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(5 Year Integrated Program)

Course Title : Nanomedicine
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Unit-I
Introduction to Nanotechnology

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What is a nanometer?

- 10^{-9} meters
- One billion nanometers in a meter
- One million times smaller than the head of a pin
- A thousand times smaller than a bacterium
- 10 Hydrogen atoms lined up
- A sugar molecule
- An atom is 0.1 to 0.5 nm in diameter
- DNA molecules are 2.5 nm wide
- Virus is about 100 nm wide, bacterium 1000 nm
- Width of human hair – 100,000 nm
- Head of a pin – a million nanometers wide

What is Nanotechnology?

Nanotechnology is science, engineering, and technology conductedat the nanoscale, which isabout 1 to 100 nanometers.

- Nanotechnology is an interdisciplinary field that integrates all aspects of sciences and engineering manipulating nanomaterials
- Quantum Dots – 1 – 50 nm diameter
- Carbon Nanotubes – 1 – 3 nm in diameter
- Graphene – 1 carbon atom thick

- Making things to nanoscale
- Technology using science to solve problems
- Technology with smallest feature sizes of 10nm

Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, andengineering.

What is Integrated Nanotechnology?

- Chemistry, biology, physics of nanotechnology integrated with engineering
- An integrated technology that is collaborative between the fields
- Using nanotechnology in standard macroscale /mesoscale settings

Richard Feynman
American Physical Societymeeting at the California Institute of Technology(CalTech) on December 29, 1959;
started theideas and concepts behind nanoscience and nanotechnology with a talk entitled “There’sPlenty of Room at the Bottom”

Norio Taniguchi
In his explorations ofultraprecision machining, coined the termnanotechnology.It wasn't until 1981, with the development of thescanning tunneling microscope that could "see"individual atoms, that modern nanotechnologybegan.

Materials' characteristics, such as theircolour, strength, conductivity and reactivity,can differ substantially between thenanoscale and the macro.

Carbon 'nanotubes' are 100 times strongerthan steel but six times lighter.

Having the potential to increase theefficiency of energy consumption, helpclean the environment, and solve majorhealth problems.

Massively increase manufacturing production at significantly reduced costs.

Risk Assessment and Concerns Raised About Nanotechnology

- The toxicity of bulk material, such as solid silver, does not help predict the toxicity of nanoparticles of that same material.
- Nanoparticles have the potential to remain andaccumulate in the environment.
- They could accumulate in the food chain.
- They couldhave unforeseen impacts on human health.
- The public has not been sufficiently involved in debates on the applications, uses, and regulation of nanotechnology

Cell – natural nano factory and its distinct features

A cell is a perfect nano factory, full of biological nanomachines. It is a masterpiece of nature design.

• Self assembly - All bio- nanomachines are formed by self-assembly, which is not only driven by chemical forces, but also assisted by bio- chaperones, and subjected to the timing control.

• High specificity - Enzyme molecular machines and antibodies, their recognition specificity to target molecules is far beyond the that of host-guest chemistry.

• High efficiency - The turnover number of biological nanomachines (e.g. enzymes) is about 103 , which is much higher than that of chemical catalysts and mimetic enzyme.

• High fidelity – E.g. DNA, its fidelity determines the stability of genome. There are at least three defense lines to prevent errors during replication. Through this molecular mechanism, the probability of a newly synthesized DNA containing a wrong base is mere 10-8 -10-10 .

• Chemical energy driven - comes from food and is stored in form of ATP that becomes the universal "energy currency" for all kind of life systems.

• Self regulation – A cell has a self-regulation mechanism to control information flow, material flow and energy flow. Any mistake would mislead the cellular process and cause problems.

As a highly interdisciplinary discpline, nanobiotechnology has extensive influence on, e.g.

• promoting the interdisciplinary development of life science with chemistry, physics, material and information science and mechanical engineering, and solve many basic scientific problems.

• enhancing industrial capacity and create new opportunities for economic growth

• advancing technologies in medicine, environmental protection and agriculture to contribute to human well-being Due to the above reasons, developed economies have adopted nanobiotechnology as the important part of their nanotechnology research plans, and China does the same.

Conclusion Emerging frontier technologies are often double-edged swords. The whole world should reach a consensus to promote the development and peaceful use of nanobiotechnology under the framework of ethics and international rules