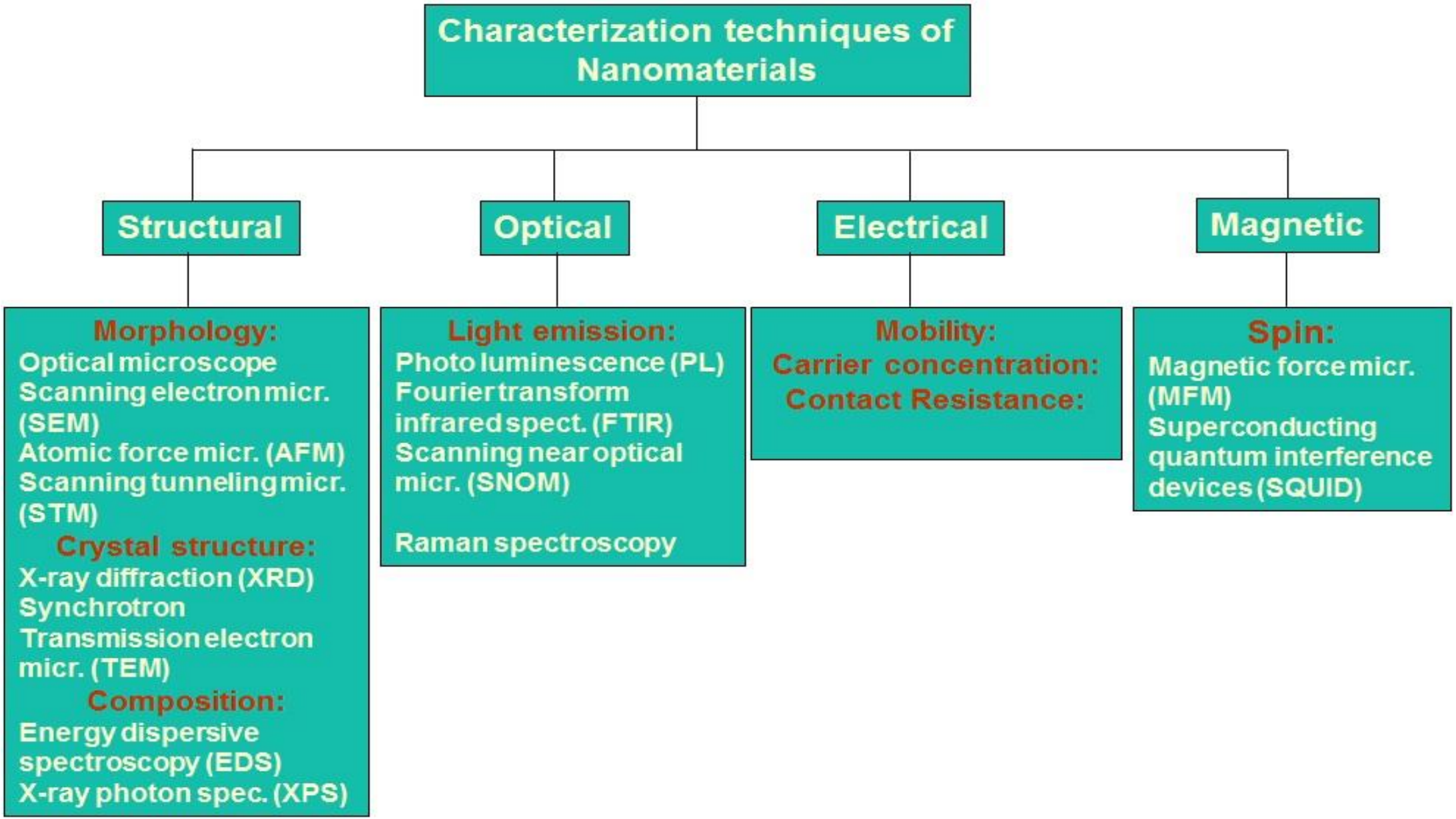
Two Different Approaches to Nanofabrication

- **Top ⇨ Down:**
  - Start with the bulk material and "cut away material" to make the what you want

- **Bottom ⇨ Up:**
  - Building what you want by assembling it from building blocks (such as atoms and molecules).
  - Atom-by-atom, molecule-by-molecule, or cluster-by-cluster



How to analyse nanomaterials?



Use of Nanomaterials / Why Study Nanoscience?