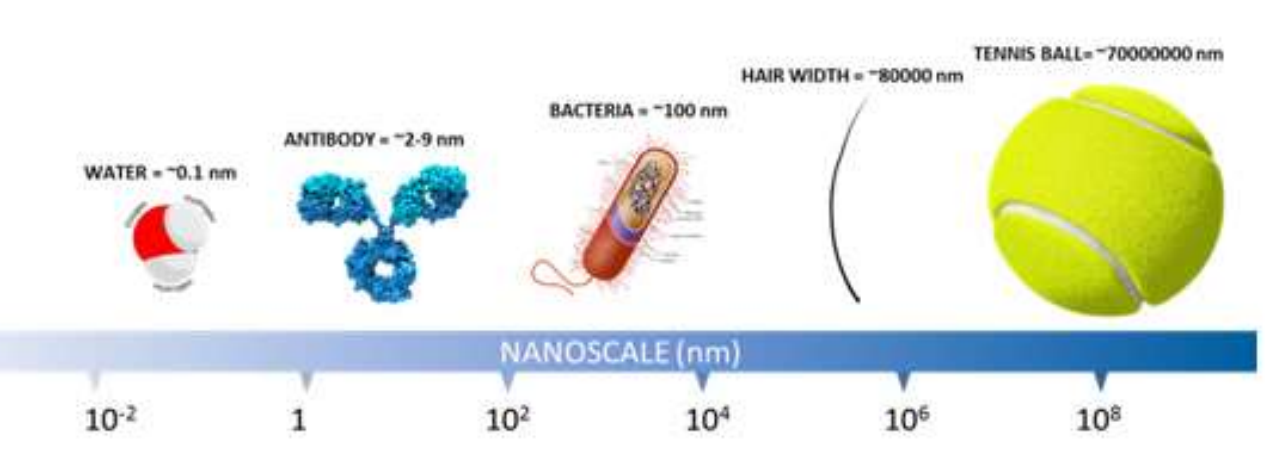
INTRODUCTION TO NANOTECHNOLOGY

IMPACTS & NECESSITY OF NANOTECHNOLOGY

What is Nanotechnology?



While many definitions for nanotechnology exist, the NNI* calls it "nanotechnology" only if it involves all of the following:

*National Nanotechnology Initiative

1. Research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometer range.

2. Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.

3. Ability to control or manipulate on the atomic scale.

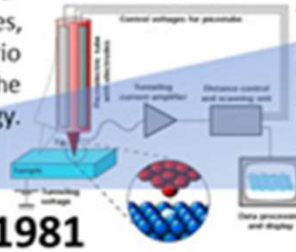
Nanotechnology: Past Present and Future

1959

The ideas that define nanoscience and nanotechnology were mentioned long before the terms were coined, in a lecture by American physicist Richard Feynman "There's Plenty of Room at the Bottom" in 29, 1959. Feynman described processes that would allow scientists to manipulate and control individual atoms and molecules.

1974

While working on the development of ultra-precision machines, that Professor Norio Taniguchi coined the term nanotechnology.



1981

Gerd Binnig and Heinrich Rohrer developed the scanning tunnelling microscope (STM), that modern nanotechnology began. The STM allowed researchers to view atoms on the surface of materials for the first time ever, and since then nanotechnology began its gradual growth. However, recently the nanotechnology market has exploded and become a hotbed of innovation.

1989

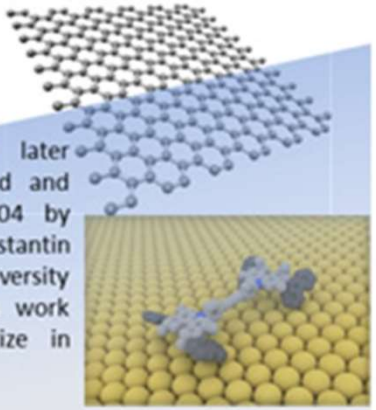
Don Eigler and Erhard Schweizer at IBM's Almaden Research Center manipulated 35 individual xenon atoms to spell out the IBM logo. This demonstration of the ability to precisely manipulate atoms ushered in the applied use of nanotechnology

1990's–2000's

Research groups and commitees formed to drive nano-related research. Consumer products making use of nanotechnology began appearing in the marketplace.

2004

The material was later rediscovered, isolated and characterized in 2004 by Andre Geim and Konstantin Novoselov at the University of Manchester. This work won the Nobel Prize in Physics in 2010

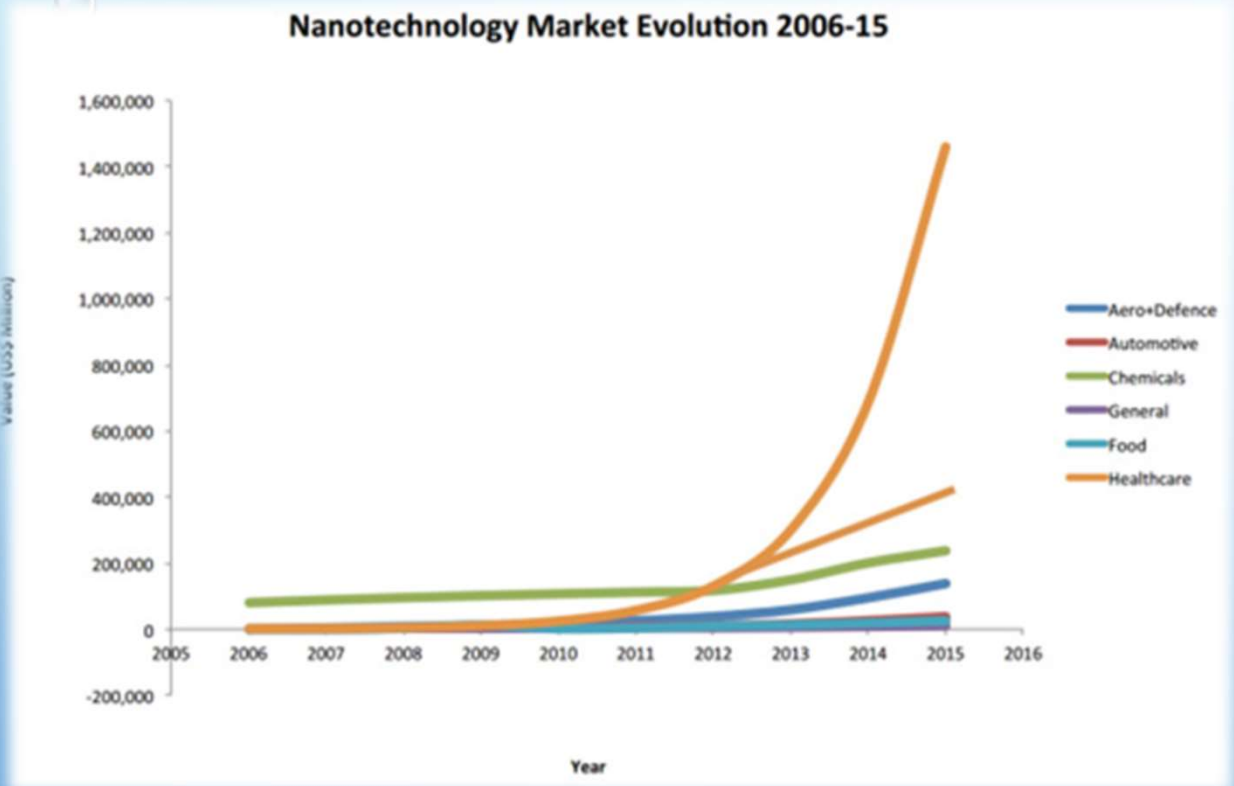


2016

Jean-Pierre Sauvage, J. Fraser Stoddart, and Bernard Feringa win the Nobel Prize in Chemistry for their research in developing Nano-scale machines including a 'nanocar'

https://www.nano.gov/timeline

Nanotechnology: Past Present and Future



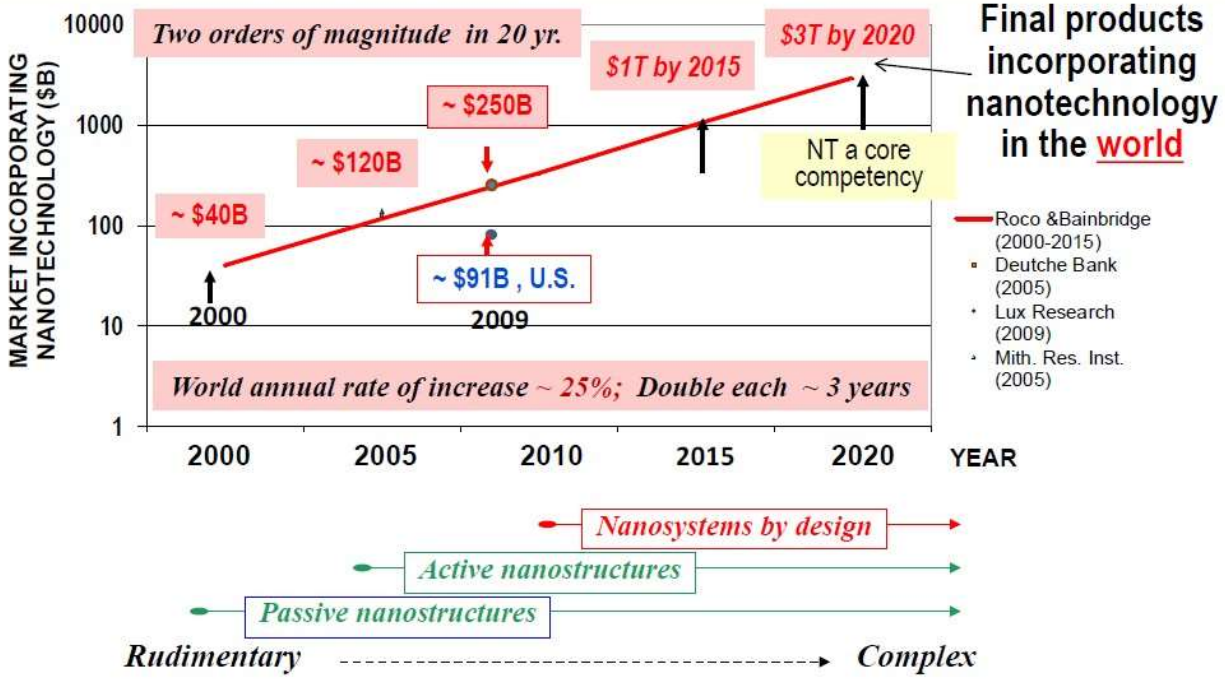
- The European Commission estimates the sector to be worth in excess of **USD 1 trillion**,
- Between 2007 and 2011, the EU alone invested approximately EUR 896 million in nanotechnology related research.
- The worldwide investment in nanotechnology is estimated to be close to a quarter of a trillion USD, with both China and the USA investing upwards of **USD 2 billion**.
- A larger number of manufactured nanomaterials are produced on the European market, e.g. coatings (paints, lacquers), anti-bacterial clothing, cosmetics, and food products.

"Nanomaterials are widely used in consumer and industrial applications"

Nanotechnology: Past Present and Future

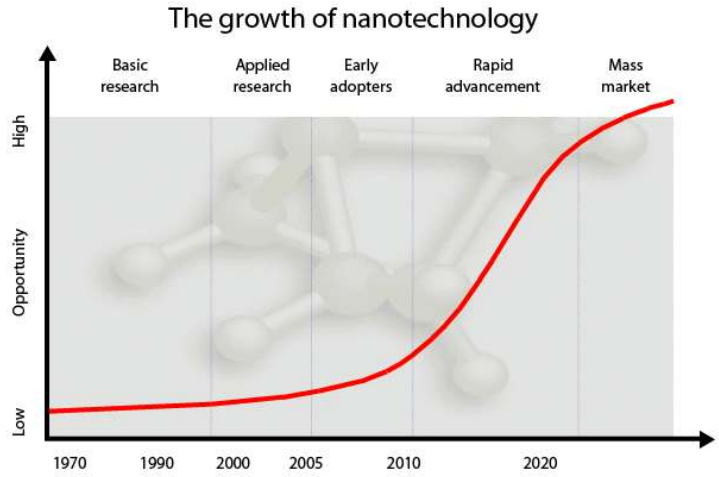
WORLDWIDE MARKET INCORPORATING NANOTECNOLOGY

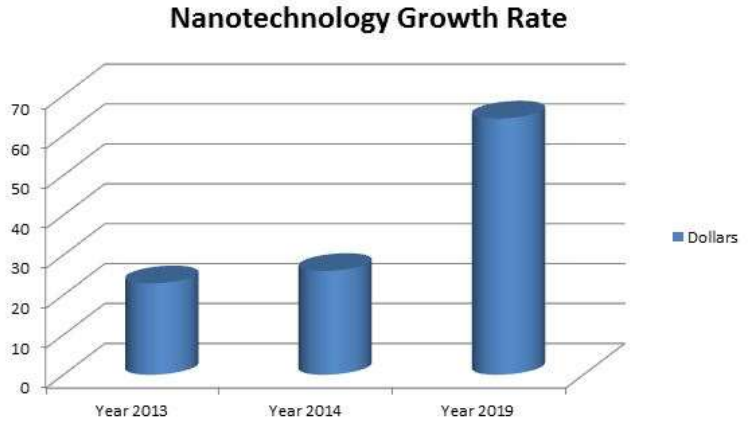
- Estimation made in 2000 after international study in > 20 countries
- THE ESTIMATIONS ARE IN AGREEMENT WITH SURVEYS UNTIL 2010; then, LUX surveys larger in 2012 (world $731B, US $235B; ~40% annual increase)



Refs: Roco and Bainbridge, "Societal Implications.." 2001; and NANO2, Fig 3 [3]

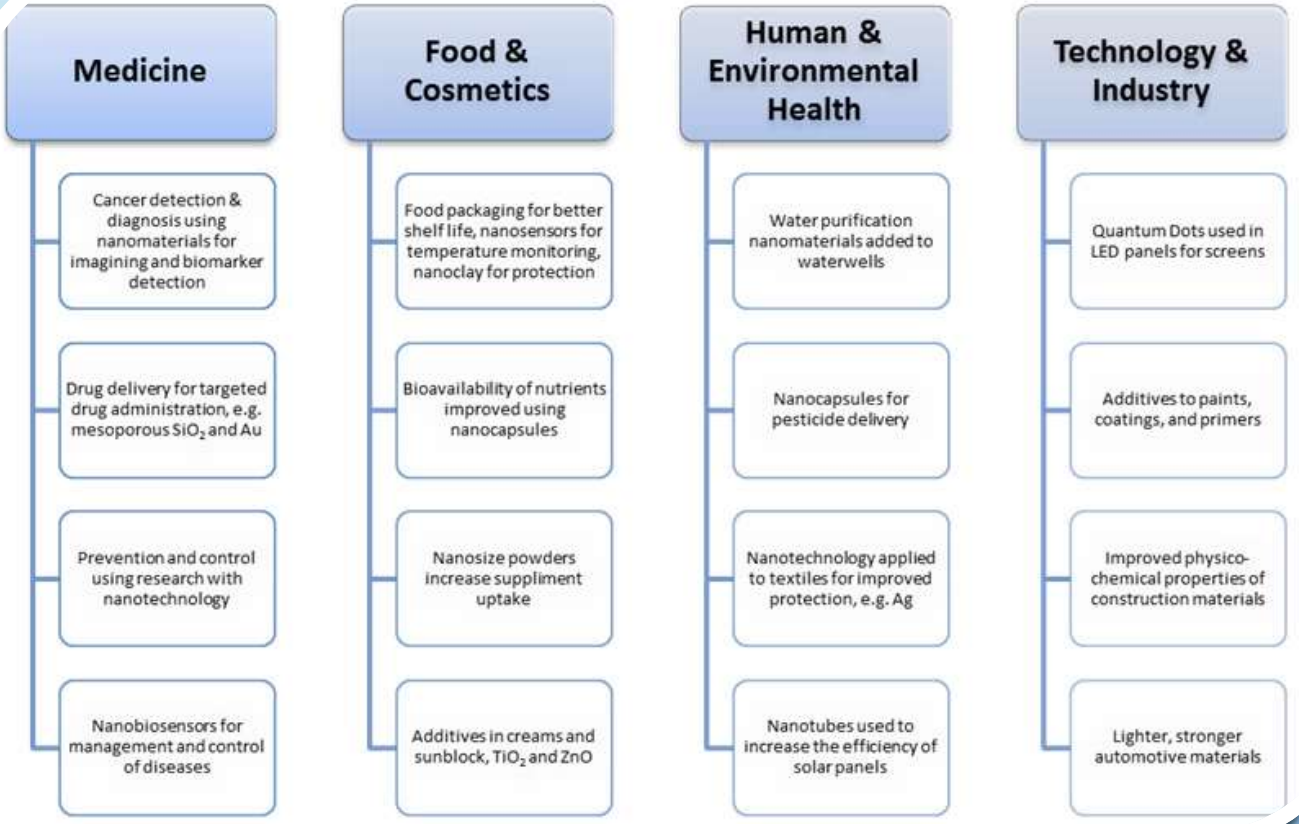
MC Roco, April 10 2014





Nanotechnology: Past Present and Future

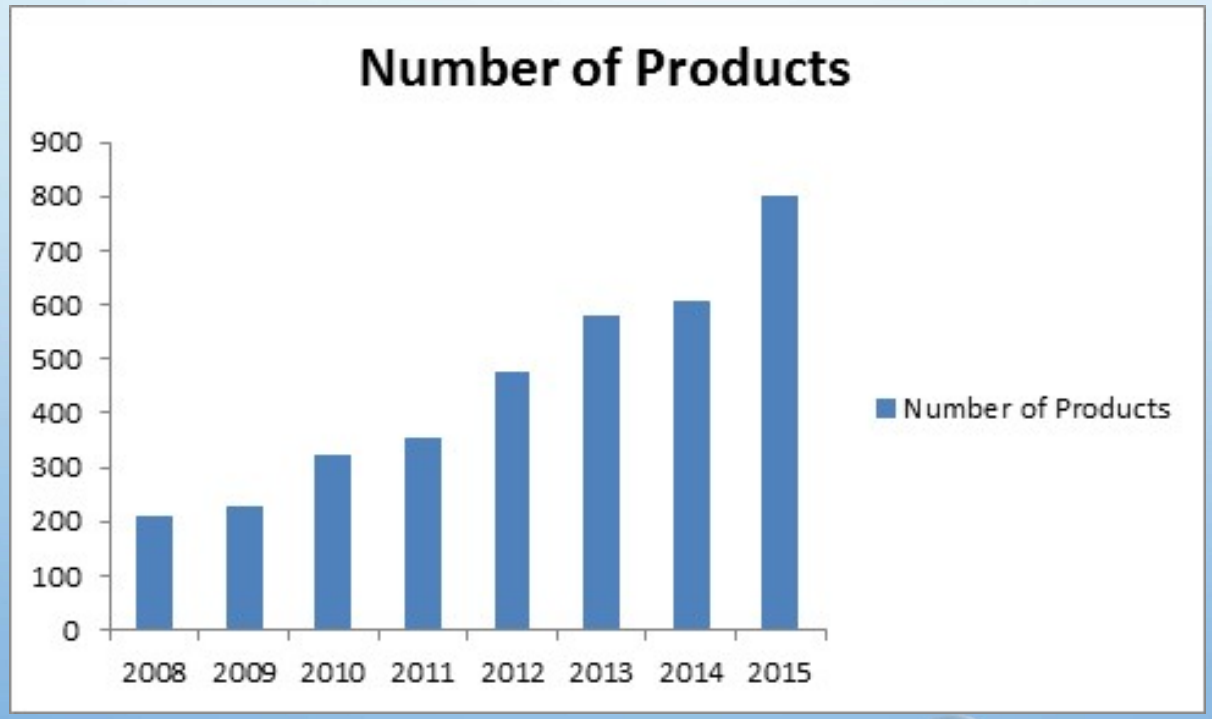
Applications and Possibilities



- Nanomaterials offer lightweight and strong materials for applications in the automotive and construction industries.
- Nanotechnology in coatings make surface materials more durable, water- and stain-resistant, offering solutions in the textile industry for both high street fashion and for high-end sporting equipment.
- Many high-performance electronic devices rely on nanotechnology, e.g. Quantum Dot (QD) technology for LED screens and smartphones (QDs offer high resolution and accurate colour reproduction).
- **Nanomaterials** are providing novel solutions for medical applications and cosmetics, hence the health and beauty sector has seen the greatest rise in nanotechnology focused research.

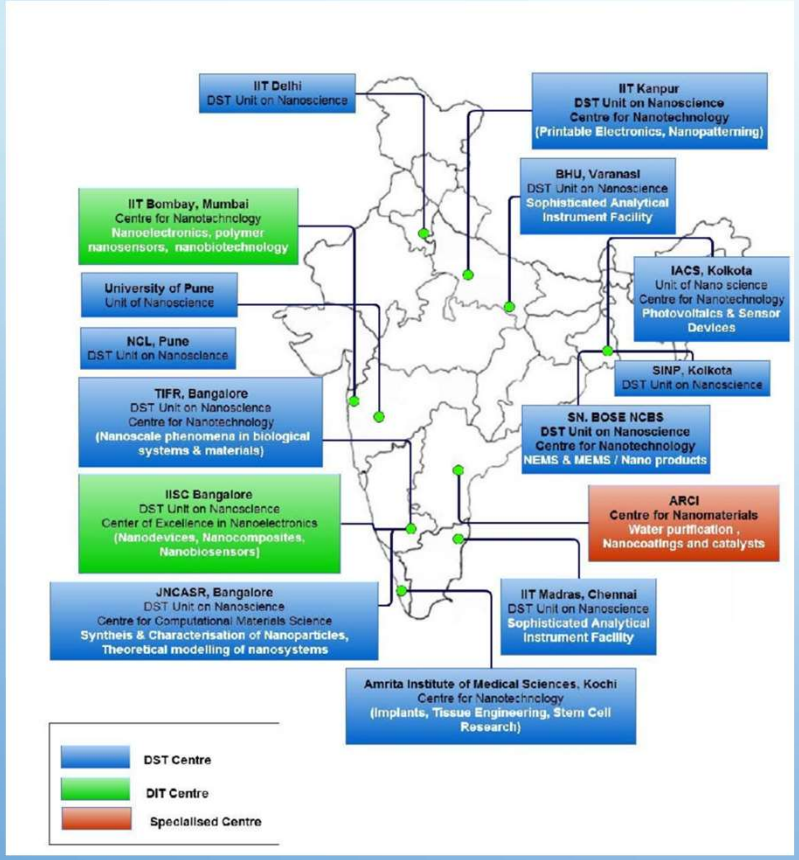
Nanotechnology: Past Present and Future

Production Growth of Nanotechnology Products



Nanotechnology: Past Present and Future

Nanotechnology in India



National Nanotechnology Initiative through Nanomission has impacted the following industries to tie up with academia and R&D labs to develop products and processes

1.NFMTC – IITM and MCRC and Orchid Pharma
2.Nanotech Centre – UoH and Dr Reddy's Lab
3.Centre Innovative Smart Textile- IITD, ARCI and Industries
4.Centre for Pharmaceutical Nanotech – NIPER and Pharma Industries
5.Rubber Nanotechnology – MGU and Apollo Tyres
6.Nanophosphor Application Centre, UoA – Nanotech Corp, USA

- Various startups have also entered the market of nanotechnology in various domain areas of nanoscience and nanotechnology.

https://www.electronicsforu.com/technology-trends/tech-focus/nanoscience-nanotechnology-india-happening