INTRODUCTION TO NANOTECHNOLOGY & EFFECT OF NANOMATERIALS ON ENVIRONMENT & HUMAN HEALTH

INTRODUCTION

Nanotechnology has emerged as a growing and rapidly changing field. New generations of nanomaterials will evolve, and with them new and possibly unforeseen environmental issues.There are currently about 800 products in the market that have been developed using nanotechnology.Our economy will be increasingly affected by nanotechnology as more products containing nanomaterials move from research and development into production and commerce.According to a prediction by 2015, nanotechnology will be a $ 3 trillion a year global industry. So one can estimate that due to manufacture of these huge quantity of materials how much nanoparticles are emitted and polluting the environment.

- General population exposure may occur from environmental release from the production and use of nanomaterials.No data have been identified quantifying the releases of nanoparticles from industrial processes or the fate of nanoparticles, after release into the environment.However due to the small size of nanoparticles, they will likely stay airborne for a substantial longer time than other types of particulate.
- The most likely pathway for general population exposure from release from industrial processes is direct inhalation of materials released into the air during manufacture.

What is nanotechnology?

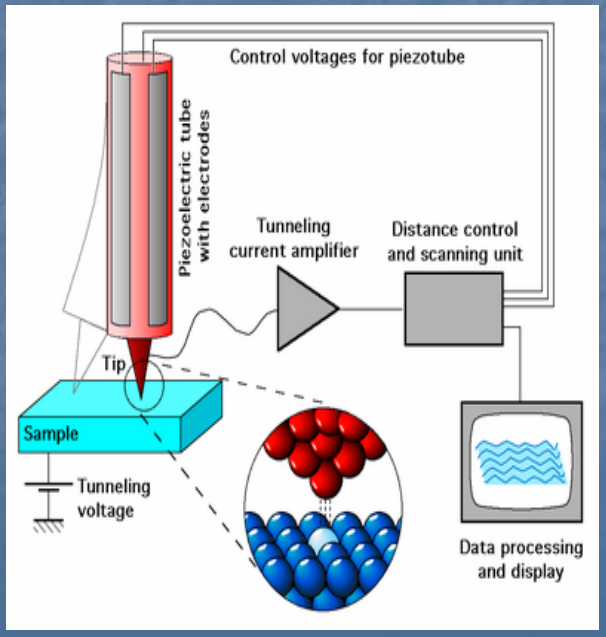
- Nanotechnology is defind by a unit of length,the nanometer which is equal to 10^-9 m. The word nano means “dwarf” and is used for a billionth.
- On this scale, a diameter of strand of human hair is roughly 75000 nm and one would require to 10 hydrogen atoms to lie end to end to make 1 nm.
- Nanotechnology which may sound new to our ears, has been the tool of nature since the beginning .
- The sea shells,pigments on the wings of beautiful butterfly,wonderful shades on the fresh roses and various other amazing flowers and birds are all manifestations of nanotechnology which may be said to be nothing but the art of nature.

- With the advent of nanotechnological instruments like STM and AFM, we have the required nano-vision and is possible now to see and manipulate atoms and molecule for obtaining desired results.

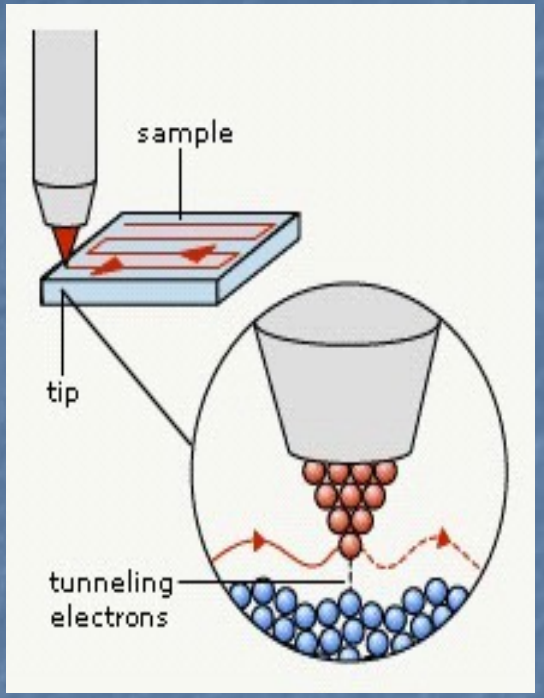
Tools In Nanotechnology

- Basically there are two tools for measurement at nanoscale:
  1. STM (Scanning Tunneling Microscope)
  2. AFM (Atomic Force Microscope)
- **STM (Scanning Tunneling Microscope):**

  STM was invented in 1981 by Binning & Rohrer who shared the Noble prize in physics with Ernst Ruska.
- In an STM, a metal probe with a point so fine that its tip is a single atom is brought close to the surface of a conducting or semi-conducting material.
- When a voltage of only 10 mV or so is applied between the probe and the surface,electron can tunnel across the gap between them,if the gap between them is small enough,a nanometer or too.



- STM can be used for atom manipulation Which was accidentally discovered by Eigle and Weiss while studying the Absorption and ordering of Xenon on a platinum surface.
- They found that the probe tip may be used to control a position of an atom on the top of the surface called “Adatom”.



Atomic Force Microscope:

For topographical imaging, another type of Microscope AFM or Scanning Force Microscope (SFM) is Commonly used .

- In this type of microscope,the interacting force between probe and sample is measured as an indication of sample probe distance.
- Since no current is involved it can image both conducting and insulating surfaces.This is its major advantages over STM.
- This is its major advantages over STM however its resolution is in general not as high as STM.
- The probe of an AFM is often called a cantilever.

Nano-Revolution

- Nano technology leads to “Industrial Revolution II”.
- A development of nanotechnology is expected to changes results in every discipline of science and technology.
- It will now be possible to synthesize a material with mechanical,electronic,biological and chemical properties required for specific needs.
- This will become feasible because of the achievement of the capability to built submicron structures having individual molecules and atoms at desired positions with nanometer precision.
- This nanotechnological innovation will lead to fundamental discoveries & development in all scientific areas such as medicine,genetic engg.,biotechnology, quantum physics, and environmental engineering.

Benefits To Mankind

- Early detection of viruses by nanosensors.
- Victory over diseases like cancer and AIDS.
- Targeted drug delivery.
- Biocompatible orthopaedics implant.
- Healthier and longer span of life.
- Pollution free technology.
- Cheap and plenty of energy.
- This will lead to peace and prosperity on earth.

Future Scenario Of Nanotechnology

Year	Projected Scenario
2010	Nanotechnology will be visible everywhere
2015	Advances in nanoelectronics and computers.
2020	Nanomaterials in plenty.
2025	Nanotechnology energy year.
2030	Nanorobotics.

What are nanoparticles?

- A nanoparticle is a microscopic particle whose size is measured in nanometers. It is defined as a particle with atleast one dimension less than 100 nm.
- The properties of materials changes as their size approaches the nano-scale e.g. the bending of bulk copper (wire, ribbon etc) occurs with the movement of copper atoms/clusters at about 50 nm scale. Copper nanoparticles smaller than 50 nm are considered superhard materials that do not exhibit the same malleability and ductility as bulk copper.

- Types of nanoparticles:

  Nanoparticles falls into 3 major groups;

1. Natural nanoparticles.
2. Incidental nanoparticles.
3. Engineered nanoparticles.

1.Natural Nanoparticles:

Naturally occuring nanomaterials such as volcanic ash, magnetotactic bacteria, mineral composites and other exists in our environment.

2.Incidental Nanoparticles:

Waste nanoparticles produced as a result of some industrial processses are incidental nanoparticles.

3.Engineered Nanoparticles:

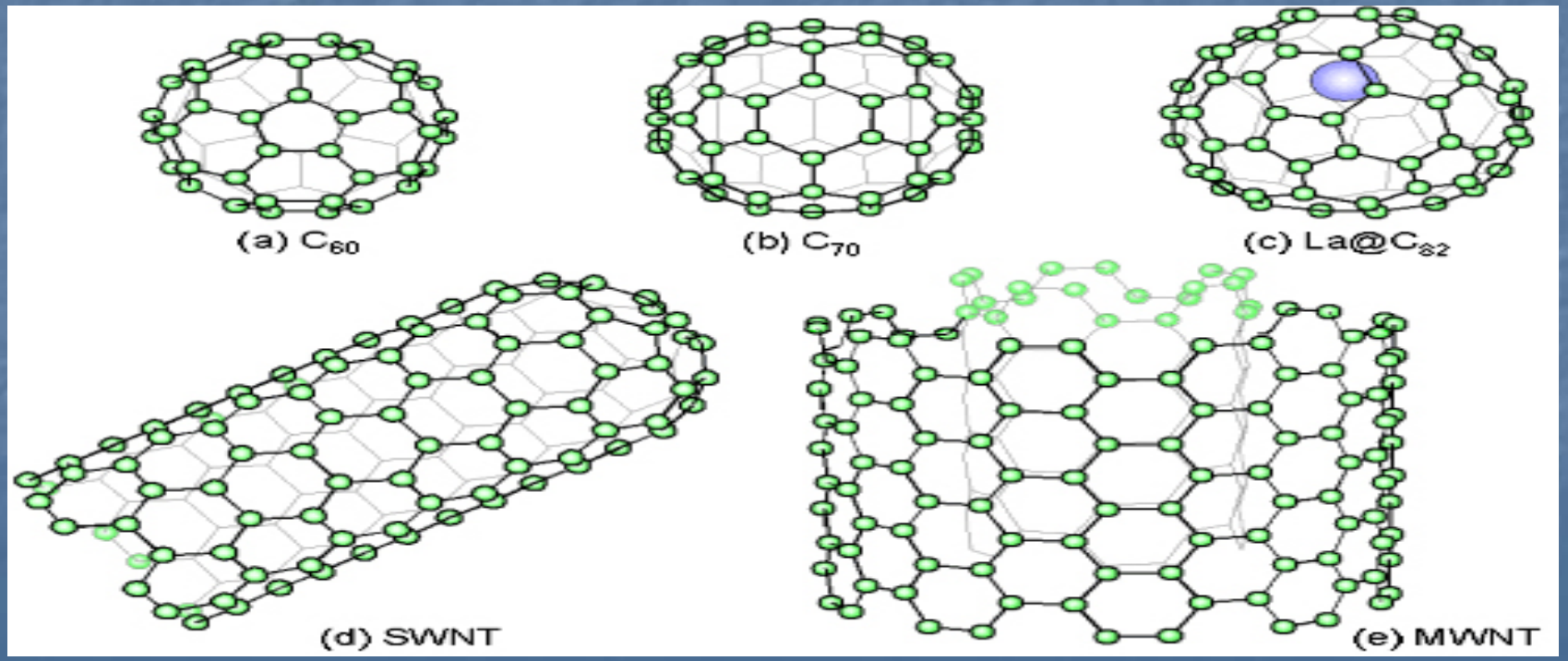
These are the nanoparticles which are purposely produced by the manufacturing and production processes of nanomaterials e.g. nanotubes, quantum dots etc.

Environmental Application Of Nanoparticles

- Researcher have extracted Photosynthesis protein from spinach chloroplast and coated them with nanofilms that converts sunlight into electrical energy, which one day may lead to energy generating films and coatings.
- Another example of converging technology is the development of nano-meter sized sensors devices that can detect specific compounds with in the natural environment.
- Chloro-organics are a major class of contaminants at waste sites ,and several nanomaterials have been applied to aid in their remediation. Zero-valent iron has been used successfully in the past to remediate the groundwater by the construction of permeable reactive barrier (iron wall) of zero valent ion to intercept and dechlorinate chlorinated hydrocarbons such as trichloroethylene in groundwater plume.

- Current average overall energy loss in transmission lines is 7%. Power transmission could be improved by using carbon nanotubes (fig.1) that provide better conduction of large quantities of high voltage electricity than copper wires, at one-sixth the weight.
- Proctor & Gamble is using titanium oxide (TiO_2) nanoparticles to provide transparency in sunscreen lotions, as a less toxic alternatives in the organic molecules.
- Titanium dioxide and zinc oxide as nanomaterials have been shown to effectively catalyze both the reduction of halogenated chemicals and oxidation of various other pollutants, and heterogeneous photocatalysis has been used for water purification of treatment systems.
- Nano titanium dioxide (nano-TiO_2) particles are being incorporated into building materials such as cement and surface coatings in order to reduce ambient air nitrogen oxide (NO_x) levels.

- Today it is technologically feasible to manufacture, programmable nanofilters that eliminate the pressure requirement for desalinization and reduce the expenses by 99%,meaning the end of water shortages in arid regions. It could also alter regional environment and converts deserts to forests by removing large amount of fresh water from the oceans. (Postulated by Mulhale)



Ecological Effect Of Nanoparticles

- Nanoparticles may affect aquatic or terrestrial organisms differently larger than particles of the same materials.
- Cheng (2005) reported that aggregates of single walled carbon nanotubes added to zebrafish embryos reduced hatching rates at 72 hours, but by 77 hours post fertilization all embryos in the treated group had hatched.
- Nanomaterials may be effective bactericidal agents against both gram positive and gram negative bacteria in growth media.
- For terrestrial mammals, toxicity test data on rats and mice obtained for human health risk assessment should be considered.
- Yang and Watt (2005),reported that aluminium nanoparticles(13 nm) slowed root growth in soil medium. Species test included commercially

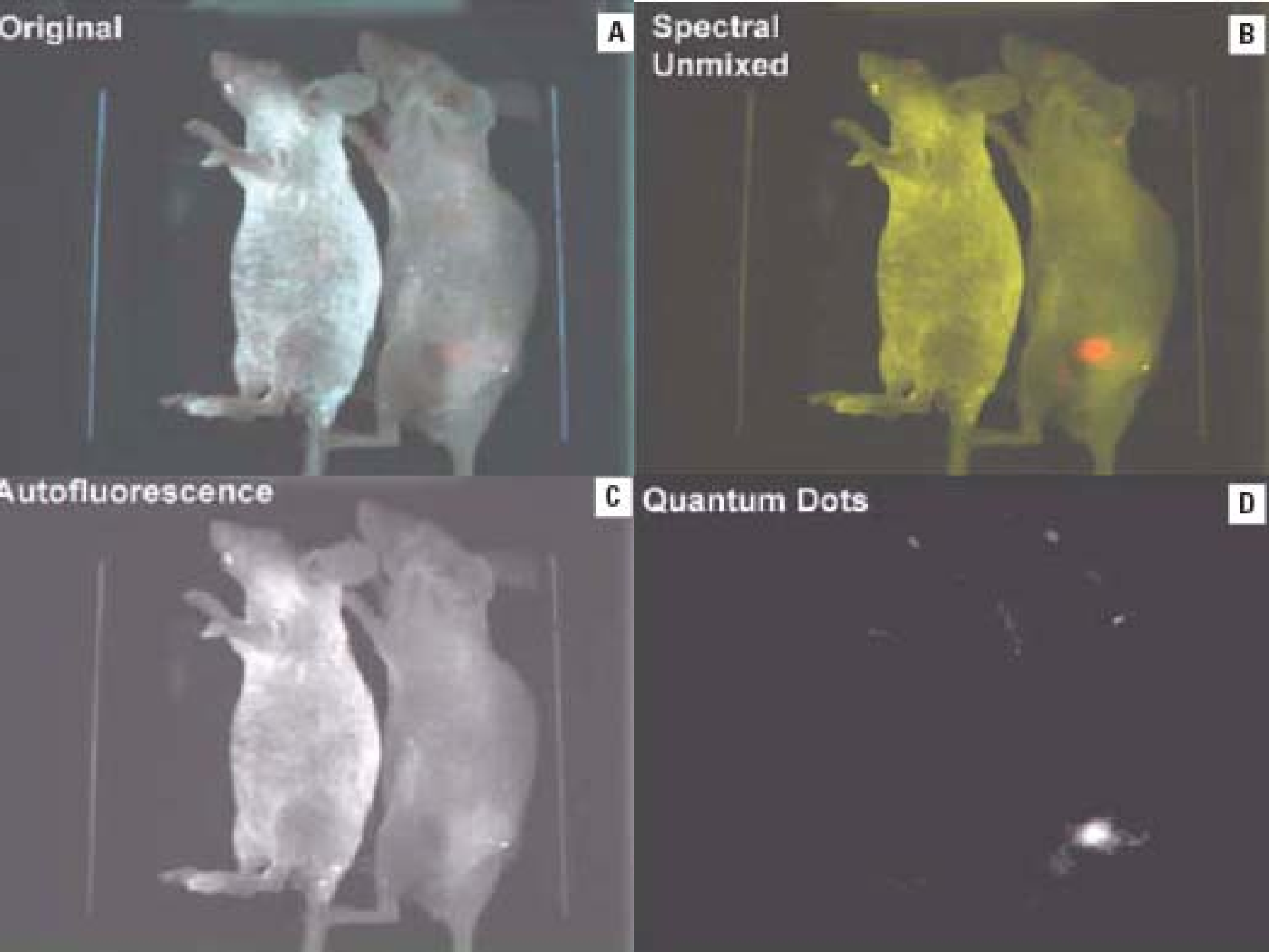
Important species like corn, cucumber, soyabean, cabbage and carrot. Larger alumina particles(200-300 nm) did not slow root growth, indicating that the alumina itself was not causing the toxicity.

Effect On Human Health:

- Some nanomaterials have ability to enter animal tissues by passing through cell membranes or cross the blood-brain barrier.
- Inhaled nanoparticles may become lodged in the lungs.
- Nanomaterials have a greater risk of being absorbed by skin than macro-sized particles.
- Nanoparticles affect the cardiopulmonary system of human being.

- Nanoparticles of titanium dioxide and zinc oxide used in large numbers of cosmetics, sunscreens are photoactive producing free radicals and causing DNA damage to human skin cells when exposed to UV light.
- 500 nm TiO2 particles have only a small ability to cause DNA strand breakage; 20 nm particles of TiO2 are capable of causing complete destruction of super-coiled DNA.
- Nanoparticles may access to the blood stream through inhalation or ingestion and even via skin absorption, if the skin is damaged.
- Unlike larger particles, nanoparticles may be transported within the cells and may be taken up by cell mitochondria and the cell nucleus,where they can induce major structural damage to mitochondria, cause DNA mutation, and even ,results in cell death.

- Once in blood stream, nanomaterials can be transported around the body and are taken up by organs and tissues including the brain, heart, liver, kidneys, spleen, bone marrow and nervous system.
- The major distribution sites for nanoparticles appeared to be the Liver, followed by spleen. Diseases of the liver suggests that the accumulation of even harmless foreign matter may impair its function and results in harm.
- Carbon nanotubes have been shown to cause the death of Kidney cells and to inhibit further cell growth.


Original
A
Spectral
Unmixed
B
Autofluorescence
C
Quantum Dots
D

Conclusion:

1. The effect of nanoparticles when they have entered the cells are largely unknown.
2. There are a variety of studies going on into the health and environmental impacts of many applications of nanotechnology and it is in everyone's interest to ensure that any new compound is fully characterized and the long term implications studied before it is commercialized.
3. When this form of molecular engineering (Nanotechnology) is achieved, it will results in a manufacturing revolution with more promising for society than the computer revolution.
4. Lastly I hope that this technology in future gives us "clean and green environment" which is the ultimate goal of an environmentalist.

THANK YOU