Paper – 6.2

Genetics, Biotechnology and Nanotechnology

Unit – 12, NANOTECHNOLOGY

Introduction

A biological system can be exceedingly small. Many of the cells are very tiny, but they are very active; they manufacture various substances; they walk around; they wiggle; and they do all kinds of marvellous things—all on a very small scale. Also, they store information. Consider the possibility that we too can make a thing very small that does what we want—that we can manufacture an object that manoeuvres at that level.

What is Nano?

- The word nano is derived from Greek – meaning dwarf or Extremely small
- A nanometer is about the size of ten atoms in a row
- In the terms of units of measure – one billionth of a meter, 1/ 1,000,000,000 (10^{-9} m)

Size comparison between Macro, Micro, and Nano

- Macro - A honey bee is approximately 12nm long
- Micro - A human hair is 60 to 100 micrometers in diameter
- Nano - The DNA helix is 0.002 micrometers wide or 2nm wide.

Nanoscience

It is the branch of science which deals with the study of nanomaterials

Nanotechnology

Nanotechnology is defined as the study and use of structures between 1 nanometre and 100 nanometres in size.

or

Nanotechnology is the study of phenomena and fine-tuning of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

Nanobiotechnology

Nanobiotechnology is defined as the applications of techniques of Nanotechnology for the development and improvement of biotechnological process and products.

or

Nanobiotechnology is that branch of nanotechnology that deals with biological and biochemical applications or uses.

or

Nanobiotechnology refers to the ways that nanotechnology is used to create devices to study and improve biological systems.

History

- The first ever concept was presented in 1959 by the famous professor of physics Dr. Richard P. Feynman.
- The term “Nano-technology” had been coined by Norio Taniguchi in 1974.
- 1981 IBM invented STM scanning tunnelling microscope which can move single atoms around
- 1985 new form of carbon discovered --- C60 buckminister fullerene 60 carbon atoms arranged in a sphere made of 12 pentagons and 20 hexagons
- 1991 carbon nanotubes discovered “graphitic carbon needles ranging from 4 nm – 30 nm and up to 1 micron in length” (Sumino Iijima)
- 1993 First high quality quantum dots prepared --- very small particles with controlled diameters of CdS, CdSe, CdTe
- 2001 prototype fuel cell made with nanotubes
- 2002 Nanomaterials make stain repellent trousers Nano-care khakis have nanowhiskers (10-100 nm in length)

Some common terms related to nanotechnology and its applications:

Nanoscale : The scale of measurement to the atomic and molecular size, normally 1 to 100 nanometers. A nanometer (nm) is one-billionth of a meter — smaller than the wavelength of visible light and a hundred-thousandth the width of an average human hair.

Nanowires : Nanowires are wires with a very small diameter, sometimes as small as 1 nanometer.

Nanoparticles : any particle less than 100 nm.

Nanomaterials : They contain nanoparticles, smaller than 100 nanometres in at least one dimension.

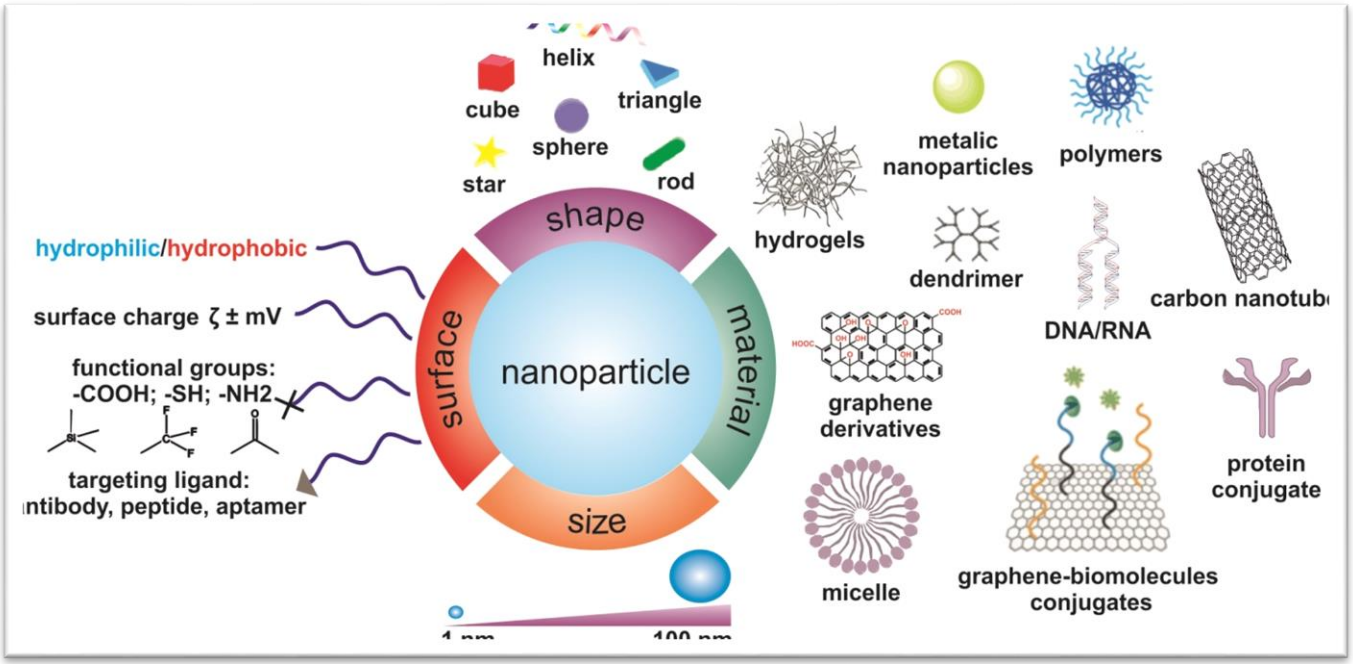
Buckyball : Buckminsterfullerene C60, also known as the “buckyball,”

Nanotube : Based on carbon or other elements, these systems consist of graphitic layers seamlessly shaped into cylinders. Carbon nanotubes are found in 1985. Fullerenes played vital role in discovery of carbon nanotubes. The molecule discovered was named as C60.

Nanomedicine : the application of nanotechnology to the prevention and treatment of disease in the human body.

Types of Nanomaterials

Based on their size, shape, origin structure there are many types of nanomaterials



The most current Nanomaterials could be organized into 4 types

1. Carbon based materials
2. Metal based materials
3. Dendrimers
4. Composites

1. Carbon based materials

- ✓ These nanomaterials are composed mostly of carbon, most commonly taking in the form of hollow sphere, ellipsoids or tubes.
- ✓ Spherical and ellipsoid carbn nanomaterials are referred to as fullerenes, while cylindrical ones are called nanotubes.
- ✓ These particles have many potential applications, including improved films and coatings, stronger and lighter materials, and applications in electronics.

2. Metal based materials

- ✓ These nanomaterials include quantum dots, nanogold, nanosilver and metal oxides such as titanium dioxide.
- ✓ A quantum dot is a closely packed semiconductor crystal comprised of hundreds or thousands of atoms, and whose size is on the order of a few nanometres to few handred nanometres. Changing the size of quantum dots changes their optical properties.

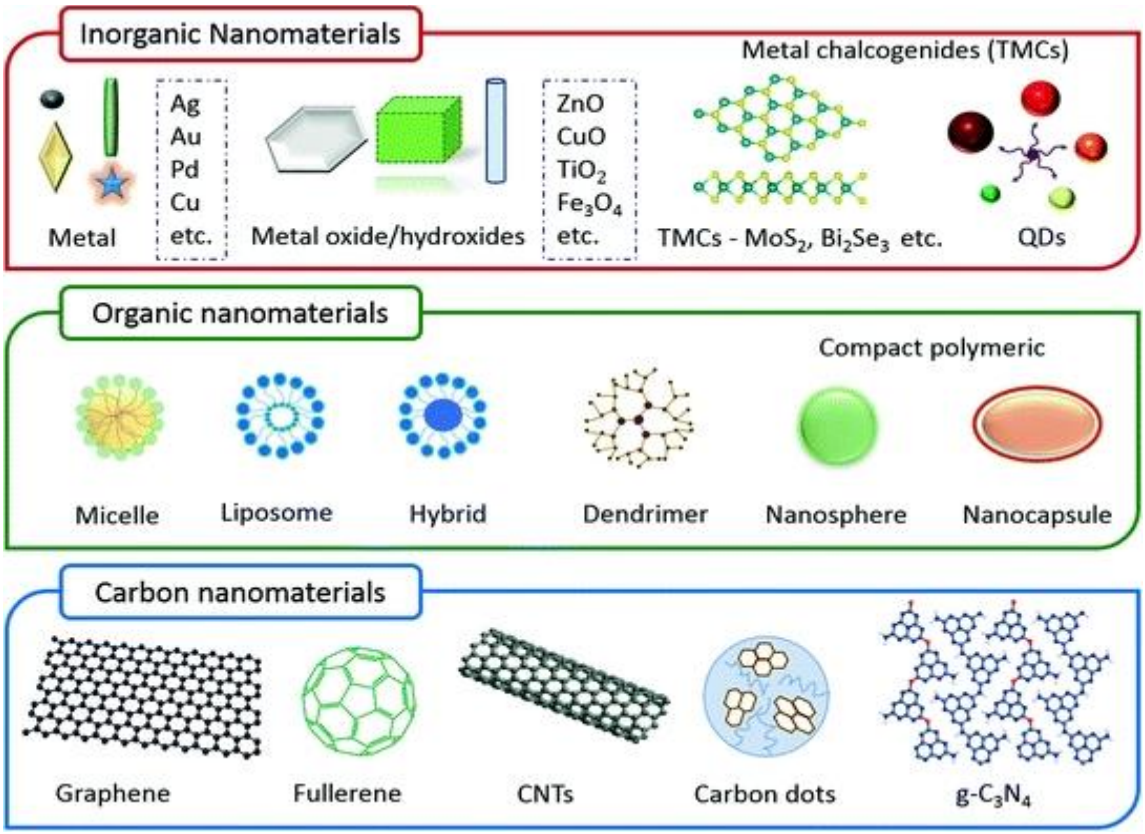
3. Dendrimers

- ✓ These nanomaterials are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis.

- ✓ Three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery.

4. Composites

- ✓ Composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials. Nanoparticles such as nanosized clays, are already being added to products ranging from auto parts to packaging materials, to enhance mechanical, thermal, barrier, and flame-retadant properties.



Types is based on the number of dimensions, which are not confined to the nanoscale range (<100 nm).

1. **Zero-Dimensional (0-D)** Ex- Nanoparticles

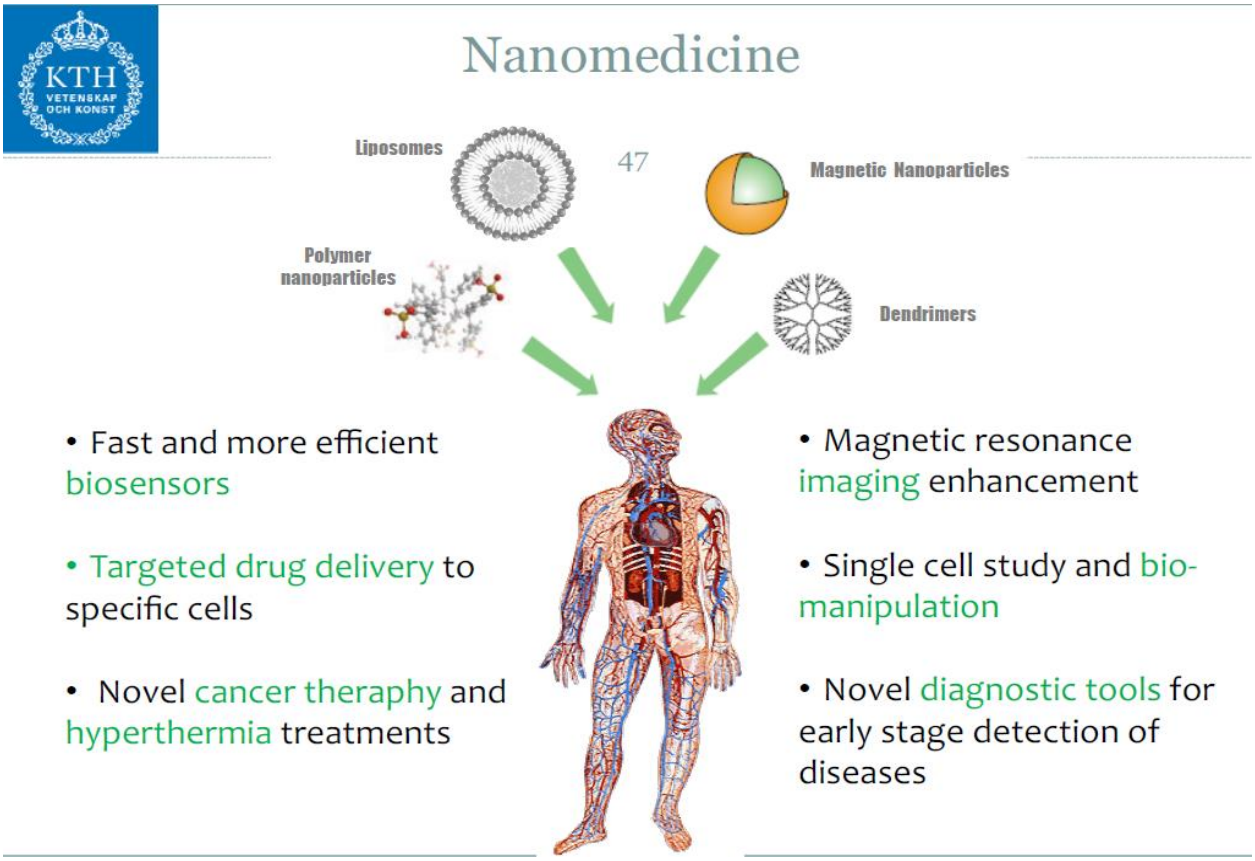
2. **One-Dimensional (1-D)** Ex- Nanotubes, Nanorods and Nanowires.

3. **Two-Dimensional (2-D)** Ex- Nanofilms, Nanolayers and Nanocoatings.

4. **Three-Dimensional (3-D)** Ex- Bulk Nanomaterials

Application of Nanotechnology

Nanobiotechnology in healthcare:



Medicine: Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body. When it's perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patient's healthy cells.

Neuro-electronics: Nerve Tissue Talking to Computers through neuro-electronic networks interface nerve cells with semiconductors.

Detection of disease: Quantum dots glow in UV light Injected in mice, collect in tumors and Could locate as few as 10 to 100 cancer cells

Prevention from virus: Nanocoatings over proteins on viruses Could stop viruses from binding to cells

Environmental Nanobiotechnology :

Better Air Quality: Nanotechnology can improve the performance of catalysts used to transform vapors escaping from cars or industrial plants into harmless gasses. That's because catalysts made fromnanoparticles have a greater surface area to interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalyst simultaneously, which makes the catalyst more effective.

Cleaner Water: Nanotechnology is being used to develop solutions to three very different problems in water quality. One challenge is the removal of industrial wastes, such as a cleaning solvent called TCE, from groundwater. Nanoparticles can be used to convert the contaminating chemical through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminates dispersed in underground ponds and at much lower cost than methods which require pumping the water out of the ground for treatment.

Other Applications:

Electronics: Nanotechnology holds some answers for how we might increase the capabilities of electronic devices while we reduce their weight and power consumption.

Food: Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits that food delivers.

Fuel Cells: Nanotechnology is being used to reduce the cost of catalysts used in fuel cells to produce hydrogen ions from fuel such as methanol and to improve the efficiency of membranes used in fuel cells to separate hydrogen ions from other gases such as oxygen.

Solar Cells: Companies have developed nanotech solar cells that can be manufactured at significantly lower cost than conventional solar cells.

Batteries: Companies are currently developing batteries using nanomaterials. One such battery will be a good as new after sitting on the shelf for decades. Another battery can be recharged significantly faster than conventional batteries.

Space: Nanotechnology may hold the key to making space-flight more practical. Advancements in nanomaterials make lightweight spacecraft and a cable for the space elevator possible. By significantly reducing the amount of rocket fuel required, these advances could lower the cost of reaching orbit and traveling in space.

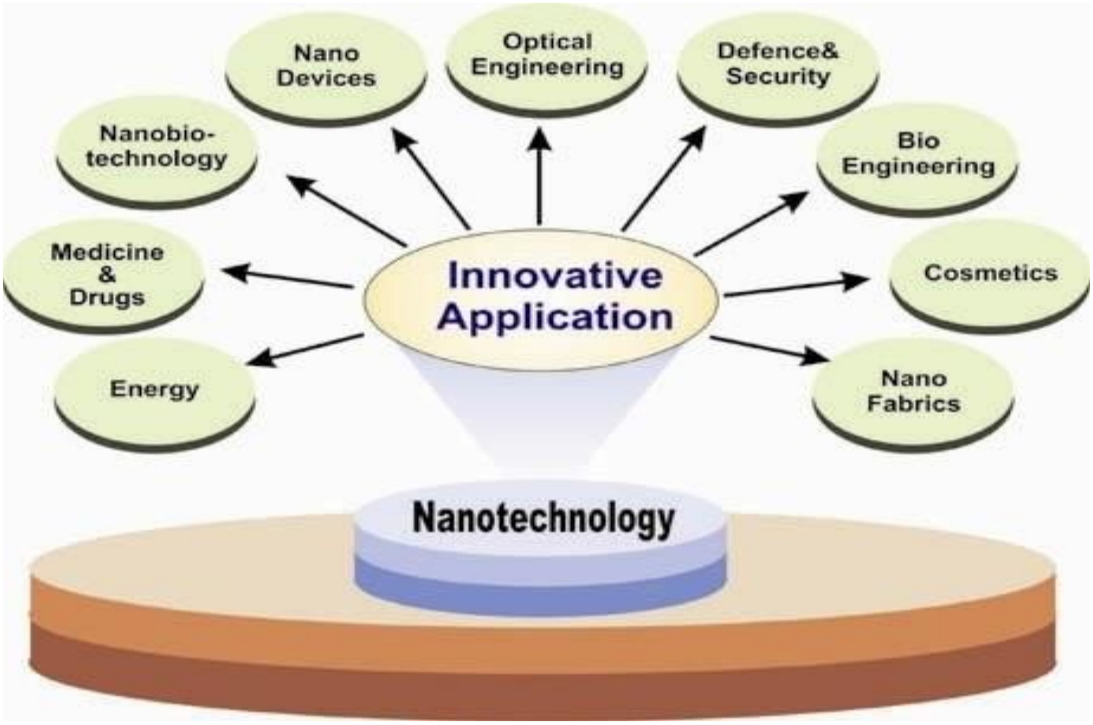
Fuels: Nanotechnology can address the shortage of fossil fuels such as diesel and gasoline by making the production of fuels from low grade raw materials economical, increasing the mileage of engines, and making the production of fuels from normal raw materials more efficient.

Chemical Sensors: Nanotechnology can enable sensors to detect very small amounts of chemical vapors. Various types of detecting elements, such as carbon nanotubes, zinc oxide nanowires or palladium nanoparticles can be used in nanotechnology-based sensors. Because of the small size of nanotubes, nanowires, or nanoparticles, a few gas molecules are sufficient to change the electrical properties of the sensing elements. This allows the detection of a very low concentration of chemical vapors.

Cosmetics: L'Oreal has used polymer nanocapsules to deliver active ingredients, e.g. retinol or Vitamin A, into the deeper layers of skin.

Sporting Goods: If you're a tennis or golf fan, you'll be glad to hear that even sporting goods has wandered into the nano-realm. Current nanotechnology applications in the sports arena include increasing the strength of tennis racquets, filling any imperfections in club shaft materials and reducing the rate at which air leaks from tennis balls.

Fabric: Making composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previouslyused techniques.



Nanotechnology Research Institutes in India

Nanotechnology Research Center	Location	Year Of Estb.	Objective
Bhabha Atomic Research Center	Mumbai	1954	To fulfill its mandate of indigenous nuclear power programme and various other applications of nuclear energy, etc.
Central Electronics Research Institute	Rajasthan	1953	Advanced research and development in Electronics.
Indian Association for the Cultivation of Sciences (IACS)	kolkata	1876	To foster high quality fundamental research in frontier disciplines of the basic sciences.
Solid State Physics Laboratory	Delhi	1962	research in the field of Solid State