SRI AKILANDESWARI WOMEN'S COLLEGE WANDIWASH

INTRODUCTION & APPLICATION OF NANOTECHNOLOGY

CLASS : I PG PHYSICS

Ms. M. SARASWATHI

Assistant Professor

Department of Physics

SWAMY ABEDHANANDHA EDUCATIONAL TRUST, WANDIWASH

Introduction

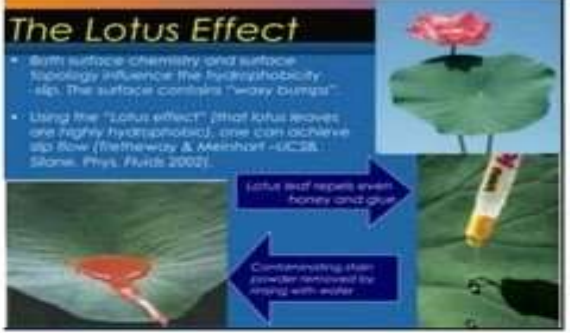
- 'Nano', a **Greek** word that means **'dwarf'.**
  - The word **'nano'** is used to refer to **10^{-9}** or a billionth part of one meter.

The term **'Nanotechnology'** was first defined by **Taniguchi** of the Tokyo Science University in 1974.

- It is generally used for materials of size between **1 to 100 nm.**
- They are also referred to as **Nanoparticles.**
- In Nanotechnology, a particle is a small object that behaves as a unit with respect to its transport and properties.

The Lotus Effect

- both surface chemistry and surface topology influence the hydrophobicity -slip. The surface contains "wavy bumps".
- Using the "Lotus effect" (that lotus leaves are highly hydrophobic), one can achieve slip flow (Rothstein & Meinhart –UCSB, Stone, Phys. Fluids 2002).

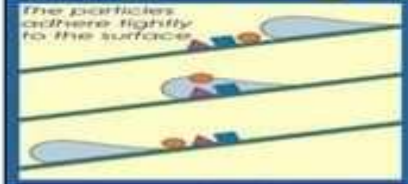


The Lotus Effect

Correlation between ultrastructure and wettability

Super hydrophobic surfaces

The Lotus Effect in action: self-cleaning surfaces



Water drop is rolling over the dirt particles on a smooth Hydrophobic surface

Water drop takes up the dust Covering a super hydrophobic surface

Mechanism of the Lotus-Effect

The Spider Silk Effect

"The Novel Biomimetic Nanocomposites from Spider Silk – Silica Fusion Proteins for Bone Tissue Engineering"

Spider Silk

↓

biological silica

↓

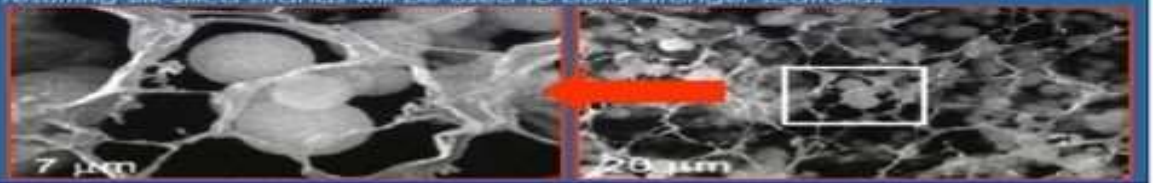
extremely strong composite nanomaterial scaffolds

↓

medical applications & (bone tissue engineering) industrial application

The Spider Silk Effect

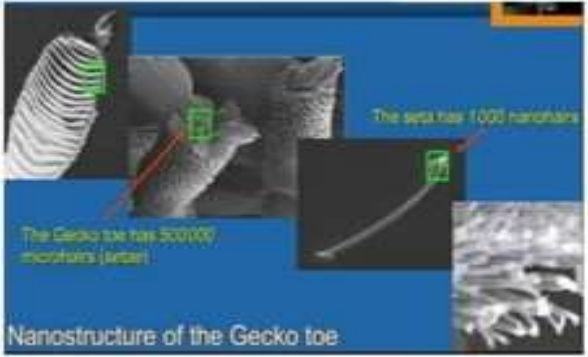
Taking advantage of silk's self-assembling properties, the researchers made films and fibres out of the resulting fusion proteins. The silica particles form in a narrow range of sizes of between just 0.5 and 2 microns in diameter, unlike their natural counterparts, which vary over a broader range from 0.5 to 10 microns, which coated the strands of silk and made them stiffer. The resulting silk-silica strands will be used to build stronger scaffolds.

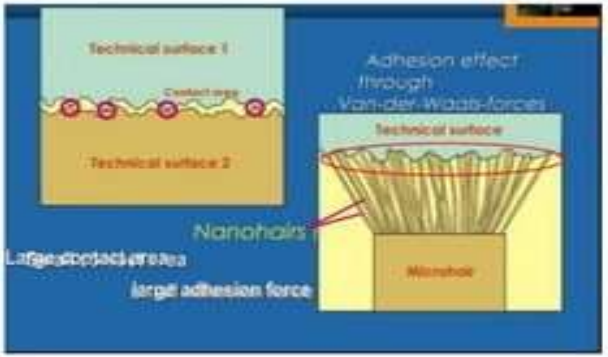


SEM images of silica composite materials that present on fusion protein.


The Gecko Feet Effect

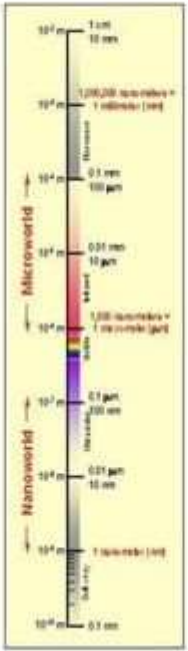

The Gecko Feet Effect
500 000 000 nanohair
Gecko sticking at the wall
Geckos get a grip using Van-der-Waals-forces


The seta has 1000 nanohairs
The Gecko toe has 500000 microhairs (setae)
Nanostructure of the Gecko toe

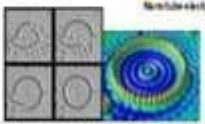

Technical surface 1
Contact area
Technical surface 2
Adhesion effect through Van-der-Waals-forces
Technical surface
Nanohairs
Microhair
large adhesion force

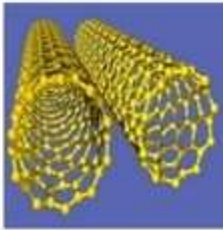
The Scale of Things – Nanometers and More

Things Natural



Things Manmade





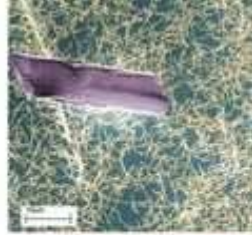
DEFINITION OF NANOTECHNOLOGY

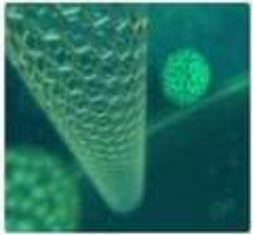
- *"Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications."*
- *Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.*

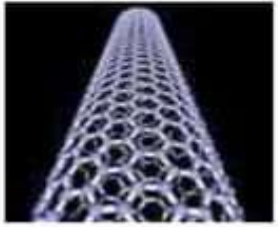
National Nanotechnology Initiative, 2007
The European Commision

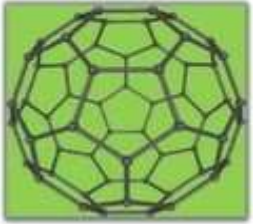
Terminologies

- Nanometer
- Technology
- Nanotechnology
- Nanoscience
- Nanofluidics
- Nanomanipulator
- Nanosensor
- Nanocomposite
- Nanofood
- Zetapotential
- Quantum dot
- Self assembly

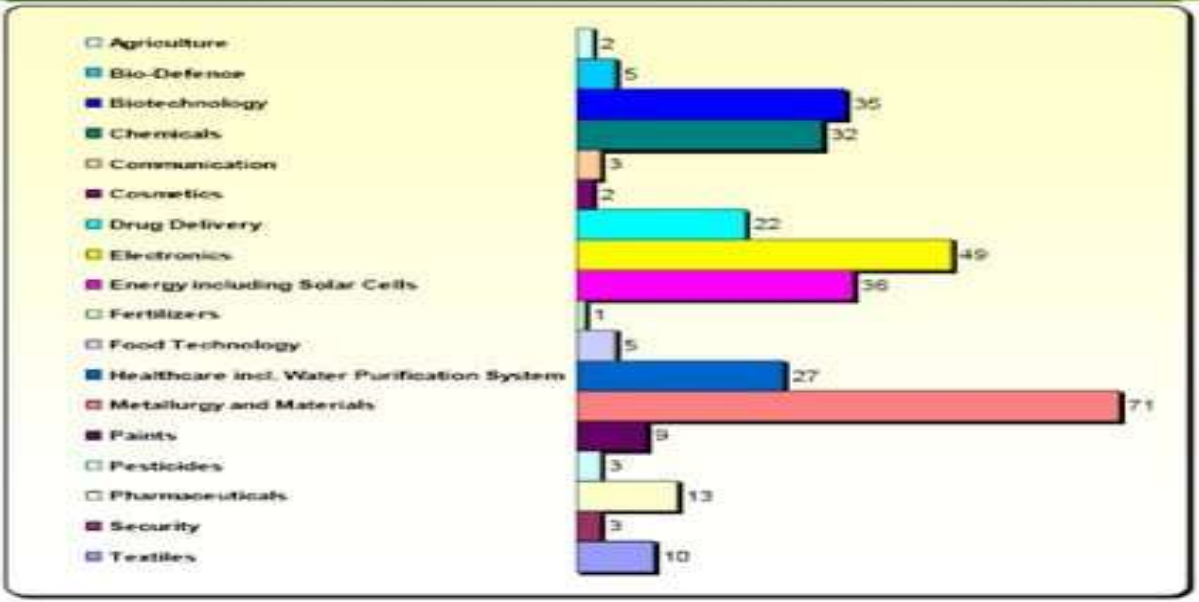








Present area of activities in the field of Nanotechnology in India The priority



How Big is a Nanometer?

Prefixes for SI Units		
Prefix	Meaning	Notation
giga-	1,000,000,000.	1.E+09
mega-	1,000,000.	1.E+06
kilo-	1,000.	1.E+03
m	1.	1.E+00
milli-	.001	1.E-03
micro-	.000001	1.E-06
nano-	.000000001	1.E-09

http://www.nisenet.org/catalog

Why nanotechnology?

At the nanoscale, strange things happen to materials :–

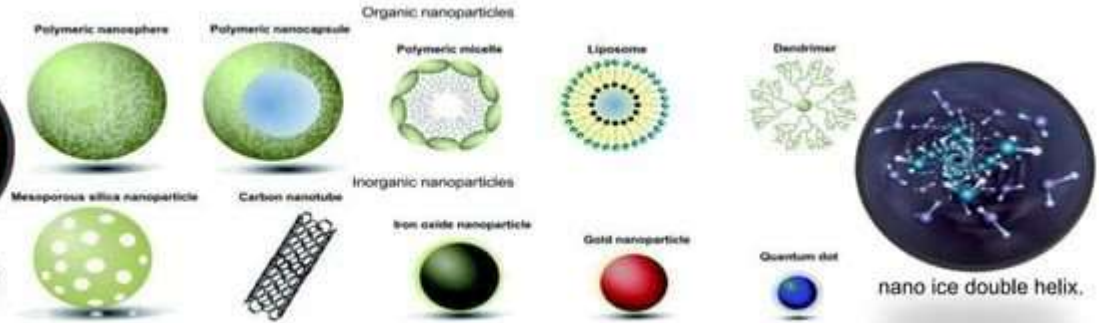
their **properties can change**.

- **Reactivity**
- **Size**
- **Magnetism**
- **Thermal** – melting temperatures
- **Mechanical** – adhesion (stickiness)
- **Optical** - prisms, *etc*

What is nanomaterial?

- Is defined as any material that has unique or novel properties, due to the nanoscale structuring.
- They are subdivided into nanocrystals, nanopowders, and nanotubes: A sequence of nanoscale of C60 atoms arranged in a long thin cylindrical structure.

Fig. (Carbon-60) Buckyball

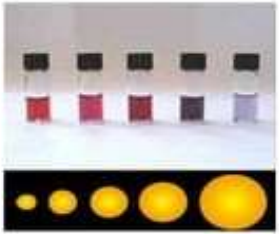


nano ice double helix.

Striking properties of *Nanoparticles*

The properties of nanoparticles are dependent their size.

- Tremendous driving force for diffusion
- Superparamagnetism
- quantum confinement
- Semi conduction
- Quantization of electronic energy
- surface resonance
- Highly reactive



Nanoparticles with different particle sizes can have different physical properties. For example, gold nanoparticles of different sizes appear as different colors.

Changes in properties		
	Bulk scale	Nano scale
Si	Insulator	Conductive
Cu	Malleable and ductile	stiff
TiO_2	White colour	colorless
Au	Chemically inert	Chemically active

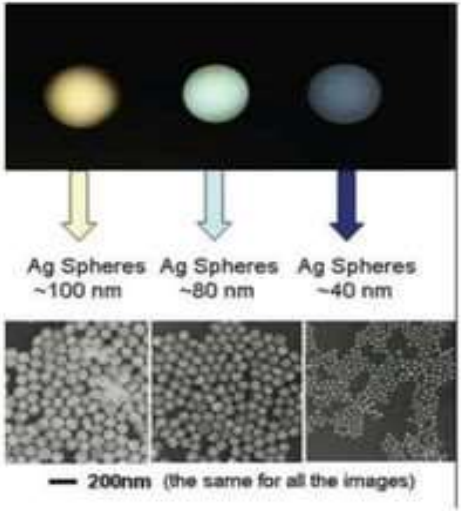
Things behave differently in nano-world

- Carbon in the form of graphite (i.e. pencil lead) is soft, at the nano-scale, can be stronger than steel and is six times lighter

- Nano-scale copper is highly elastic metal at room temperature, stretching to 50 times its original length without break.

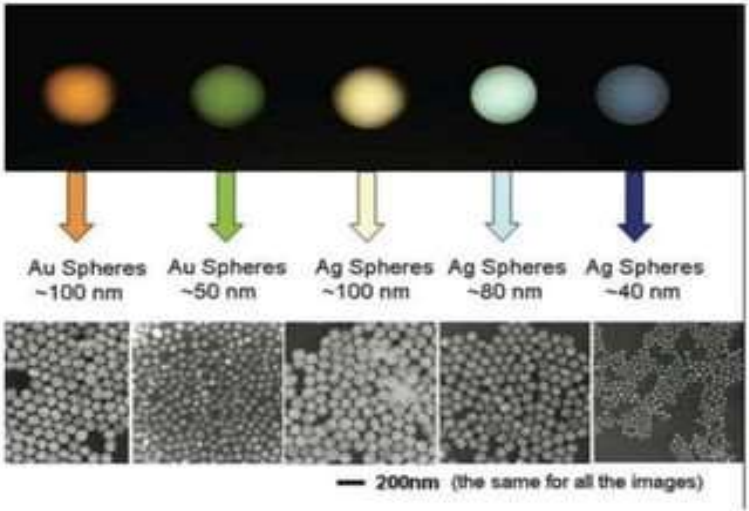
- Shiny orange yellow Gold changes its colour to brownish black on reducing the size

Stained Glass: Size and Shape Matter



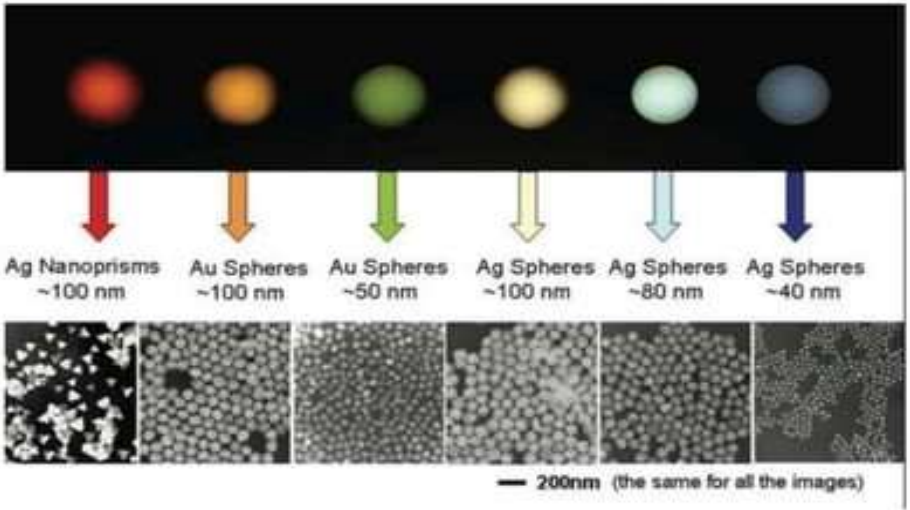
Controlling the Quantum World: The Science of Atoms, Molecules, and Photons, 2007

Stained Glass: Size and Shape Matter



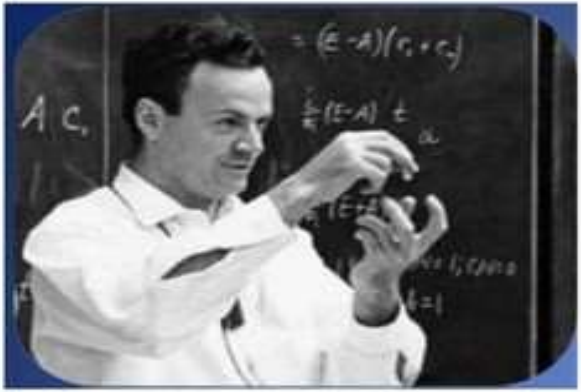
Controlling the Quantum World: The Science of Atoms, Molecules, and Photons, 2007

Stained Glass: Size and Shape Matter



Controlling the Quantum World: The Science of Atoms, Molecules, and Photons, 2007

Nano pioneers

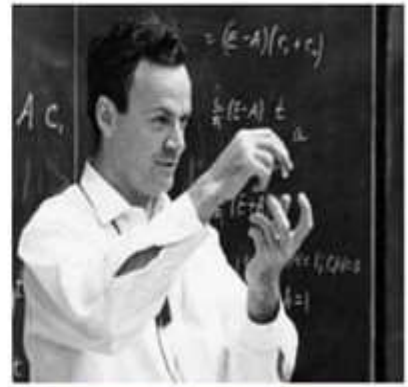


Father of nano technology
Nobel Laureate-1965
Richard Feynman, Physicist

Norio Taniguchi,
coined the term "Nanotechnology" (1974)

History

- The first ever concept was presented in 1959 by the famous professor of physics **Dr. Richard Feynman.**
- Invention of the **scanning tunneling microscope** in 1981 and the discovery of **fullerene**(C60) in 1985 lead to the emergence of **nanotechnology.**
- The term **"Nano-technology"** had been coined by Norio Taniguchi in 1974



Physicist Richard Feynman

THERE'S PLENTY OF ROOM At THE BOTTOM

Timeline:

2000 Yr Ago	**Sulfide nanocrystals** used by Greeks an Romans to dye hair.
1000 Yr Ago	Gold nanoparticles of different sizes used to produce different colors in stained glass windows.
1959	Richard Feynman's speech - **"There's plenty of room at the bottom"**
1974	First Molecular Electronic Device patent.
1981	IBM Invents **scanning probe microscope**
1981	Drexel published Molecular Engineering : molecular machinery
1985	Curl, Kroto, Smalley **discovered buckey balls.**
1989	IBM Almaden Research Center : **wrote IBM with 35 Xenon atoms.**
1991	Discovery of **carbon nanotubes** by Sumin Iijima at NEC Research Labs.
1993	First US research lab devoted entirely to nanoscience. Smalley at Rice University.
2000	US launch of National Nano-technology Initiative (NNI)
2003	President Bush signs Nanotechnology R&D act - $3.7 Billion over 4 years

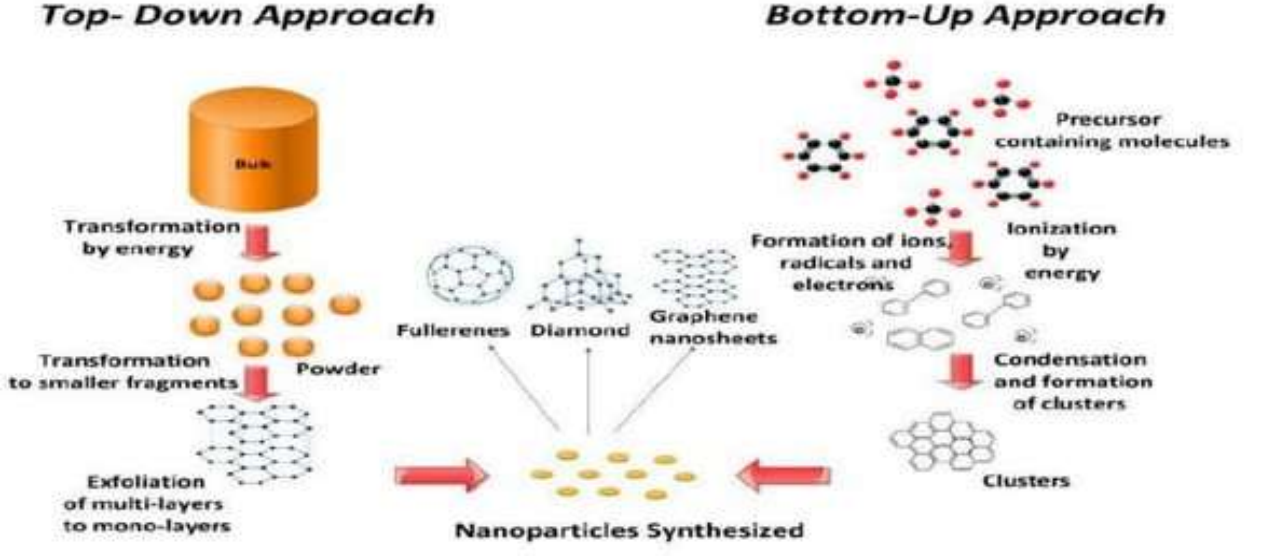
METHODS OF NANOPARTICLE PRODUCTION

1. Physical Methods

2. Chemical Methods

3. Biological Methods

APPROACHES OF NANOPARTICLE PRODUCTION



GREENSYNTHESIS OF NANOPARTICLES

- The biomolecules present in plants act as reducing agent and also as capping agent which favours the synthesis of size controlled nanoparticle.
- Reducing sugars, Phenolic compounds and protein molecules aid in reduction and protein in capping the formed nanoparticle.
- highly economical and for the large-scale synthesis of NPs

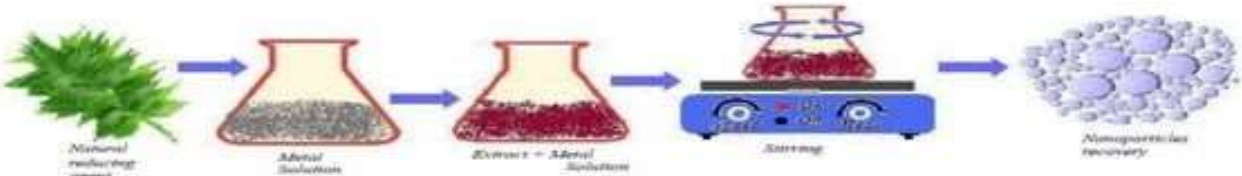


Figure 2: Synthesis of nanoparticles from plant extract.

- Highly stable and spherical ZnO NPs using Aloevera extract have also been synthesized (Dinesh *et. al.*,2015)

CHARACTERISATION OF NANOPARTICLES

- Nanoparticles have different analytical requirements than conventional chemicals, for which chemical composition and concentration are sufficient metrics.
- Nanoparticles have other physical properties that must be measured for a complete description, **such as size, shape, surface properties, crystallinity, and dispersion state.**

Microscopes such as scanning electron microscope used to determine surface morphology of synthesized nano particles.

An ultraviolet–visible spectrophotometer can provide information about concentration (Peak) of nutrient.

Measuring Instruments

- Measuring equipments are the cornerstone of nanotechnology.

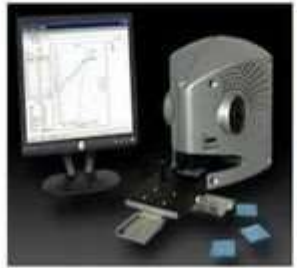


Fig : UV visible spectrophotometer

Fig : Particle size analyser

Fig : ICP-OES

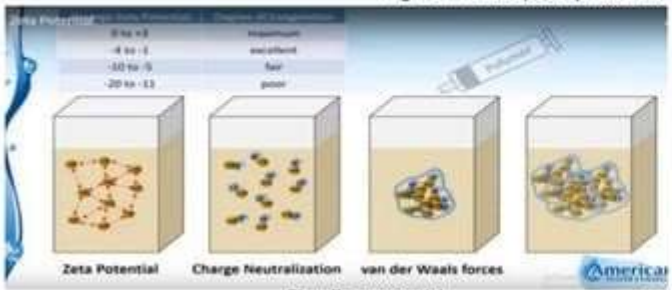


Fig : Zeta potential

Fig : Scanning Tunneling Microscope

Fig : Scanning Electronic Microscope

Nano- technology principles

- Nano functions on three principles

1. Quantum physics
2. Surface area phenomenon
3. Cation exchange phenomenon

1. Quantum physics

- A nanoscale crystal with a diameter that is typically between 2-20 nm, having unique electrical and optical properties that are dependent on its size.

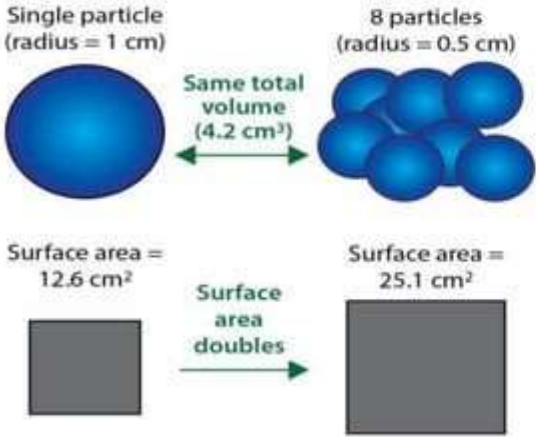
2. Surface area phenomenon

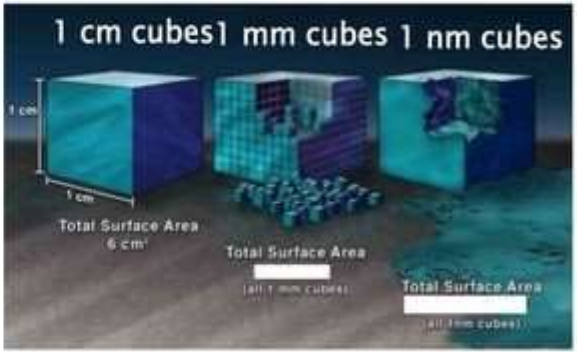
An Illustration:

- A cube of iron measuring 1.0 cm on each side has total surface area of 6.0 cm^2 centimetres
- Further, when this cube is divided into smaller cubes of 0.1 cm side, the surface area of each cube is 0.6 cm^2 the total number of cubes is 100 thus total surface area becomes 0.6 x 100 = 60 cm^2
- By colloidal chemistry iron cube can be divided into particles of 1 nanometre size, then the total surface area becomes equivalent to 60,000,000 cm^2.

- Water and nutrient retention and their availability is a surface phenomenon.
- As the surface area increases, their availability to plants also increases

2. Surface area phenomenon





3.Cation exchange phenomenon

- Electro-magnetic charges on particles originate by two means:

1. Broken edges – Expose negative charge on the surface.

2. Isomorphic substitution – When a higher valent ion is replaced by a lower valent ion, the excess charge appears on the surface.

- In case of nano-particles the electro-magnetic charge is mainly due to broken edges.

3.Cation exchange phenomenon

- The nano-particles carry negative electro-magnetic charges on its surface.
- These charges are capable of attracting, holding and exchanging cations such as Ca^{+2} , Mg^{+2} , K^{+}, Fe^{+2} , Zn^{+2} , Mn^{+2} , Cu^{+2} etc.,
- Because of smaller particle size and larger surface area, the quantum of cations held by nano-particles is enormous as compared to those held by clay / humus particles.

Applications of Nanotechnology

Electronics

Environment

Manufacturing

Energy

Nanotechnology

Transportation

Materials

Agriculture

Life Sciences

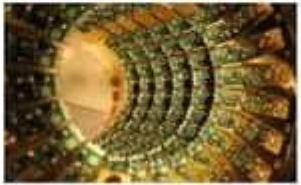
Applications Of Nanotechnology

❑Electronics:

- Nano Transistors
- Nano Diodes
- OLED (Organic Light Emitting Diode)
- Plasma Displays
- Quantum Computers
- Nano Robots







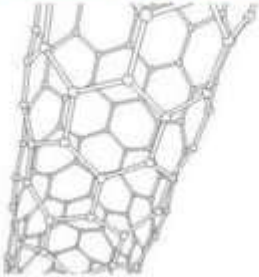

Applications Of Nanotechnology

❑**Energy:**

- Batteries
- Fuel Cells
- Solar Cells

❑**Materials:**

- Nano Tubes
- Aerogel
- Nano Particles



Applications Of Nanotechnology

❑Life Sciences:

- Targeted Drug Delivery
- Artificial Retina
- Tissue Regeneration

Applications Of Nanotechnology

Nanotechnology in Agriculture

Goals of applying nanotechnology in Agriculture

- Increase crop production and yield
- Increase resource use efficiency

Specific applications include

- Nanogenetic manipulation of crops
- Controlled release of nano-fertilizers
- Nano-Biosensors
- Nano pesticides and Nanoherbicides
- Nano-Bio farming
- Nanochar
- Nanohydrogels
- Geohumus
- Soil remediation
- Seed treatment

Nanotechnology in India

- IIT Mumbai is the premier organization in the field of nanotechnology.
- Research in the field of health, environment, medicines are still on.
- Starting in 2001 the Government of India launched the Nano Science and Technology Initiative (NSTI).
- Then in 2007 the Nanoscience and Technology Mission 2007 was initiated with an allocation of Rupees 1000 crores for a period of five years.
- The main objectives of the Nano Mission are:
  - basic research promotion,
  - infrastructure development for carrying out research,
  - development of nano technologies and their applications,
  - human resource development and
  - international collaborations.

Advantages Of Nanotechnology

- **Medical Advantages**
  - End of Illnesses (I.e. Cancer, heart disease)
  - Universal immunity (I.e. aids, flu)
  - Body Sculpting (I.e. change your appearance)
  - Stop the aging Process
  - Painless Child births
  - To make new surgical devices
  - Changing the untasteful medicine into tasteful
- **Industrial Advantages**
  - Computers a billion times faster and a million times smaller
  - Automatic Pollution Cleanup
  - Manufacturing at almost no cost

Advantages Of Nanotechnology

- **Other advantages**
  - Architecture, Engineering and Construction industry
  - Materials Producers
  - Usage Superior Education
  - in Textiles Industries
  - With NT we can create unique materials and products which are stronger, lighter, cheaper, durable, precise

Disadvantages Of Nanotechnology

- Health and safety issues
- Social & Political issues
- Environmental issues
- War
- Gray goo
- Mass production
- Loss of jobs (manufacturing, farming, etc)
- Oil Becomes worthless
- Diamonds become worthless
- Atomic weapons more accessible and destructive

CONCLUSION

- Potential application and advantages of Nano technology are vast.
- This new technology will first of all, keep us healthy because of Nano robots that will repair every damage that we have in our body.
- Nanotechnology will give us an abundant energy because it will transform energy more effectively.
- Increasing crop yield through Precision agriculture driven by Nano technology desirable for maximizing output and reducing input

Future of Nanotechnology

- Nanotechnology will redesign the future of several technologies, products and markets.
- Scientists and engineers can now work with materials at the atomic level to create stain-proof fabrics, scratch-resistant paints, more efficient fuel cells and batteries
- Experts says that nanotechnology will likely create the next generation of billionaires and reshape global business
- Industry Analysts Predict Revenues from Products Incorporating Nanotechnology to Reach Close to $3 Trillion US Within 10 Years

Nano-today is only the beginning.....

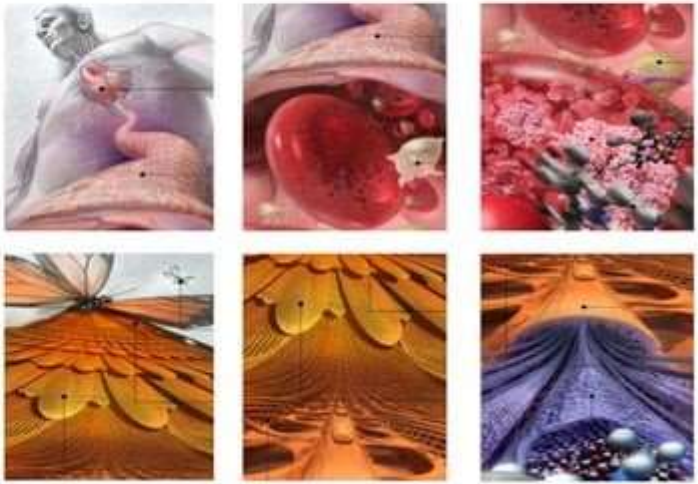
"The Next Big Thing Is Really Small".....

Any questions....???

Did Scientists "Create" Nano?

No,

it was already in nature.



http://www.nisenet.org/catalog

centimeters micrometers nanometers