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NANOTECHNOLOGY IN DENTISTRY

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ABSTRACT

The concept of „Nanotechnology" has revolutionized today"s world. The thought of minimizing the bulk or weight of any component while maintaining the efficiency of that particular product seems pretty wonderful as it compacts the thing. Recent times have seen an ample number of researches been done and progressive advancements made to the field of nanotechnology. Introduction of nanotechnology in the field of medicine and dentistry has eased the path a bit in each and every field be it diagnosis, prevention or treatment.

INTRODUCTION

The concept of 'Nanotechnology' has revolutionized today's world. The thought of minimizing the bulk or weight of any component while maintaining the efficiency of that particular product seems pretty wonderful as it compacts the thing. Recent times have seen an ample number of researches been done and progressive advancements made to the field of nanotechnology. Introduction of nanotechnology in the field of medicine and dentistry has eased the path a bit in each and every field be it diagnosis, prevention or treatment.

The word 'Nano' has been derived from Greek word which means 'Dwarf". One nanometre (nm) is a unit of length that equals 1 billionth of a meter. Quantifying it for the assumption is that a single strand of hair has a thickness of 100,000 nm. Size of an atom is 0.1 nm which shows you at what level the concept of nanotechnology works.

In nanotechnology the developed devices or materials are made so that they can perform at molecular level. Nanoasssemblers are the tiny machines working that can be controlled with the help of computers to carry on the specific tasks. The nanoassemblers could be smaller than a cell nucleus so that they could fit into places that are hard to reach out with hands or using some other technologies.

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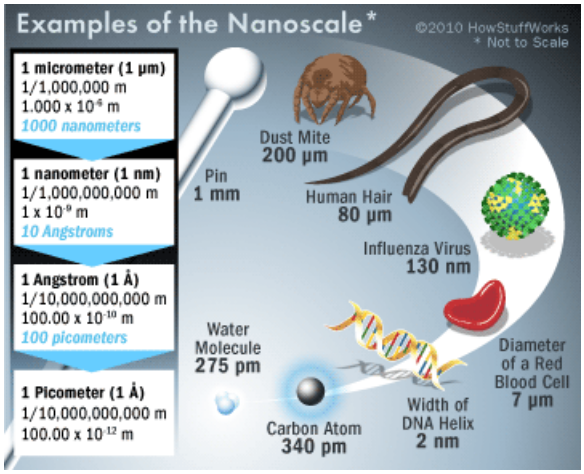


Showing the relation of Nanometre to various scales of measurements.

Nanotechnology aims towards establishing such concepts which is surreal and have huge benefits lying in front of us. It is one of the leading scientific fields today since it combines knowledge from the fields of Physics, Chemistry, Biology, Medicine, Informatics, and Engineering. These nanodevices and nanomaterials are fabricated and controlled with the help of nanotechnology tools and tecchniques, which investigate and tune the properties, responses and functions of living and non-living matter, at sizes below 100 nm. Nanotechnology is an emerging and dynamic field where over 50,000 nanotechnology articles have been published annually worldwide in recent years, and more than 2,500 patents are filed at major patent offices such as the European Patent Office.

Because of the variety of potential applications (including industrial and military), governments have invested billions of dollars in nanotechnology research. Until 2012, through its National Nanotechnology Initiative, the USA has invested $3.7 billion, the European Union has invested $1.2 billion and Japan has $750 million.

Nanostructure is not only a thing related to technology or a manmade wonder but its existence subjects to nature too, there are many natural nanoscale materials, such as catalysts, porous materials, certain minerals, soot particles, etc., that have unique properties particularly because of the nanoscale features.

Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in nanomedicine, nanoelectronics, biomaterials energy production, and consumer products. Its application in dentistry is known as "Nanodentistry". Using the nanoscience in dentistry will be helpful in diagnosing, preventing and treating various oral diseases. Its contribution is not only limited to managing diseases but can also be helpful in designing of various nanomaterials, prosthesis, implants and various advancements and continuing research in the field also shows the possibility of its growth to such an extent that it can contribute in regeneration process.

Because of the growing interest in the future of dental application of nanotechnology, a new field called nanodentistry is emerging. The development of nanodentistry will allow nearly perfect oral health by the use of nanomaterials and biotechnologies including tissue engineering and nanorobots.

The new treatment opportunities in dentistry include local anesthesia, dentition renaturalization, permanent cure of hypersensitivity, complete orthodontic realignment during a single office visit, covalently bonded diamondized enamel and continuous oral health maintenance with the help of mechanical dentifrobots (nanorobotic dentifrice) that destroy caries-causing bacteria and even repair blemishes on the teeth where decay has set in.

Behind nanotechnology's current concepts and future projections lies the possibility of a near perfect oral health by applying the technology and formulating things such as nanomaterials, tissue engineering using biotechnology, and nanorobotics. This can open a new door to diagnostic and treatment modalities.

According to Baum BJ, the three components of nanodentistry are:

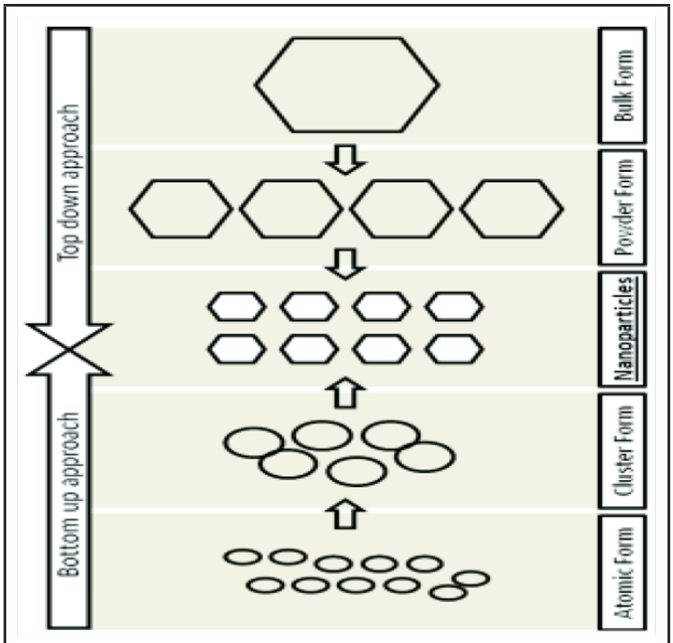
1. Nanomaterials
2. Biotechnology
3. Nanorobotics

Nanotechnology mainly consists of the processing, separation, integration, and deformation of materials by one atom or one molecule.

Today, Nanotechnology is understood by the following 4 approaches:-

1. **The Bottom Up Approach**: Seeks to arrange smaller components into more complex assemblies, the covalent bonds of which are extremely strong.[28] (Figure 4)

- DNA nanotechnology utilizes the specificity of Watson–Crick base pairing to construct well-defined structures out of DNA and other nucleic acids.
- Approaches from the field of "classical" chemical synthesis (Inorganic and organic synthesis) also aim at designing molecules with well-defined shape (e.g. bis-peptides).[29]
- More generally, molecular self-assembly seeks to use concepts of supramolecular chemistry, and molecular recognition in particular, to cause single-molecule components to automatically arrange themselves into some useful conformation.
- Atomic force microscope tips can be used as a nanoscale "write head" to deposit a chemical upon a surface in a desired pattern in a process called dip pen nanolithography. This technique fits into the larger subfield of nanolithography.
- Dental procedures using bottom up technique are as follows:-
  a. Local Anesthesia
  b. Hypersensitivity cure
  c. Nanorobotic dentifrice (dentifrobots)
  d. Dental durability and cosmetics
  e. Orthodontic treatment
  f. Photosensitizers and carriers
  g. Diagnosis of oral cancer (nanodiagnosis)



Showing top down and bottoms up approach concept

2. **The Top Down Approach**: Seeks to produce smaller devices by using larger ones in achieving precision in structure and assembly.

- Many technologies that descended from conventional solid-state silicon methods for fabricating microprocessors are now capable of creating features smaller than 100 nm, falling under the definition of nanotechnology. Giant magnetoresistance-based hard drives already on the market fit this description, as do atomic layer deposition (ALD) techniques. Peter Grünberg and Albert

Fert received the Nobel Prize in Physics in 2007 for their discovery of Giant magnetoresistance and contributions to the field of spintronics.

- Solid-state techniques can also be used to create devices known as nanoelectromechanical systems or NEMS, which are related to microelectromechanical systems or MEMS.
- Focused ion beams can directly remove material, or even deposit material when suitable precursor gasses are applied at the same time. For example, this technique is used routinely to create sub-100 nm sections of material for analysis in Transmission electron microscopy.
- Atomic force microscope tips can be used as a nanoscale "write head" to deposit a resist, which is then followed by an etching process to remove material in a top-down method.
- Dental procedures using top down approach are as follows:-

  a. Nanocomposites
  b. Nano Light-Curing Glass Ionomer
  c. Nano Impression Materials
  d. Nanosolutions
  e. Nanoencapsulation
  f. Plasma LASER application
  g. Prosthetic Implants
  h. Nanoneedles
  i. Bone replacement materials

3. **The Functional Approach**: Seeks to develop components of a desired functionality without regard to how they might be assembled.

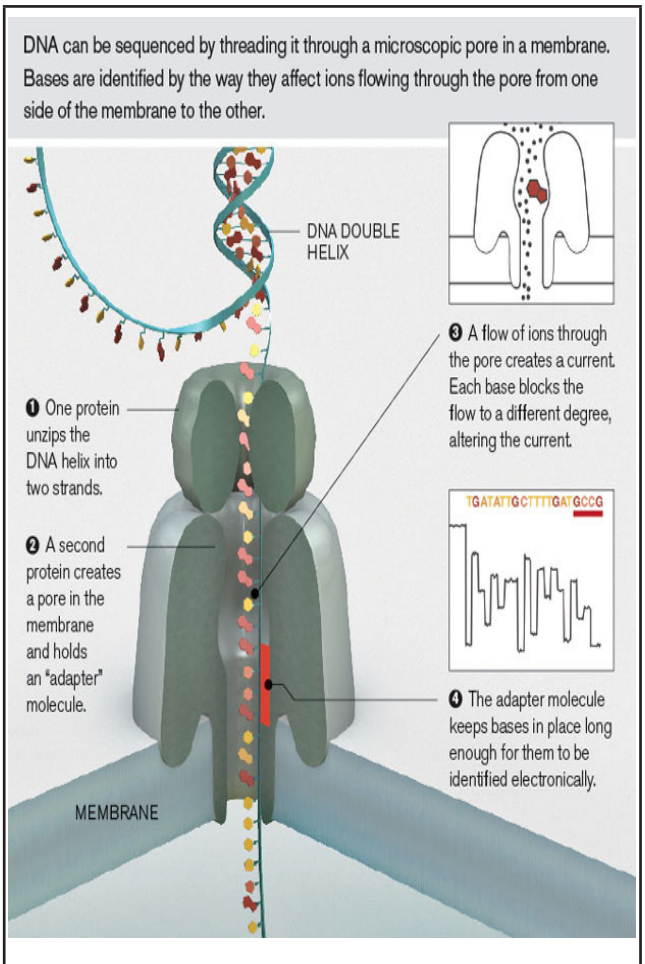
- Magnetic assembly for the synthesis of anisotropic superparamagnetic materials such as recently presented magnetic nano chains.
- Molecular scale electronics seeks to develop molecules with useful electronic properties. These could then be used as single-molecule components in a nanoelectronic device. For an example see rotaxane.
- Synthetic chemical methods can also be used to create synthetic molecular motors, such as in a so-called nanocar.

4. **The Biometric Approach**: Seeks to apply biomolecules for application in nanotechnology.[33]

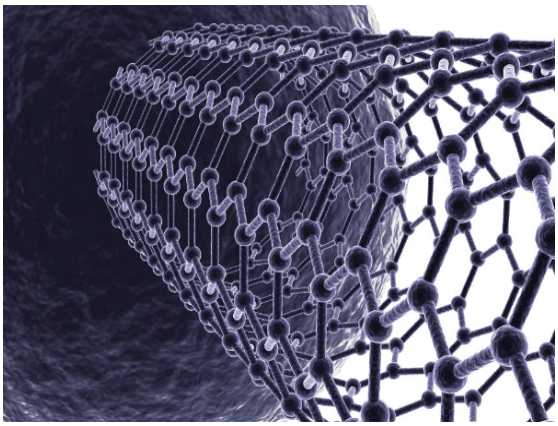
- Bionics or biomimicry seeks to apply biological methods and systems found in nature, to the study and design of engineering systems and modern technology. Biomineralization is one example of the systems studied.
- Bionanotechnology is the use of biomolecules for applications in nanotechnology, including use of viruses and lipid assemblies. Nanocellulose is a potential bulk-scale application.

There are various Nanostructures present today which accomplishes the needs of nanotechnology as an applied concept in different fields, they are as follows:-

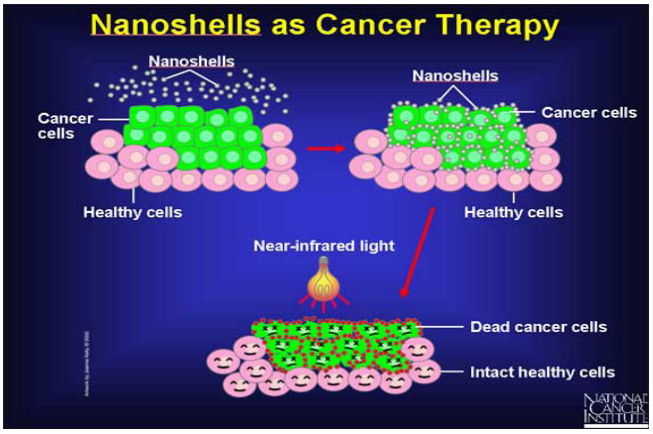
1. Nanopores
2. Nanotubes
3. Quantum dots
4. Nanoshells
5. Dendrimer
6. Nanobelt
7. Liposomes
8. Nanorods
9. Fullerenes
10. Nanowires
11. Nanospheres



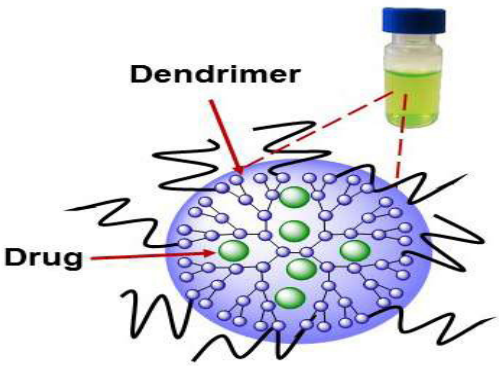
Nanocapsules



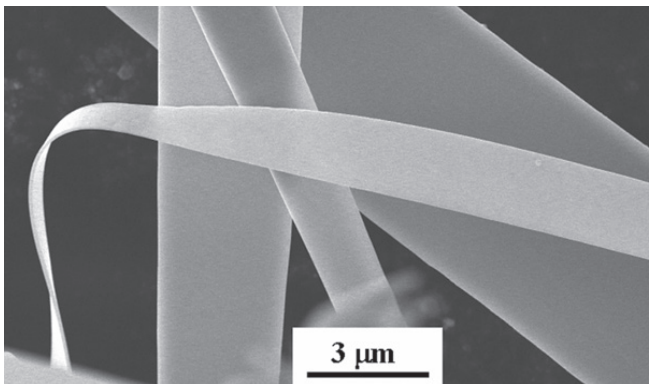
Quantum Dots Nanopores Nanotubes



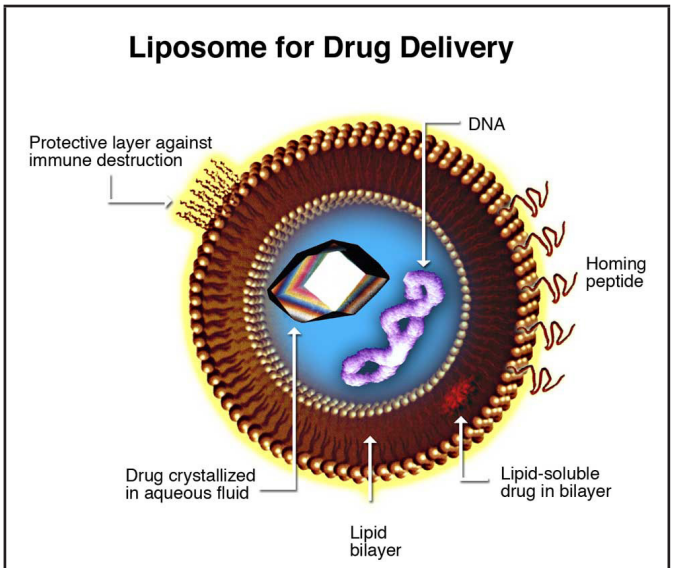
Nanoshells



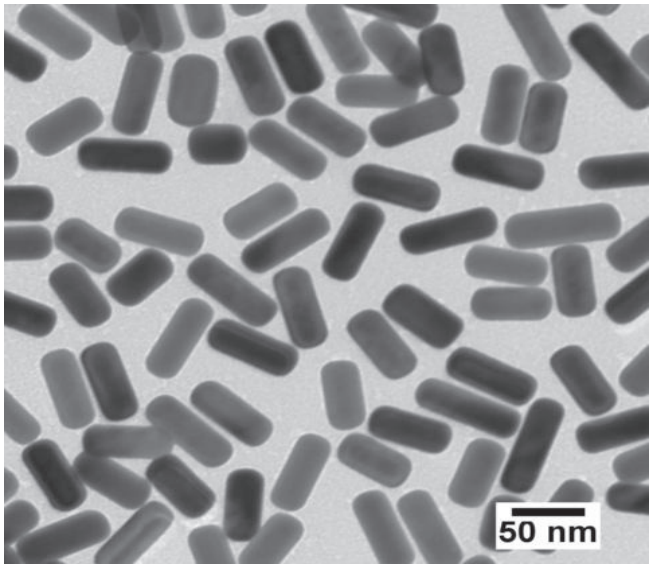
Dendrimer



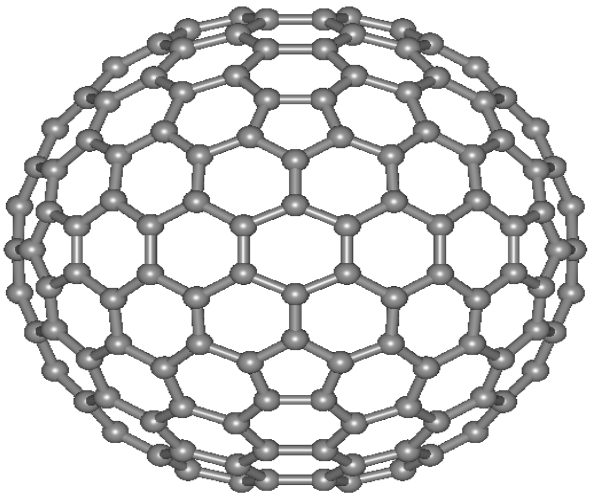
Nanobelts



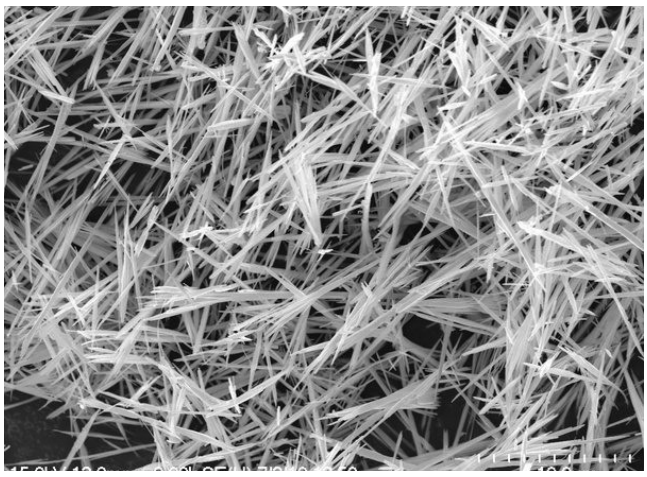
Liposomes



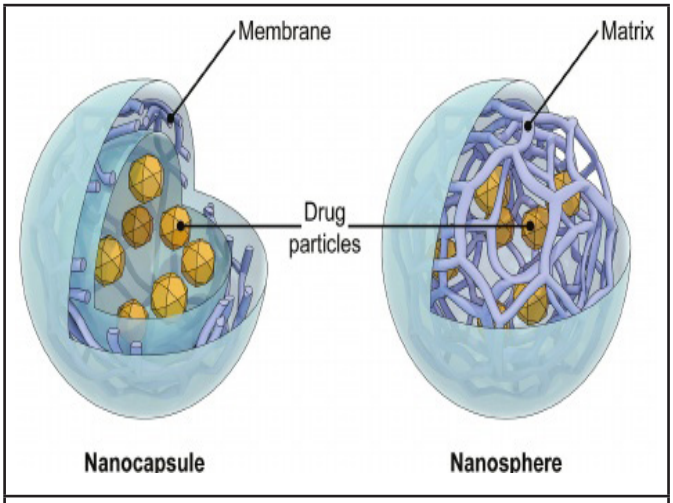
Nanorods



Fullerenes



Nanowires



Nanocapsule&Nanosphere

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