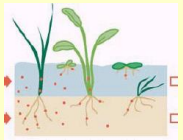
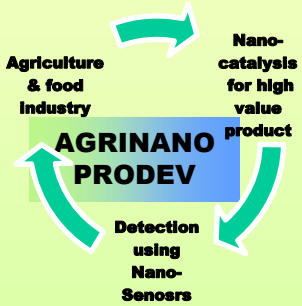
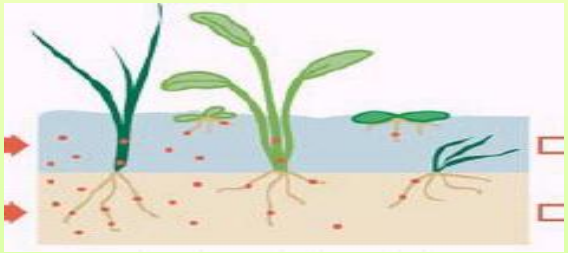


NANO TECHNOLOGY IN AGRICULTURE & FOOD INDUSTRY





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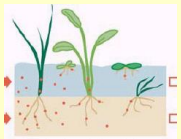
What is Nanotechnology?

Nanotechnology is the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures to create materials and devices with new or vastly different properties.

“Nano” –means “dwarf”. Technically 10^{-9}.

LOGARTHMIC LENGTH & LEVEL OF ORGANIZATION



100µm

EUKARYOTIC CELL

10µm

BACTERIA

1µm

VIRUS

100nm

PROTEIN

DNA

RNA

10nm

A,T,G,C

MOLECULES

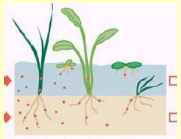
Nano = 10^{-9}

1nm

ATOMS

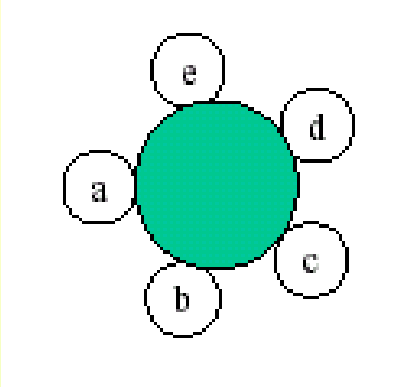
0.1nm

Prof. A. N. Misra, CUJ, India

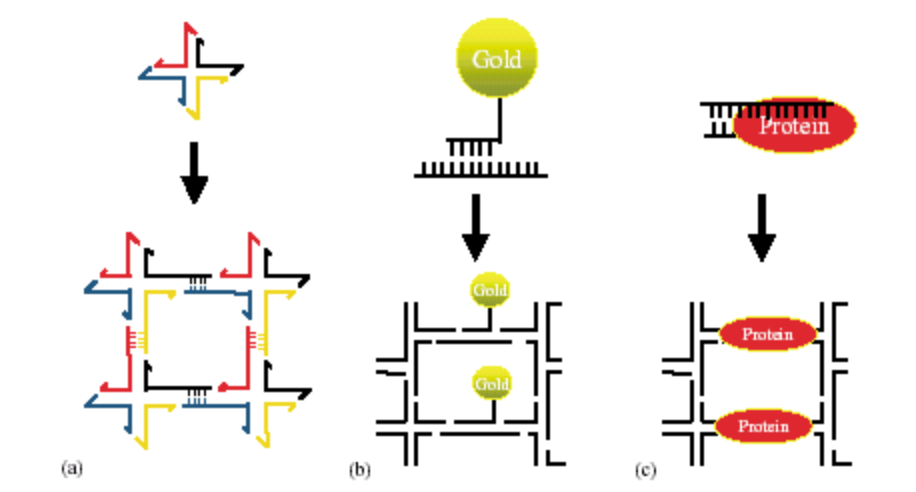


Nanotech uses materials ≈ 0.1 to 100nm, and should display different properties from bulk (or micrometric and larger) materials.

This include physical strength, chemical reactivity, electrical conductance, magnetism, and optical effects.

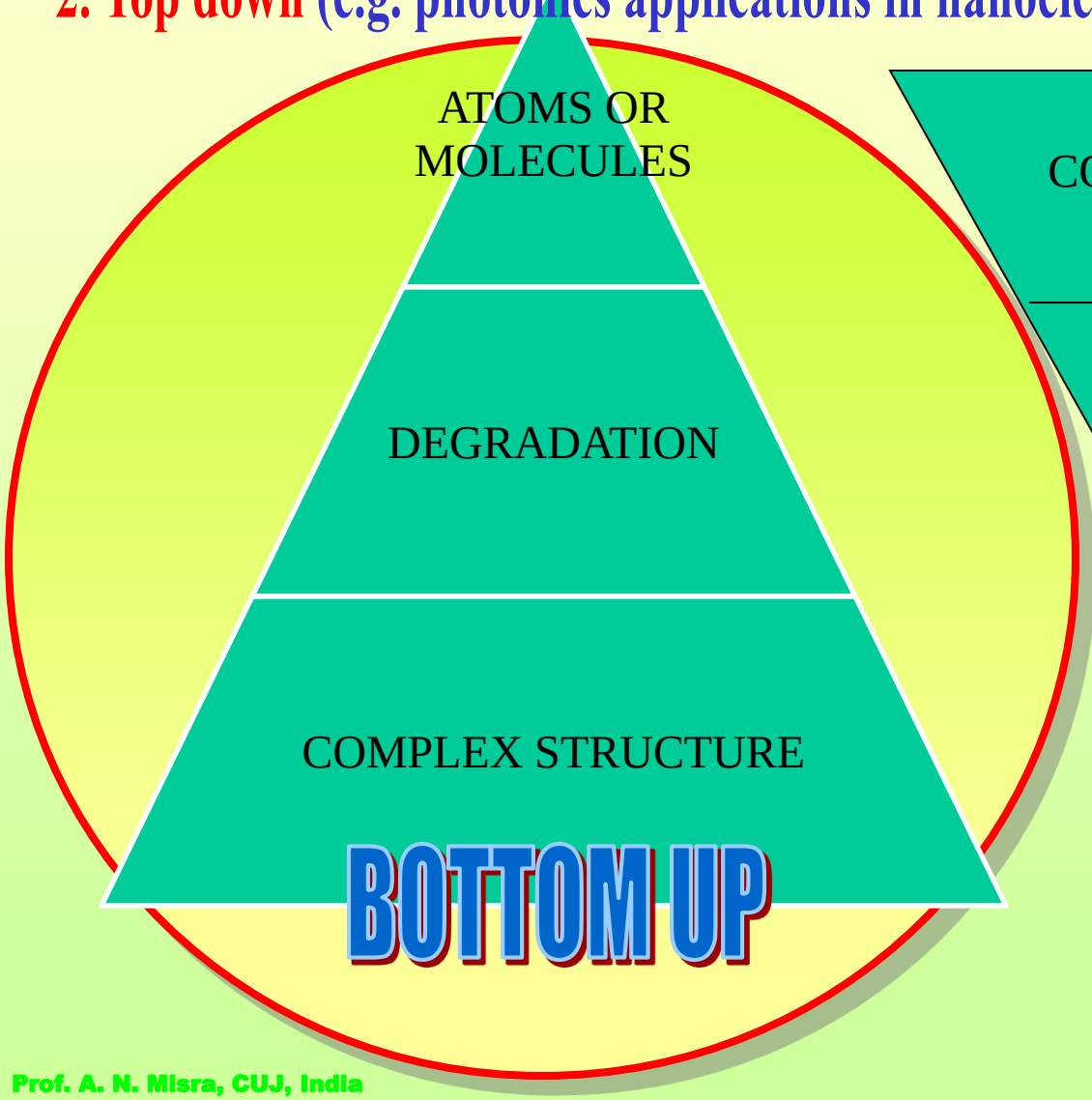


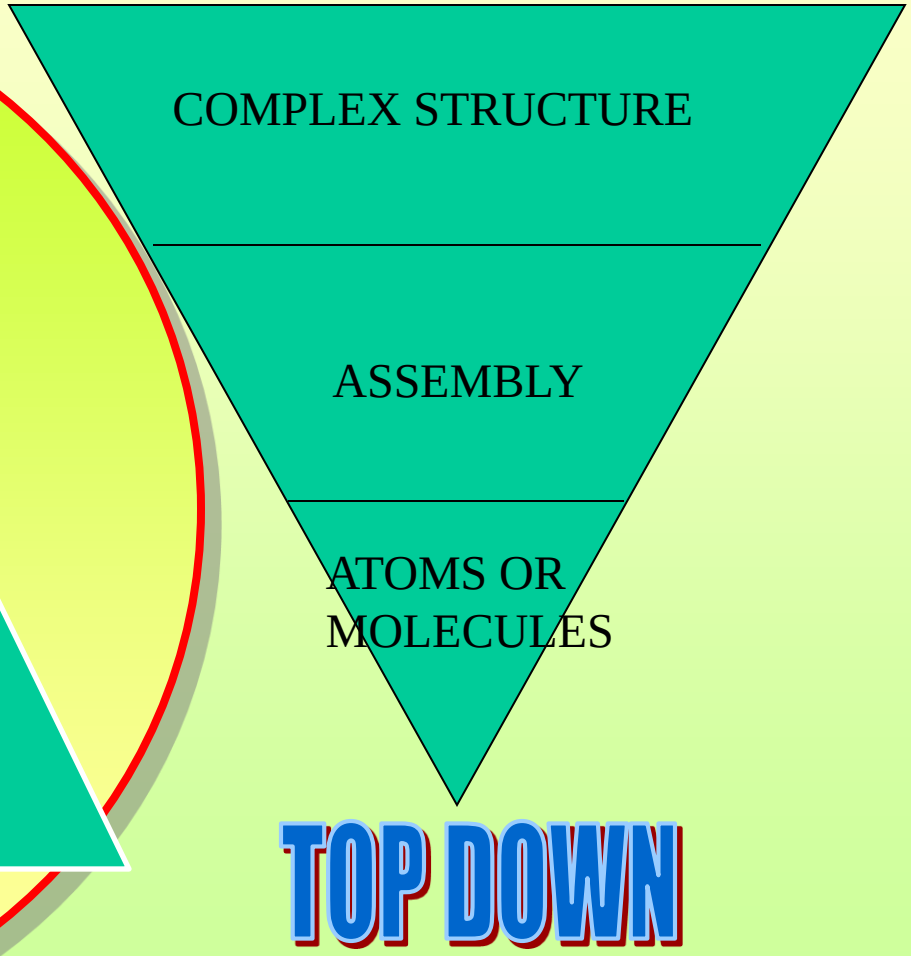
NUMBER OF SURFACE ATOMS INCREASES, WHEN THE SIZE OF THE PARTICLES DECRESE. THIS **INCREASES THE REACTIVITY** & OTHER PHYSICAL AND CHEMICAL PROPERTIES.



Working principles: 1. Bottom up (resembles chemistry or biology).

2. Top down (e.g. photonics applications in nanoelectronics and nanoengineering).

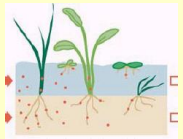




The potential of nanotechnology

health care,
textile, materials,
ICT, and energy sectors

[antibacterial dressings, transparent sunscreen lotions, stain-resistant fabrics, scratch free paints for cars, and self cleaning windows].



The application of nanotechnology to agriculture and

food industries was first addressed by USDA in Sept. 2003.

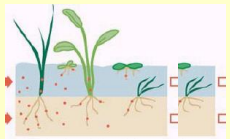
Vision: Nanotechnology will change the way food is produced, processed, packaged, transported, and consumed.

Nanotechnology in the Food Market

More than 1000 companies around the world are active in nanotech R&D. The market for the nanotech was $7.6 billion in 2003 and is expected to be $1 trillion in 2011 (Bus.Comm.Co.).

The full potential of nanotechnology in the agricultural and food industry has not yet realised.

The largest market for Nanofood in future (beyound 2010) will be Asia (Helmunt Kaiser Consultancy 2001).

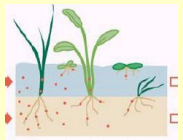


Nanotechnology in Agriculture

Rapid disease detection & Molecular treatment, enhancing the ability of plants to absorb nutrients etc.

Smart sensors and smart delivery systems to combat viruses and other crop pathogens.

- **In the near future nanostructured catalysts will be available which will increase the efficiency of biocides.**

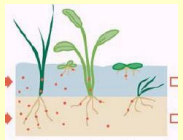


- **Environmental Protection**

  through the use of alternative (renewable) energy, and filters or catalysts to reduce pollution and clean-up existing pollutants.

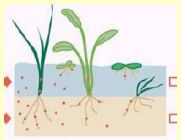
- **Controlled Environment Agriculture (CEA)**

  advanced and intensive form of hydroponics.



- **Autonomous sensors,**
  smart-sensor nanotechnology,
  for real-time monitoring in vineyards and in grocery.

- **Nano-particles or nanosurfaces -**
  trigger an electrical or chemical signal in the presence of a contaminant.

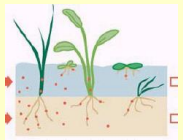


- Equipment of increased sensitivity, allowing an earlier response to environmental changes e.g. Nanosensors utilising carbon nanotubes or nano-cantilevers are small enough to trap and measure individual proteins or even small molecules.

- *Other nanosensors work by triggering an enzymatic reaction or by using nanoengineered branching molecules called DENDRIMERS as probes to bind to target chemicals and proteins.*

Smart Delivery Systems

- **Nanomedicine - with high precision & targeted delivery.**
  Encapsulation and controlled release methods. Formulations containing *nanoparticles* (100-250 nm) dissolve in water more effectively .
- ***Nanoemulsions -* Suspensions of nanoscale particles, either water or oil-based and with suspensions of pesticidal or herbicidal nanoparticles (200-400 nm).**



- **Fertiliser and pesticide *smart delivery systems* can respond to environmental changes. e.g. magnetic fields, heat, ultrasound, moisture, etc.**

- **Syngenta, LG, BASF, Honeywell, Bayer, Mitsubishi, and DuPont - nanotech plant health monitoring systems.**

Other Developments in the Agriculture:

Particle farming –
growing plants in defined soils.
E.g. alfalfa plants grown in gold rich soil, absorb gold nanoparticles through their roots.

Nano-aquaculture:

NanoCeram - Al_20_3 nanofibres - water purifier.

Nanocheck - La nanoparticles absorb PO_4^{--}.

Ultrafine, Fe nano-powder clean up contaminated soil /groundwater, catalyse oxidation and breakdown of organic contaminants viz. trichloroethene, carbon tetrachloride, dioxins, and PCBs (polychlori-nated biphenyl) to simpler C- compounds.

Iron oxide nano-particles bind and remove arsenic.

Nanotechnology in the Food Industry

Nanofood - smart packaging, on demand preservatives, and interactive foods. Nanotechnology techniques or tools are used during cultivation, production, processing, or packaging of the nano-food.

Although some of these goals are further away, the food packaging industry already incorporates nanotechnology in products.

“On-demand” food –

Thousands of Nanocapsules containing flavour or colour enhancers, or added nutritional elements (vitamins), remain dormant in the food and released only when triggered by the consumer.

Packaging and Food Safety

Smart packaging to optimise product shelf-life.

"Electronic tongue" - an array of nanosensors sensitive to gases released by spoiled food, & sensor changes colour.

"Hybrid system" film - with silicate nanoparticles. Prevents food spoilage. Reduce the diffusion of O_2, gases and moisture.

Alcohol in beer reacts with plastic bottles.

Nanocomposite clay, minimises loss of CO_2 from beer and ingress of O_2.

Antimicrobial films - absorb O_2 from the package.

NanoBioluminescence Detection Spray - engineered luminescent protein bind to the surface of microbes. Used in ocean freight shipping & fight bioterrorism.

Portable nanosensor using DNA biochips detect chemicals, pathogens and toxins in food.

Microarray "Good Food" sensors - identify pesticides on fruit and vegetables and monitor in farm environment..

BioFinger - tip of the nano-cantilever coated with chemicals allow it to bend and resonate when it binds specific molecules.

Dirt repellent coatings for packages using the lotus effect nanoscale wax pyramids.

MgO_2 and ZnO_2 nanoparticles- destroy microorganisms.

Nanotronics - monitoring and tagging of food items.

Nanofood consortium Arla Foods, Danisco A/S, Aarhus United A/S, Danish Crown amba, Systematic Software Engineering A/S, and the Interdisciplinary Nanoscience Centre (iNANO).

With a mission to provide safe food to consumers.

Food Processing

"On demand" foods. Nanocapsules incorporated into food to deliver nutrients. e.g. tuna fish oil (a source of omega 3 fatty acids) in "Tip-Top" Up bread. Nanocapsules break open only in the stomach.

NSSL - Nano-sized Self-assembled Liquid Structures to deliver nutrients to cells. The particles are expanded micelles with a diameter of ≈ 30 nm.

"*Nutraceuticals*"

Nanocochleates 50nm coiled nanoparticles incorporated in the carriers include lycopene, beta-carotene, lutein, phytosterols, CoQ10 and DHA/EPA. Nutralease particles allow these compounds to enter the bloodstream from the gut more easily.

Interactive foods - SMART FOOD will make the concept of super foodstuffs a reality.

Cosmetics industry to produce transparent creams.

NanoCeuticals which is a colloid (or emulsion) - scavenge free radicals, increase hydration and balance the body's pH.

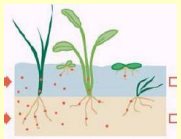
NanoClusters™, nano-powder with nutritional supplements. Enhances the absorption of nutrients.

Nanoceramic - reduces oil use by half.

Low fat ice creams by decreasing the size of emulsion particles that give ice-cream its texture.

Nanoceuticals use of silver nanoparticles in refrigerators to inhibit bacterial growth and eliminate odours.

All Spray For Life® uses a newly-designed pre-metered, non-aerosol NDS-Nanoceautical Delivery System for transmucosal administration of dietary supplements, resulting in increased-bioavailability compared with gastrointestinal absorption.



Agri cata c lysis N Sen osrs

Agriculture & food industry

Nano-catalysis for high value product

AGRINANOPRODEV

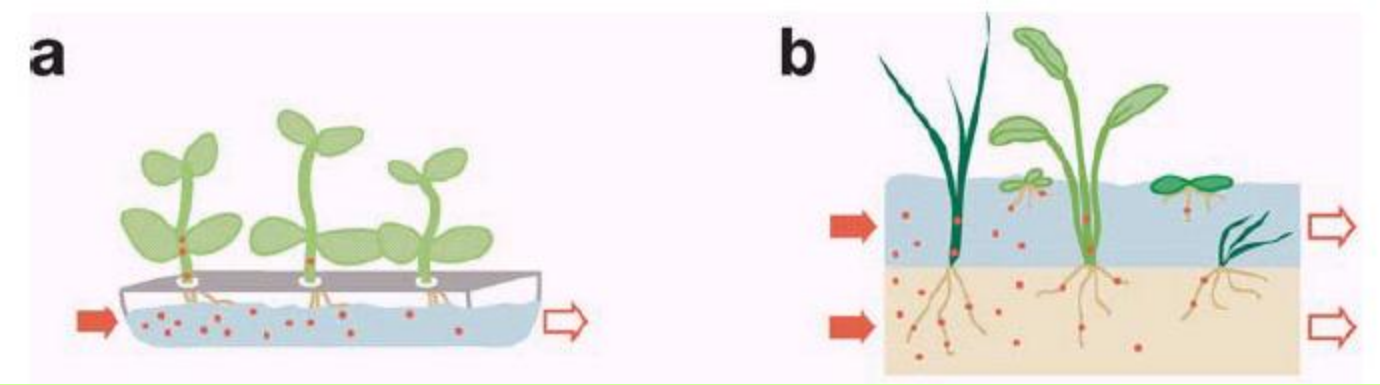
Detection using Nano-Sensors

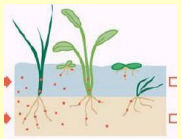
ACKNOWLEDGEMNTS:

MEENA MISRA

RANJEET SINGH

FAHIMA DILNAWAZ





Thank you