Chemistry of Nanomaterials

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Outline

- Definition and historical perfective
- Effect of nanoscience and nanotechnology in various fields

Nano

Denoting a factor of 10^{-9}

One billionth

Origin from Greek

nanos

'dwarf'

Also means Mega-Funds!!

Man: 2 m

Ant : 1 cm = 0.01 m = 10^{-2} m

One red blood cell: 10 μm

(1 μm=0.000 001 m = 10^{-6} m)

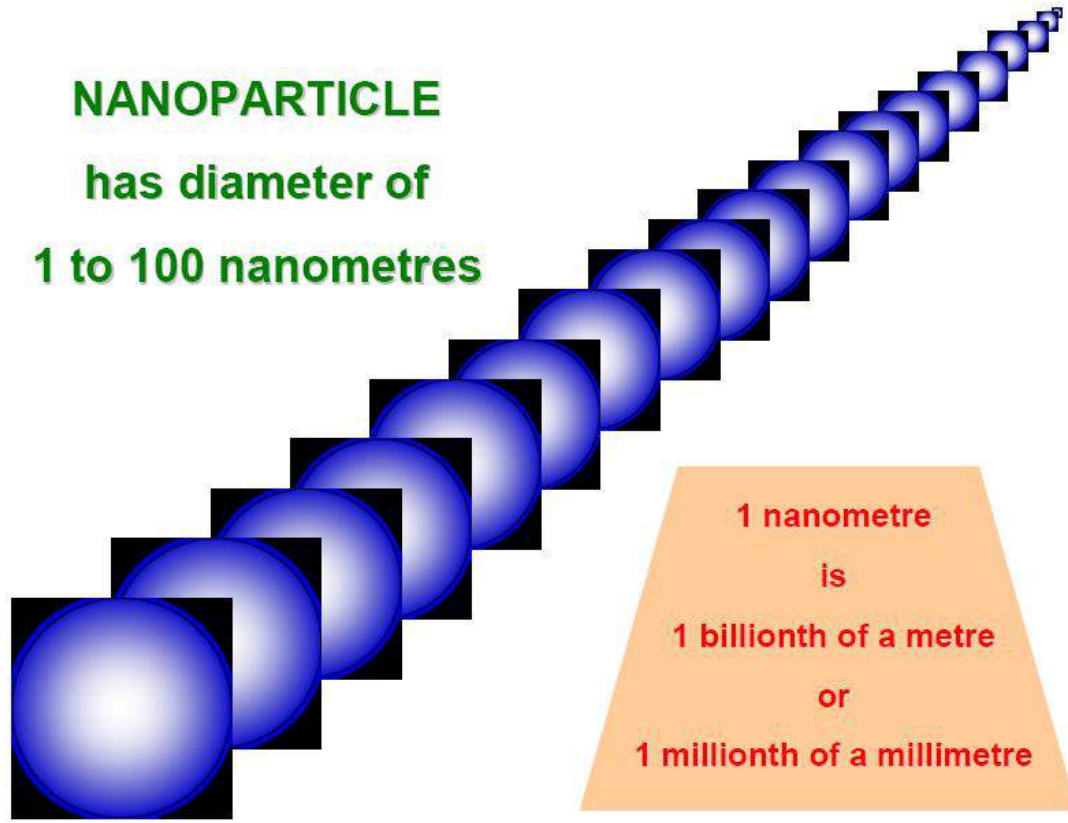
One Buckyball: 1 nm, Carbon atoms form in a soccerball structure. (1 nm = 10^{-9} m)

SIZE MATTERS !

NANOPARTICLE

has diameter of

1 to 100 nanometres



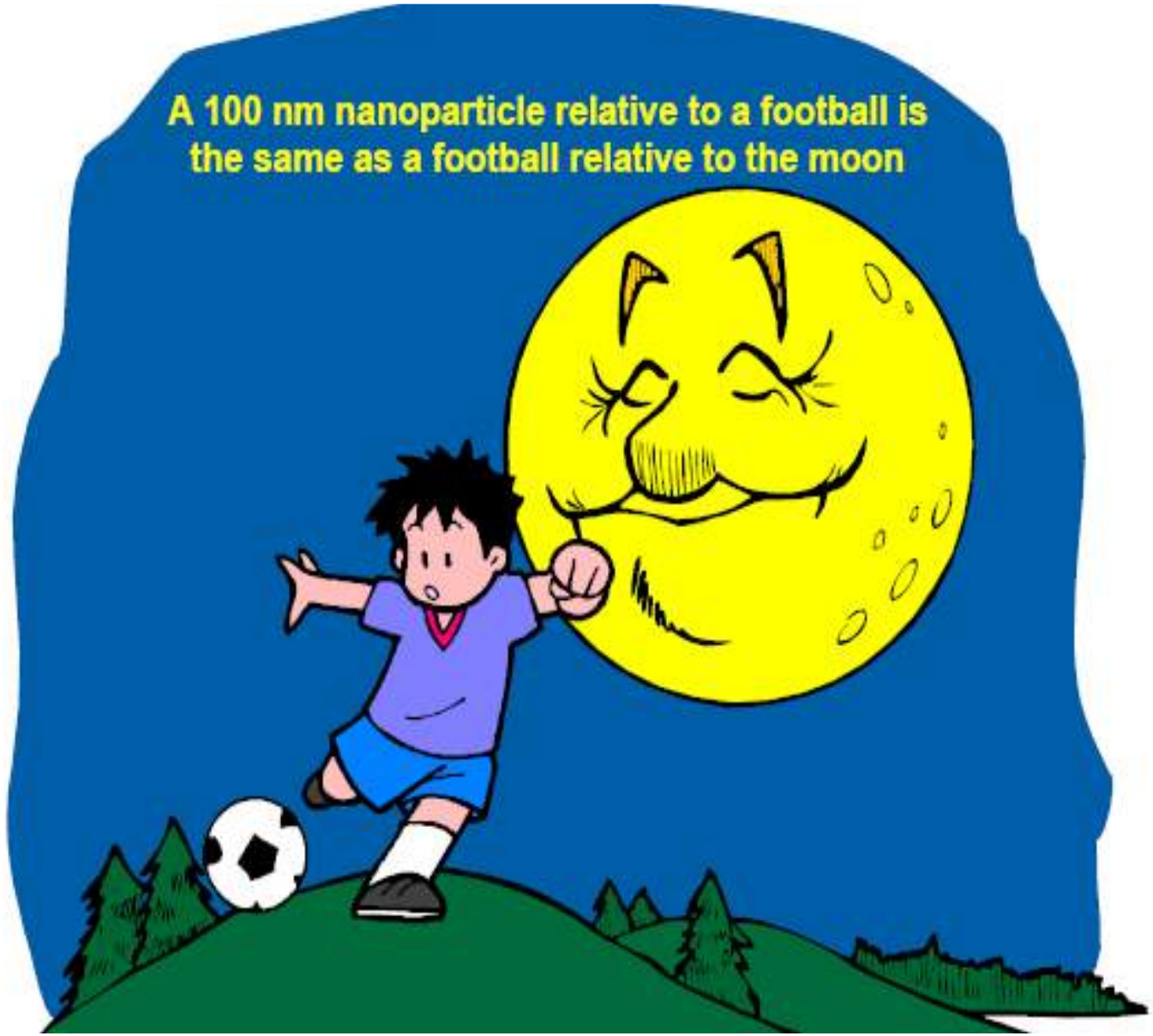
1 nanometre

is

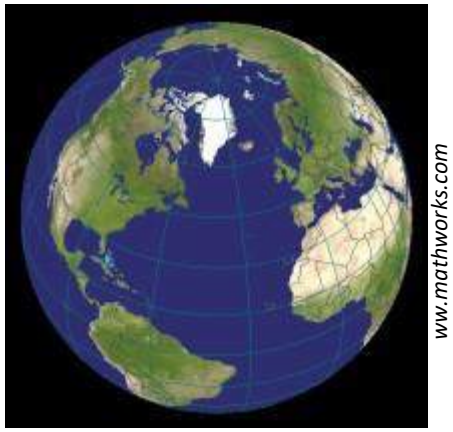
1 billionth of a metre

or

1 millionth of a millimetre


A 100 nm nanoparticle relative to a football is
the same as a football relative to the moon

What is Nanoscale

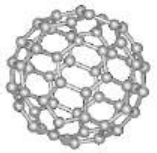


www.mathworks.com

12,756 Km

22 cm

Fullerenes C_{60}



0.7 nm

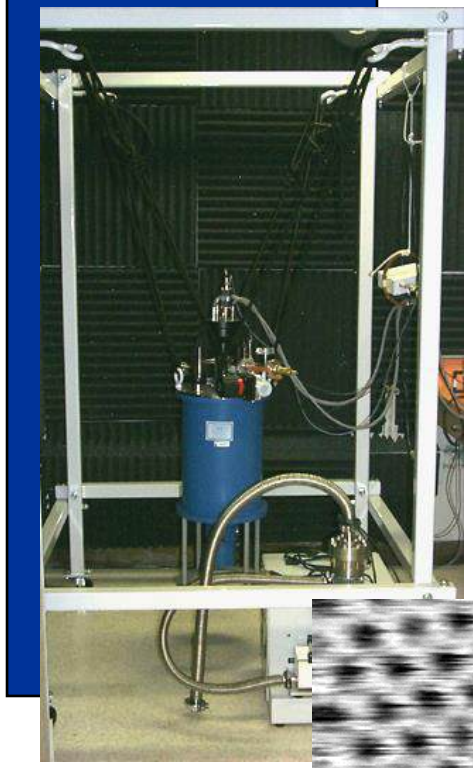
www.physics.ucr.edu

1.27 × 107 m **0.22 m** **0.7 × 10-9 m**

10 millions times smaller

1 billion times smaller

Nano Revolution



STM

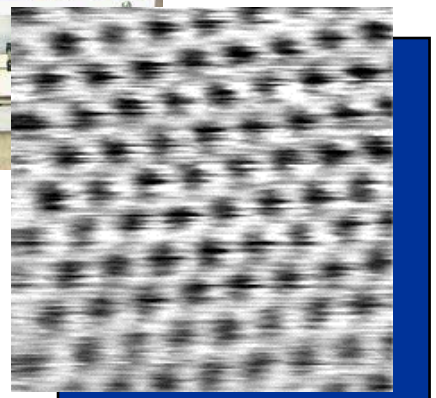


Image of Highly Oriented Pyrolitic Graphite

- 1959 Feynman Lecture *"There is Plenty of Room at the Bottom"* provided the vision of exciting new discoveries if one could fabricate materials/devices at the atomic/molecular scale.
- Emergence of instruments in the 1980s; STM, AFM providing the "eyes", "fingers" for nanoscale manipulation, measurement…
- Recently, there has been an explosion of research on the nanoscale behavior
  - Nanostructures through sub-micron self assembly creating entities from "bottom-up" instead of "top-down"
  - Characterization and applications
  - Highly sophisticated computer simulations to enhance understanding as well as create 'designer materials'

THE HISTORY

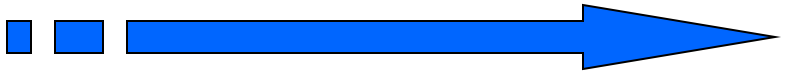
29 December 1959

- “There’s Plenty of Room at the Bottom” by physicist Richard Feynman at an American Physical Society meeting at Caltech

THE HISTORY

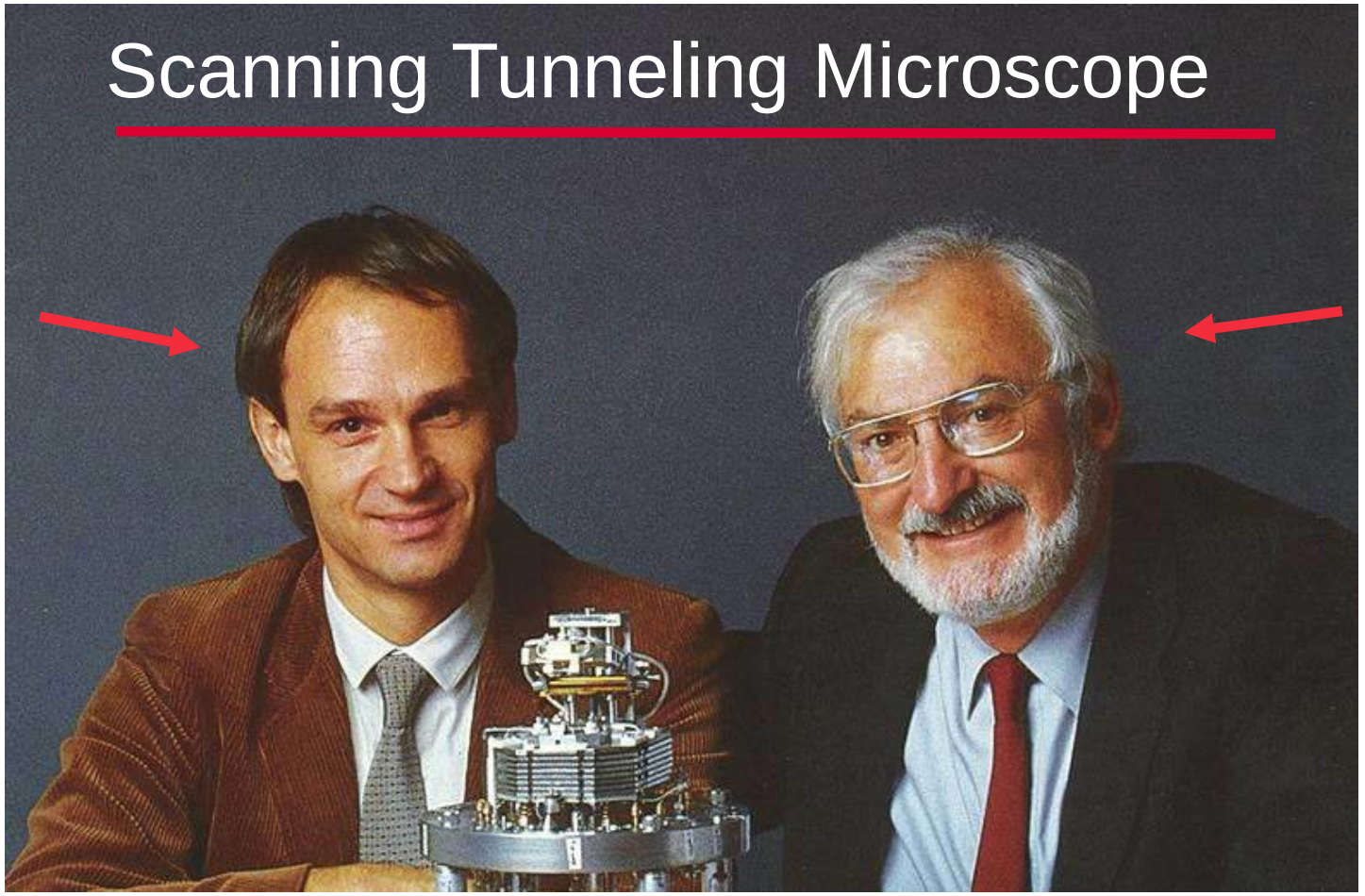
1974

- Atomic layer deposition process developed and patented
- “On the Basic Concept of ‘Nano-technology’”



Scanning Tunneling Microscope

Gerd



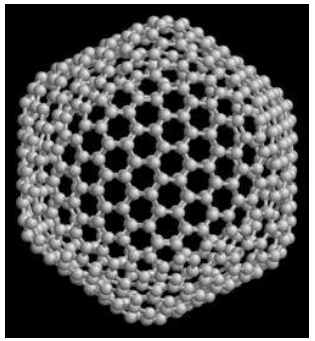
Heini

- Invented by Gerd Binnig and Heinrich Rohrer, IBM Research Division
- Atomic resolution images of surfaces
- 1986 Nobel Prize in physics

THE HISTORY

1986

- Discovery of **fullerenes**



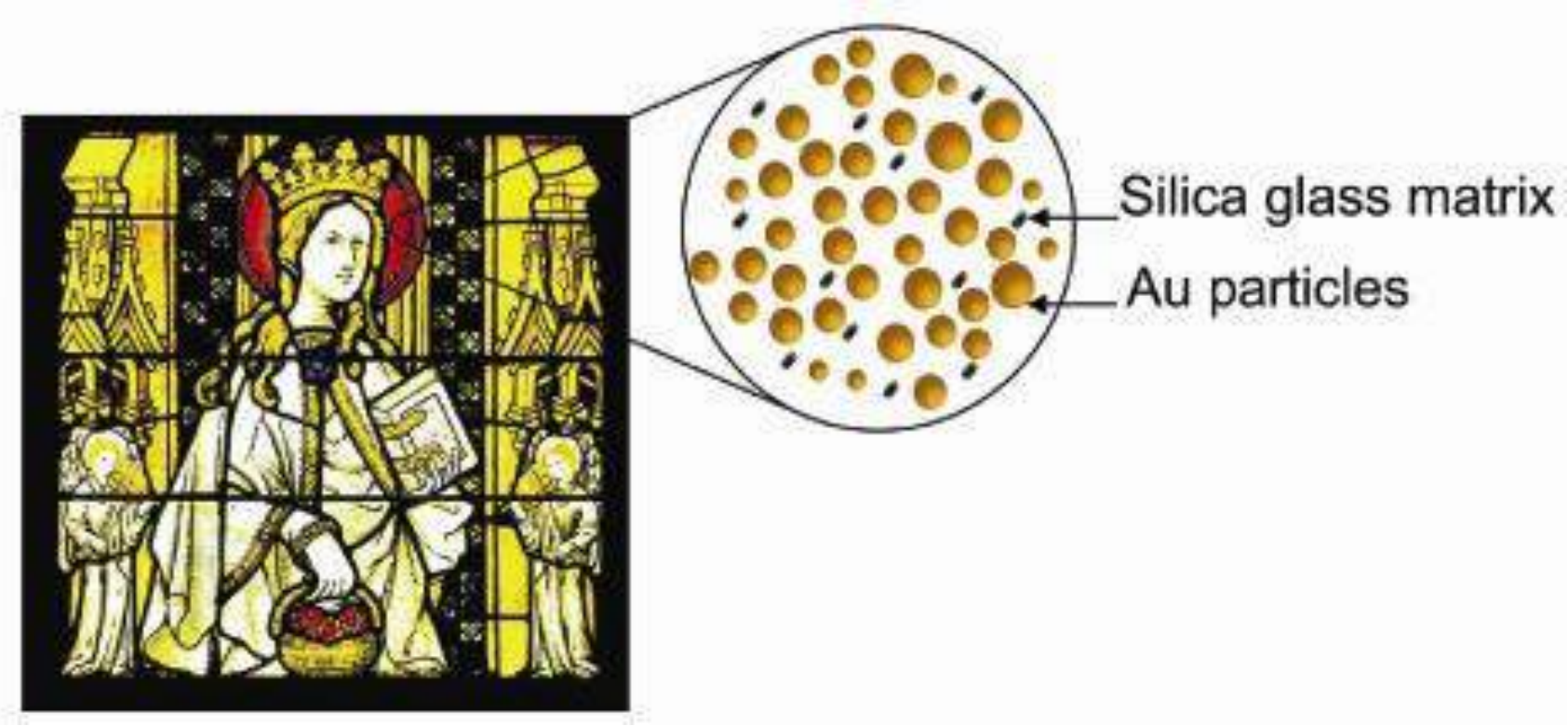
…a few years later

- Discovery of **carbon nanotubes**
- Semiconductor nanocrystal synthesis leads to **quantum dots**

The Lycurgus Cup

(glass; British Museum; 4th century A. D.)

When illuminated from outside, it appears green. However, when Illuminated from within the cup, it glows red. Red color is due to very small amounts of gold powder (about 40 parts per million)



Stained Glass Window from a Cathedral (near Cologne)

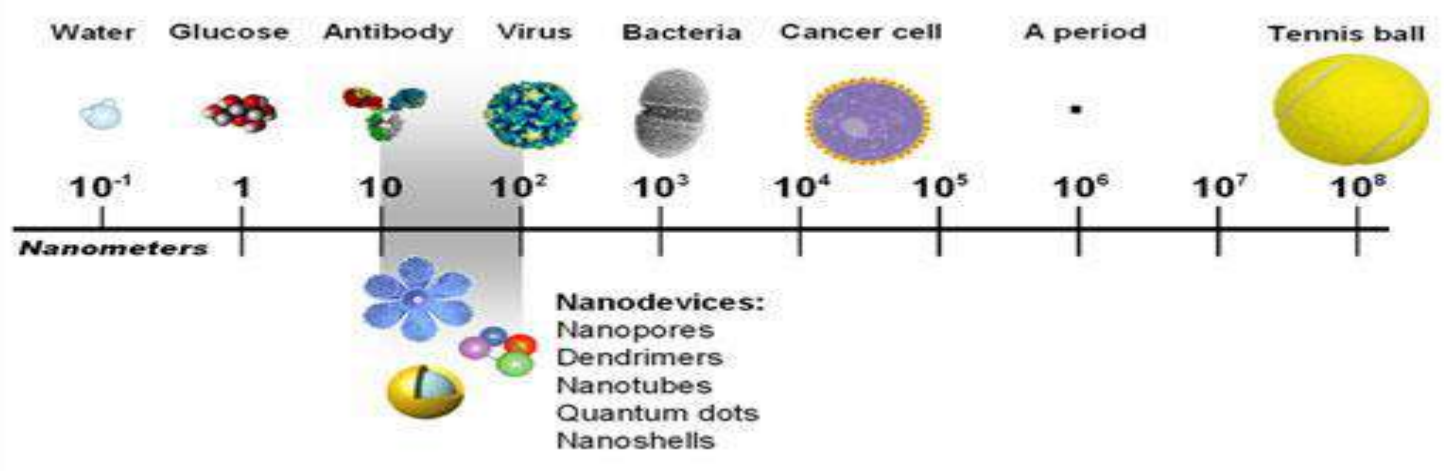
COLOR

Gold exhibits different colors depending on particle size. Ruby glass contains finely dispersed gold particles added during the glass-making process.

Definition and historical perfective

Nanomaterials

Nanomaterials are chemical substances or materials that are manufactured and used on a very small scale. Their structures range from approximately 1 to 100 nm in at least one dimension as shown in the Nanomaterials have unique and more pronounced characteristics compared to the same material without nanoscale features. Therefore, the physic-chemical properties of nanomaterials may differ from those of the bulk substance or particles of a larger.



Types of Nanomaterials

Nanomaterials are classified into several types based on their morphology as follows:

1 dimension (1D) < 100 nm - Nanorods, Nanowire.

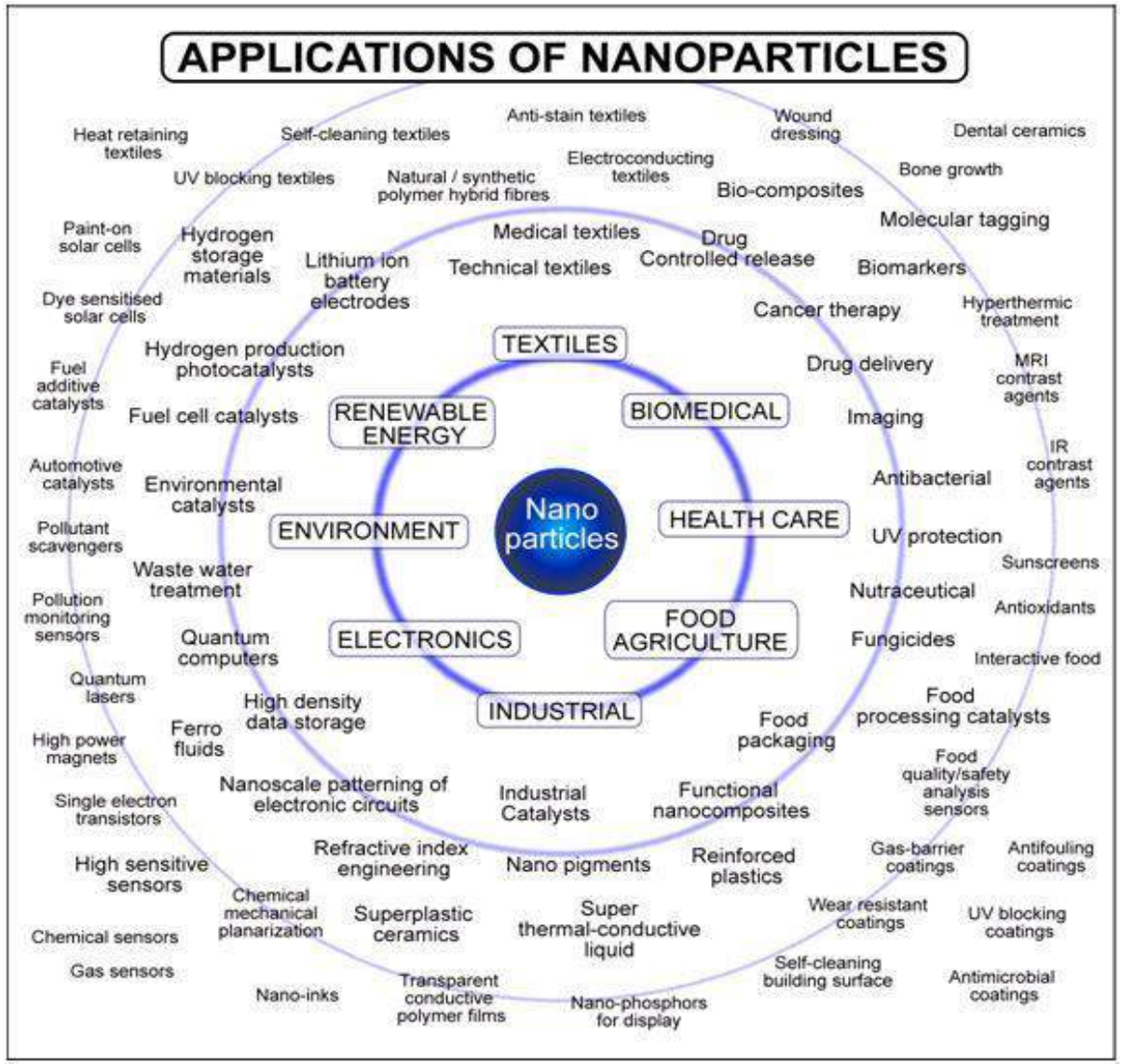
2 dimension (2D) < 100nm - Nanosheet, Nanoplatelets.

3 dimension (3D) < 100nm - Quantum dots, Nanoparticles.

Properties of nanomaterials

a) Redox potential or band gap or HOMO or LUMO gap
b) surface area (surface to volume ratio)
c) structure
d) Morphology
e) Preferential orientation

Effect of Nanomaterials on different field



Thank You