

Nanotechnology in India

[UPSC Notes]

What is Nanotechnology?

Historically, the conceptualization and ideation of nanoscience as a domain saw its beginning with a talk titled "There's Plenty of Room at the Bottom" by physicist Richard Feynman at the California Institute of Technology in late 1959.

- Feynman described a process of how manipulating and controlling individual atoms and molecules would be possible.
- In the late 1970s, Professor Norio Taniguchi coined the term nanotechnology.
- Finally, in 1981 with the help of the scanning tunneling microscope that could "observe" individual atoms, modern nanotechnology started.

Fundamentals behind Nanotechnology

- One nanometer is a billionth of a meter or 10^{-9} of a meter. For examples:
 - In an inch, there are 25,400,000 nanometers
 - sheet of newspaper is approximately 100,000 nanometers thick
- Nanotechnology involves observing and controlling individual molecules and atoms. Everything around us e.g. the food, clothes, the buildings and houses we live in, and our own bodies is made up of atoms.
- Atoms are impossible to see with the naked eye or a microscope, typically used in high schools.
- The microscopes required to observe stuff at the nanoscale were invented in the early 1980s.
- The invention of the scanning tunneling microscope (STM) and the atomic force microscope (AFM), enabled the birth of the age of nanotechnology.
- Today a wide variety of ways to make materials at the nanoscale and to take advantage of their properties like lighter weight, higher strength, enhanced control of light spectrum, and higher chemical reactivity than their larger-scale counterparts are explored by the scientists.

Applications of Nanotechnology

Nanotechnology finds its uses in a variety of sectors. Some of the uses of nanotechnology are given below:

Electronics

- Nano-RAM: It is a non-volatile RAM (Random Access Memory) based on carbon nanotubes deposited on a chip-like substrate that has a small size that permits very high-density memories.

- Nano Optomechanical S-RAM (Static RAM): This shows faster read/write time, as compared to a MEMS memory, and the processes take place without interference which further reduces time when compared to a traditional electrical enabled SRAM.

Healthcare and Medicine

- Nanotech detector- to detect heart attacks
- Nanochips to check plaque in arteries
- Nanocarriers for eye surgery, chemotherapy, etc.
- NanoFlares – used for detection of cancer cells in the bloodstream
- Nanopores – used in making DNA sequencing more efficient.
- Diabetic pads for regulating blood sugar levels
- Nanoparticles for drug delivery to the brain
- Nanosponges – are polymer nanoparticles coated with a red blood cell membrane. They can be used for absorbing toxins and removing them from the bloodstream.

Energy

- Solar/photovoltaic paints – potential to replace solar panels. A painted surface will capture energy from the sun and transform it into electricity.
- Wind power generations – nanogenerators – are flexible thin sheets that when bent can generate potential power.
- Nanobatteries – enables rechargeable lithium-ion batteries to last longer.

Food and Agriculture

- Nano fertilizers
- Hybrid polymers are used in packaging and to reduce spoilage
- Sensors for food-borne pathogens
- Nano-emulsions – to reduce bacteria in produce
- Nanoparticles based on titanium dioxide – used as antimicrobial agents

Nanotechnology in India

- The R&D work on nanotechnology began in India in 2001 with the NanoScience and Technology Initiative with initial funding of Rs. 60 crores.
- In 2007, the GOI launched a 5-year program called Nano Mission with an allocation of a budget of Rs 1,000 crores. It had a wider scope of objectives and much larger funding. Fields involved in the mission were: basic research, infrastructure development, HRD, and global collaboration.
- Several institutions such as the Department of IT, DRDO, Department of Biotechnology, Council of Scientific and Industrial Research (CSIR), etc. were roped in for the work. National Centers for Nanofabrication and Nanoelectronics were established in IIT Bombay and IISc Bangalore.

Outcomes of these initiatives

- We have published over 23,000 research papers.
- India ranked 3rd in papers published in 2018 behind only the USA and China.
- Several patent applications have been filed in this field.

Concerns

- Finance- We spend a fraction of the amount spent by leading countries like the USA, China, and Japan.
- The quality of research- Only a fraction of the papers from India figure in the top 1% of publications.

- Patents- Just 0.2% of them filed in the US Patent Office are from India.
- The manpower- Very few students take up this field. The target number of PhDs in nanotechnology is an ambitious 10, 000/year by the Ministry of HRD.
- Private sector's contribution- It is minimal in this domain despite there being a lot of potentials.

Some recent Indian innovations-

- The IIT Madras team used nanotechnology to decontaminate arsenic from water.
- A team from IIT Delhi engineered a self-cleaning technology to be used in the textile industry.

Nanotechnology International Conferences

The International Conference on NanoScience and NanoTechnology (ICONSAT) is a series of biennial international conferences held in India under the aegis of the Nano Mission, Department of Science and Technology (DST).

The Institute of Electrical and Electronics Engineers (IEEE) NANO 2022

- IEEE-NANO is the flagship IEEE international conference on Nanotechnology. It is an annual conference held since 2001.
- The 22nd edition of the IEEE International Conference on Nanotechnology (IEEE-NANO 2022) will be held from the 4th to the 8th of July, 2022 in Spain.