STATUS OF NANOTECHNOLOGY AND ITS FUTURE PROSPECTS

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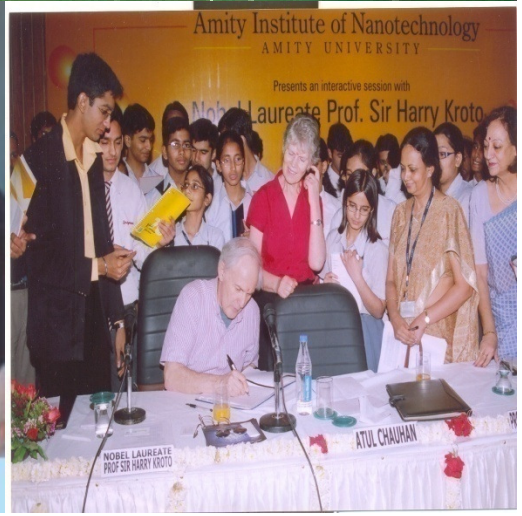
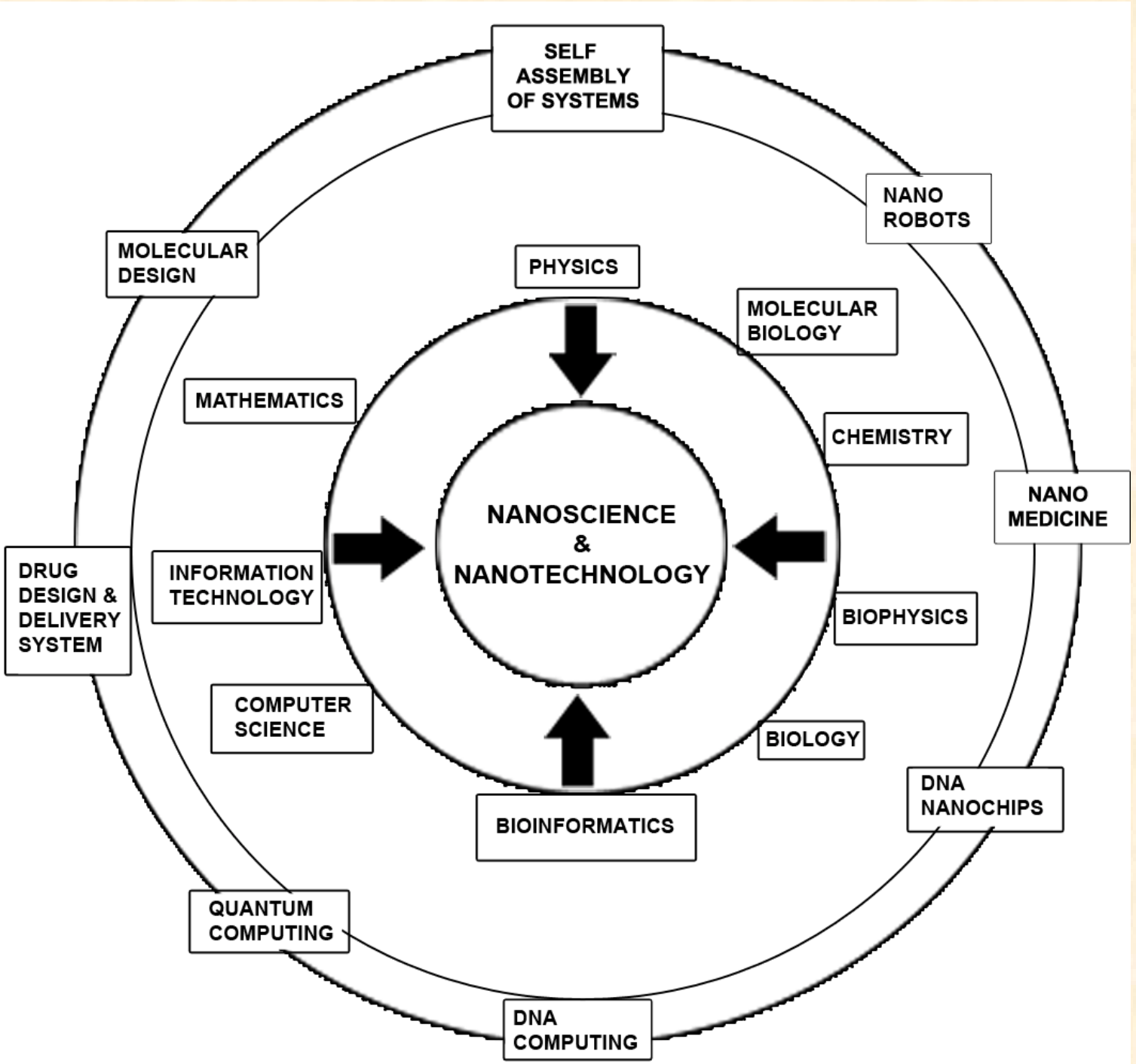
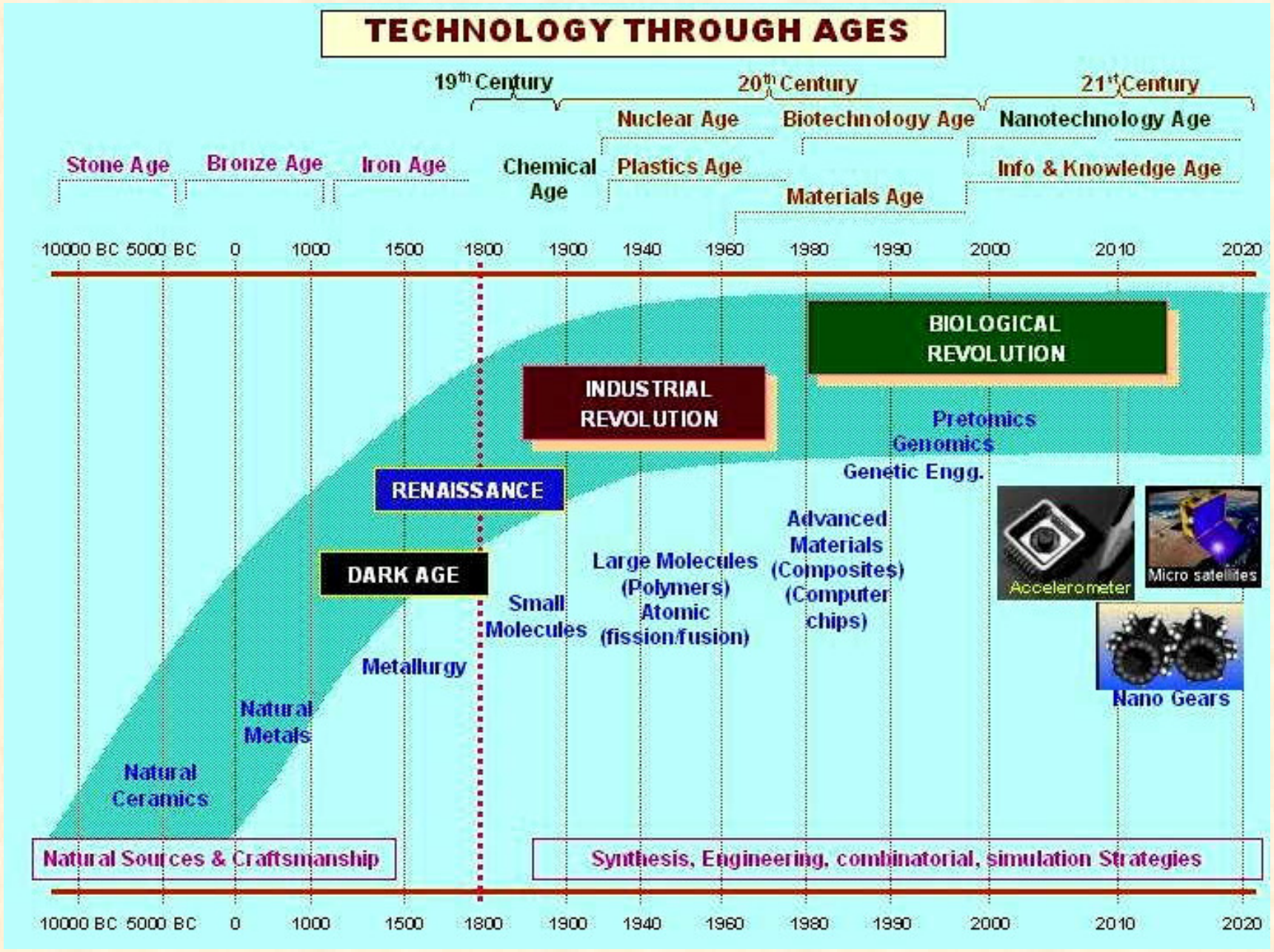
...or Y. L. Wang (Academia Sinica, Taiwan) discussing with ...he faculty and M.Tech (Nanotechnology) students




SELF ASSEMBLY OF SYSTEMS
NANO ROBOTS
MOLECULAR DESIGN
PHYSICS
MOLECULAR BIOLOGY
MATHEMATICS
CHEMISTRY
NANO MEDICINE
NANOSCIENCE & NANOTECHNOLOGY
DRUG DESIGN & DELIVERY SYSTEM
INFORMATION TECHNOLOGY
BIOPHYSICS
COMPUTER SCIENCE
BIOLOGY
DNA NANOCHIPS
BIOINFORMATICS
QUANTUM COMPUTING
DNA COMPUTING


TECHNOLOGY THROUGH AGES
19th Century
20th Century
21st Century
Nuclear Age
Biotechnology Age
Nanotechnology Age
Stone Age
Bronze Age
Iron Age
Chemical Age
Plastics Age
Info & Knowledge Age
Materials Age
10000 BC
5000 BC
0
1000
1500
1800
1900
1940
1960
1980
1990
2000
2010
2020
BIOLOGICAL REVOLUTION
INDUSTRIAL REVOLUTION
RENAISSANCE
DARK AGE
Pretomics
Genomics
Genetic Engg.
Advanced Materials (Composites) (Computer chips)
Large Molecules (Polymers) Atomic (fission/fusion)
Small Molecules
Metallurgy
Natural Metals
Natural Ceramics
Accelerometer
Micro satellites
Nano Gears
Natural Sources & Craftsmanship
Synthesis, Engineering, combinatorial, simulation Strategies

A Brief History of Nanotechnology: Smaller is Better

Greek philosopher Democritus can be considered the father of nanotechnology. In about 400 B.C. he first used the word "atom", which means "indivisible" in Greek, to describe the smallest particle of matter.

1905. Swiss physicist Albert Einstein publishes an article proving that the size of a sugar molecule is about 1 nanometer.

1931. German physicists Max Knoll and Ernst Rusk build an electric microscope, which made it possible to study nanostructures.

1959. American physicist Richard Feynman published an article about the future possibilities of nanotech.

1968. Alfred Cho and John Arthur, researchers at the Bell Corporation developed the theoretical foundation of nanotechnology in polishing surfaces.

1974. Japanese physicist Norio Taniguchi used the word "nanotechnology" to describe mechanisms smaller than one micron. The Greek word "nanos" means "old man"

1981. German physicists Gerd Binnig and Genrich Rorer built a microscope that could show individual atoms.

1985. American physicists Robert Kerl, Harold Kroto and Richard Smiley created technology that made it possible to precisely measure objects one nanometer in diameter.

1986. Nanotechnology becomes widely known to the general public.

1989. Donald Aigler of IBM arranges the name of his company with xenon atoms.

1998. Dutch physicist Sees Dekker created a transistor based on nanotechnology.

1999. American physicists James Tur and Mark Reed determined that an individual molecule can behave the same way as molecular chains.

2000. The US administration supported the establishment of the National Nanotechnology Initiative. Research in the field of nanotechnology received government funding. The federal budget allocated $500 million for such studied. In 2002, funding was increased to $604 million.

WHAT OTHERS SAY ABOUT "NANOTECHNOLOGY" *?*

"If I were asked for a area of science and engineering that will most likely produce the breakthroughs of tomorrow, I would point to nanoscale science and engineering, that is Nanotechnology."

Neal Lane,
Assistant to the President for Science & Technology &
Former Director of National of Science Foundation, USA

"Nanotechnology may well rival the development of the transistor or telecommunications in its ultimate impact."

Charles M. Vest - President,
Massachusetts Institute of Technology, USA

"Nanotechnology has given us the tools….to play with the ultimate toy box of nature - atoms and molecules. Everything is made from it…The possibilities to create new things appear limitless…"

Horst Stormer, Nobel Laureate,
Columbia University, Lucent Technology,USA

"Nanotechnology is the way of ingeniously controlling the building of small and large structures, with intricate properties; it is the way of the future, a way precise, controlled building, with incidentally, environmental beginness built in by design."

Roald Hoffmann,
Chemistry Nobel Prize Winner,
Cornell University, USA

"There is plenty of room at the bottom"- 1959

Richard Feynman
Nobel Laureate, California Institute of Technology, USA

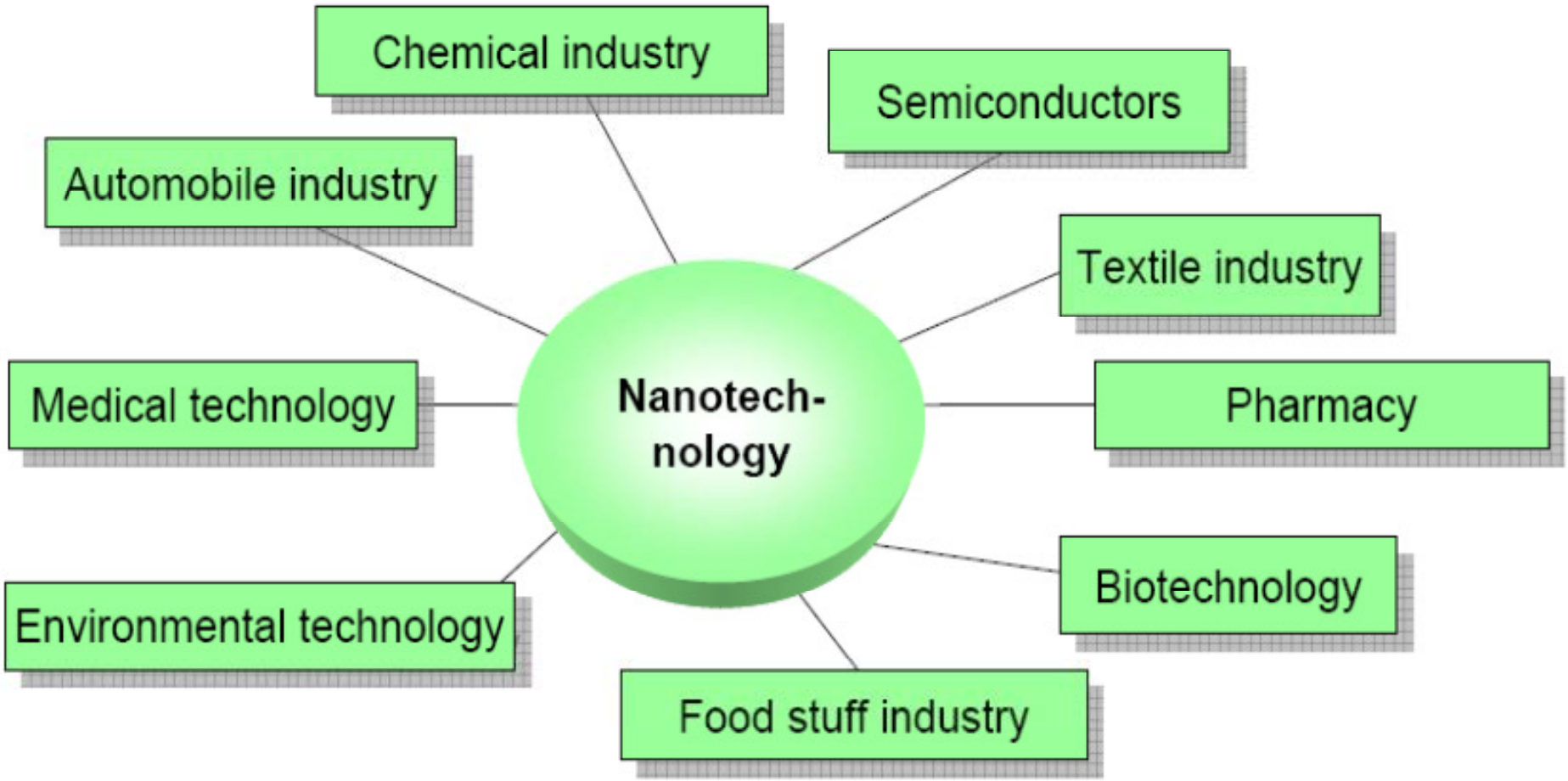
"All the information which all of mankind has ever recorded in books can be carried in a pamphlet in your hand - and not written in code, but a simple reproduction of the original pictures, engravings and everything else on a small scale without loss of resolution."

Richard Feynman
Nobel Laureate, California Institute of Technology, USA

"Nanotechnolgy is a builder's final frontier".

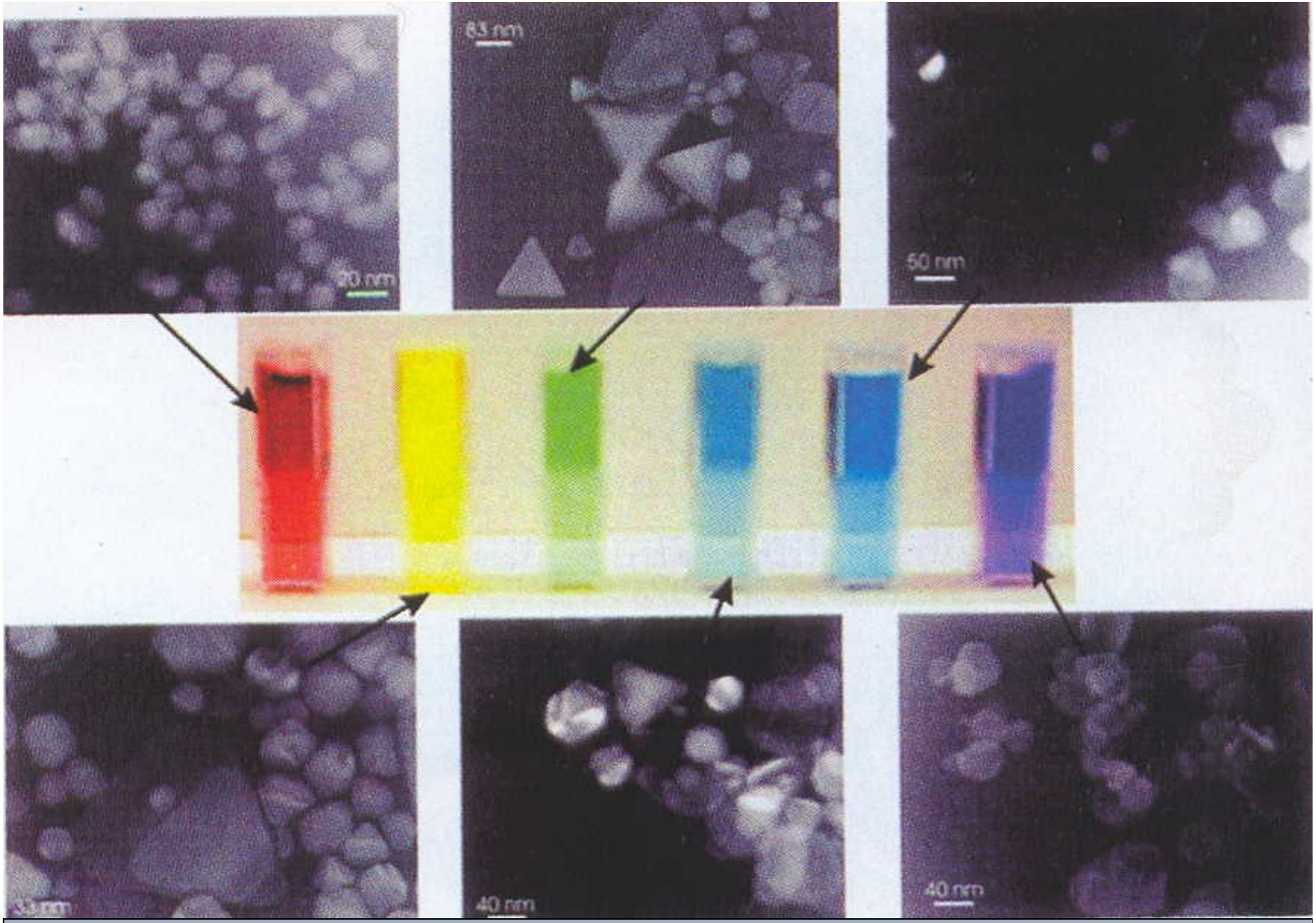
Richard Smalley,
Nobel Laureate, Rice University, USA

NANOTECHNOLOGY APPLICATIONS



NANOTECHNOLOGY: BRINGS UNIQUE PROPERTIES

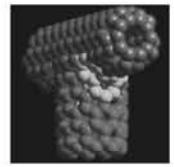
- Not only miniaturization but change in physical properties
- Laws of quantum physics
- Surface behaviour dominates over bulk material behaviour
- Metal become harder - Ni becomes non-metallic when reduced to 1-2 nm diameter.
- Ceramic becomes softer
- Composites & alloys of all variety possible
- Thin polymer, loss permeable
- Stronger, more heat resistant, transparent, light weight
- Increased chemical resistance,
- New optical properties - semiconductor particles can be turned down from red end to visible to UV by size reduction
- New electrical properties
- Novel biological properties
- New thermal properties - melting point of Cds is 1600^0C, while a 2.5 nm Cds nano crystal melts at 400^0C.

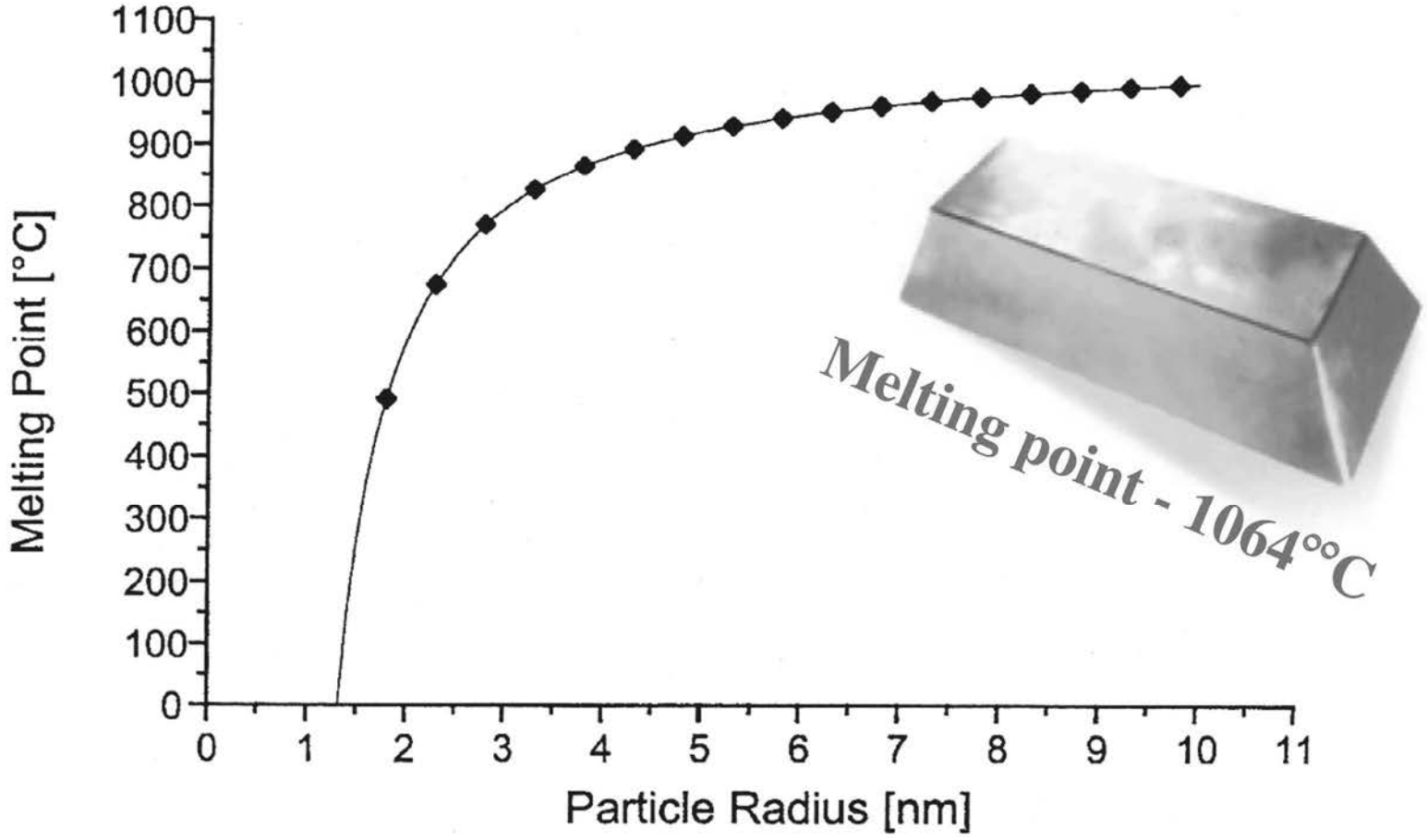


Jars of nano or gold – colour differences due to particle size and shape

Ames Research Center

Melting Point of Gold





Source: K.J. Klabunde, 2001

God's Own Creation of Nano Materials

APPLICATIONS:

Eventually we will be able to replicate anything, including diamond, water & food etc. Medicine, computers and cars may be constructed differently.

INDUSTRIAL APPLICATIONS

1. **Elimination of pollutants** :
   Nanomaterials have large grain boundaries relating to their grain size. This can react with toxic gasses like Co, N_2O in automobile catalytic converters & power generation equipment to prevent environmental pollution arising from burning gasoline and coal.

2. **High Energy Density Batteries**:
   Nanocrystalline materials can be used to separate the plates in the battery. Their foam-like structure can hold more energy. Nickel-metal hydride (Ni-MH) battreies made of nickle and metal hydride require very less re-charging and last for longer time.

3. **High Sensitivity Sensors** :

Co Sensor is made of ZrO (Ziroconia). Oxygen of zirconia reacts with carbon of Co to partly reduce zirconia. But when zirconia is in the form of nanomaterial its reactivity is many times more with carbon, and hence increasing the sensitivity of the sensor.

4. **Fuel efficiency for Auto mobiles** :

Some nanomaterials are stronger, harder, wear-resistant and corrosion resistant, they may long lasting and fuel combusion more efficient. Diesel engine cylinders are coated by nano zirconia and alumina, so that they retain heat and results in complete combusion of fuel.

5. **Flat Panel Displays**

By using nanophosphors emissivity could be decreased may times more leading to much higher brightness than the existing ones. It improves resolution.

6. **Tougher and Harder Cutting Tools**

Cutting tools made of nanocrystalline materials like tungston carbide, tantalum carbide, titanium carbide are much harder, wear resistant, corrosion resistant and long lasting.

HEALTH CARE:

1. **Medicine**

   Patients will drink fluids contain nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses and make them harmless.

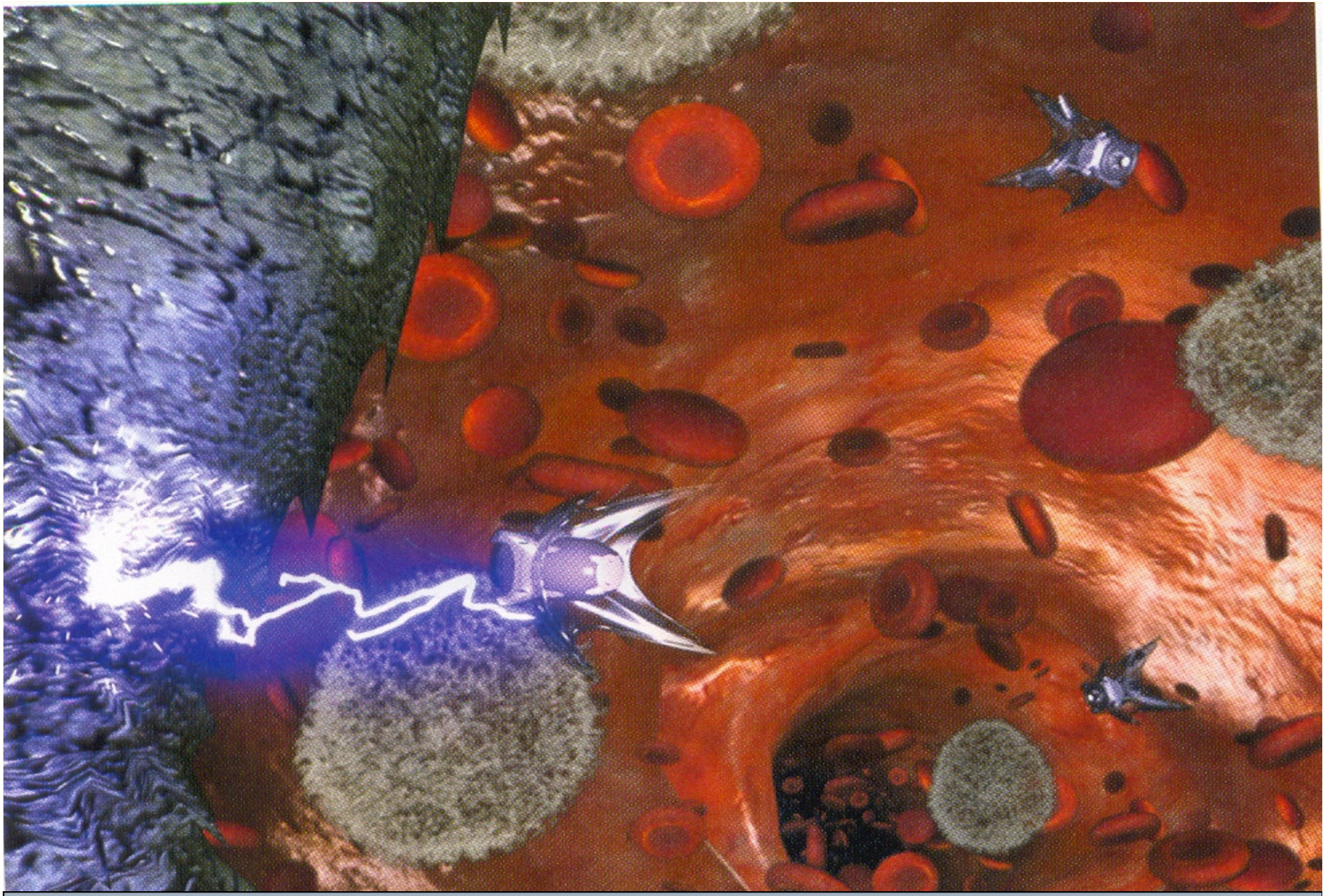
   Nanorobots could also be programmed to perform delicate surgeries.

2. **Information Gathering**

   With nano device it is possible to explore and analyze living systems in greater details than ever before. Molecular machines operation in human body, could monitor lavels of different compounds and store information, can determine both their location and time. The molecular machines could then be filtered out of the blood supply, and stored information can be analyzed, providing the picture of healthy and injured tissues.

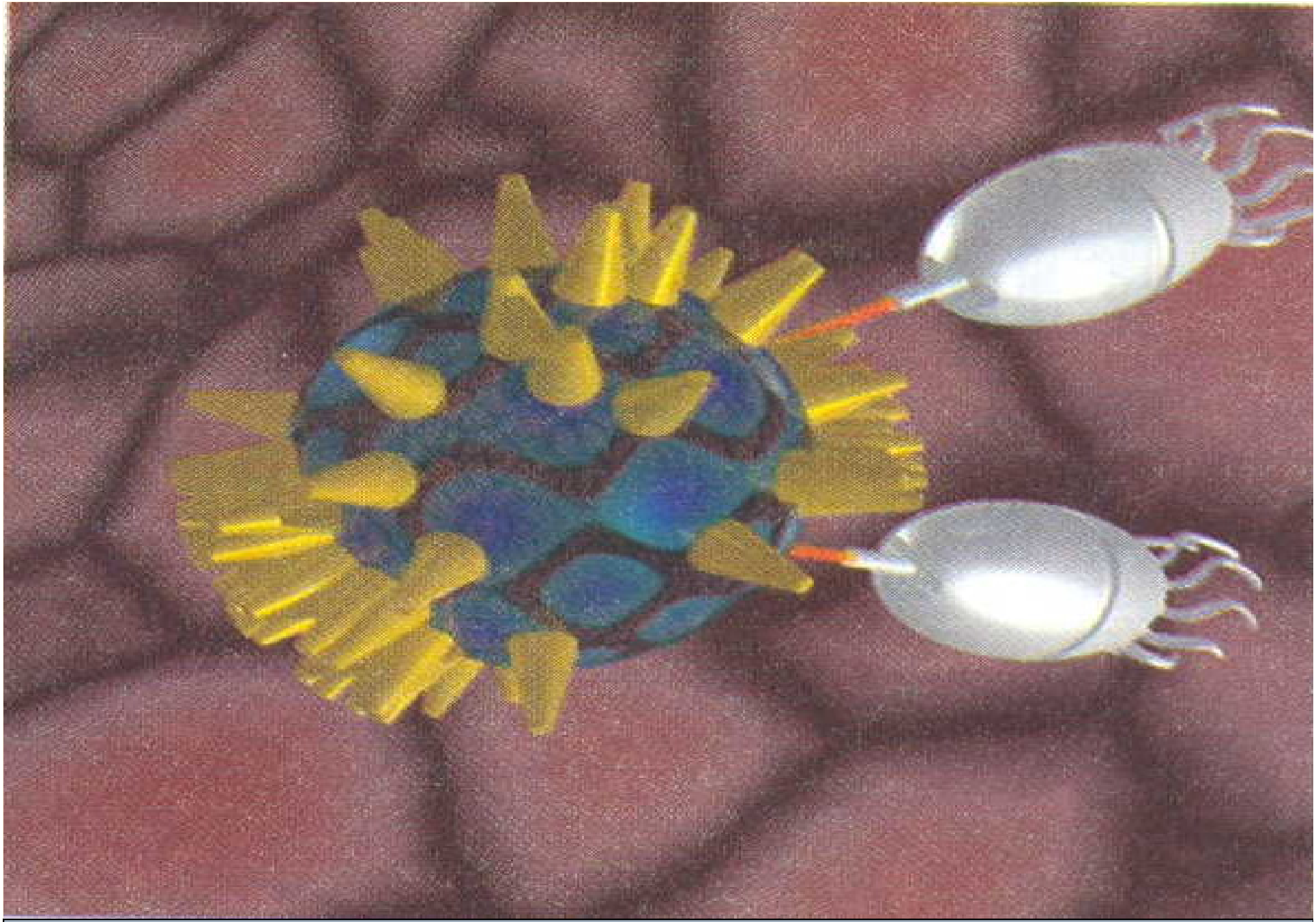
3. **Surgery**

   Nanorobots can change your appearance. They can be programmed to perform cosmetic surgery, re-arranging atoms to your ear, nose and eye colour.



apeutic nanorobots capable of detecting and destroying pathogens find a large nu
Of parasites in the patient's bloodstream and begin their attack.

Mobile nanorobotic janitors (green) patrol the lungs, collecting inhaled debris and Transporting it to recycling stations (blue-gray)

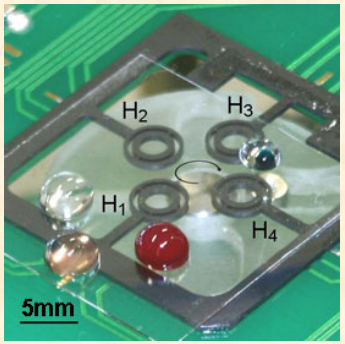


Two medical nanorobots in a pulmonary alveola killing a virus using nanolasers

Nanoscale Devices and Integrated Nanosystems

Lab on Chip

- A lab on chip integrates one or more laboratory operation on a single chip
- Provides fast result and easy operation
- Applications: Biochemical analysis (DNA/protein/cell analysis) and bio-defense

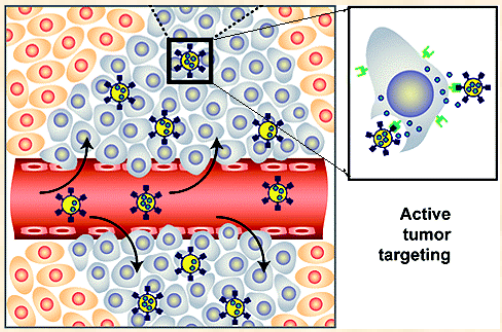


Lab on chip gene analysis device – IBN Singapore, 2008

Drug Delivery Systems

Impact of nanotechnology on drug delivery systems:

- Targeted drug delivery
- Improved delivery of poorly water soluble drugs
- Co-delivery of two or more drugs
- Imaging of drug delivery sites using imaging modalities



Targeted drug delivery
– *ACS Nano 2009, DOI: 10.1021/nn900002m*

How nanotech might be used against cancer

Scientists are beginning to develop microscopic tools to discover and treat cancer. Here are some general ways they hope to eventually use these innovations:

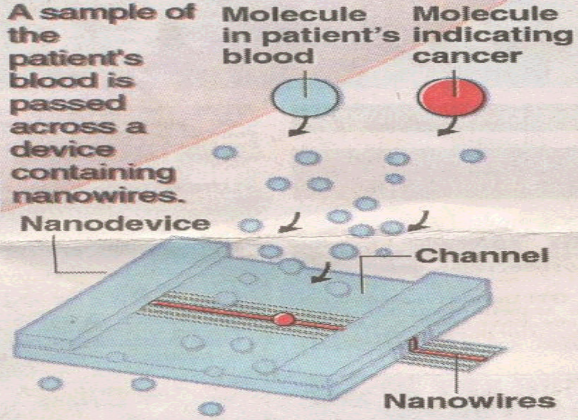
DETECT TUMORS

One goal is to spot cancer far earlier than can be done now, when treatment is likely to be most effective.

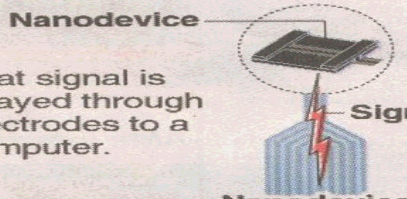
A sample of the patient's blood is passed across a device containing nanowires.

Molecule in patient's blood

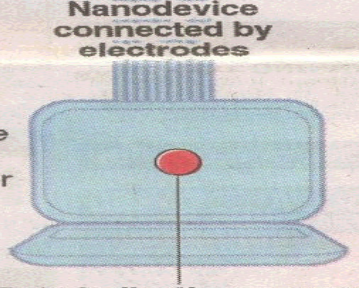
Molecule indicating cancer



The molecules associated with cancer will react with the nanowires, signaling the presence of a particular type of cancer.



That signal is relayed through electrodes to a computer.

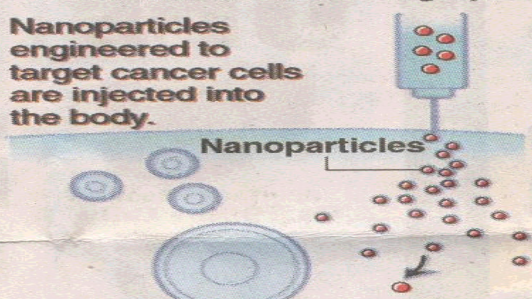


The early warning of cancer greatly improves the patient's prospects for survival.

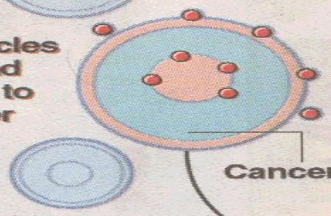
GET A CLEARER PICTURE

Highlighting tiny clusters of cancer cells should help doctors detect whether cancer has spread, or is shrinking in response to treatment -- without the need for surgery.

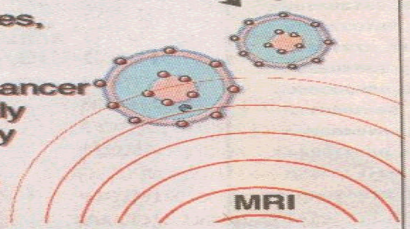
Nanoparticles engineered to target cancer cells are injected into the body.

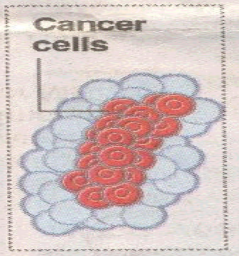


The nanoparticles locate, and then bind to the cancer cells.



The particles, which are magnetic, allow the cancer to be readily detected by magnetic resonance imaging, or MRI.



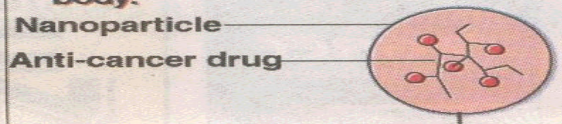


The MRI allows doctors to see whether the cancer has spread to lymph nodes, for instance, without surgically removing lymph tissue. It could also be used to show whether treatment has cleared cancer from the lymph nodes.

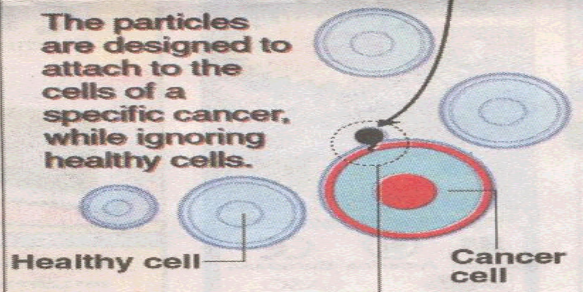
TARGET DISEASE

Drugs encased in packages small enough to slip through cancer cell walls kill tumors without damaging healthy cells, reducing the side effects of treatment.

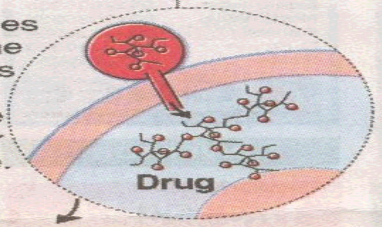
A nanoparticle containing a powerful anti-cancer drug is injected into the body.



The particles are designed to attach to the cells of a specific cancer, while ignoring healthy cells.



The nanoparticles attach to the cancer cells and then release the anti-cancer drug inside.



The anti-cancer drug kills only the cancer cells, while leaving the healthy cells undisturbed

SOURCES: National Cancer Institute; MIT; Robert Langer, MIT

AARON STECKELBERG/GLOBE STAFF

HINDUSTAN TIMES, NEW DELHI
FRIDAY, SEPTEMBER 25, 2009

'Nano-technology will make man immortal by 2029'

Ray Kurzweil, known to have predicted future technologies decades ahead, believes man can reverse ageing.

Press Trust of India
letters@hindustantimes.com

LONDON: A futuristic American scientist has predicted that man could become immortal in as little as 20 years' time through nanotechnology and better understanding of the body mechanism.

Ray Kurzweil, known to have predicted future technologies decades ahead has written in The Sun ,"I and many other scientists now believe that in around 20 years we will have the means to reprogramme our bodies' stone-age software so we can halt, then reverse, ageing. Then nano-technology will let us live for ever."

The 61-year-old, lauded by Microsoft founder Bill Gates as the smartest futurist on Earth said," We are living through the most exciting period of human history.

"Computer technology and our understanding of genes - our body's software programs - are accelerating at an incredible rate. "

The scientist says that already, blood cell-sized submarines called nanobots are being tested in animals. These will soon be used to destroy tumours, unblock clots and perform operations without scars.

Ultimately, nanobots will replace blood cells and do their work thousands of times more effectively, he added.

According to his theory called the Law of Accelerating Returns mankind will experience a billion-fold increase in technological capability for the same cost in the next 25 years.

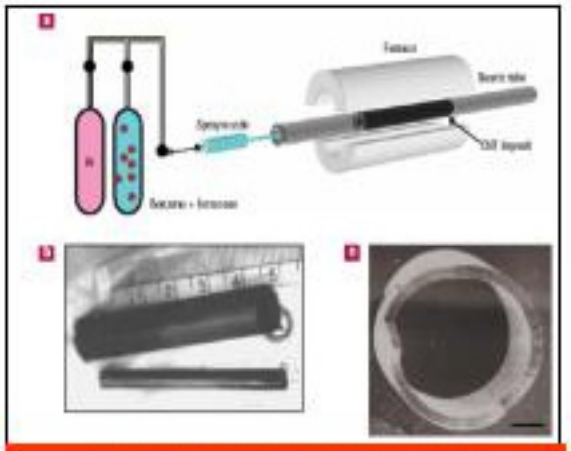
Nanotechnology will help in making humans achieve immortality said Kurzweil, "By the middle of the next century we will have back-up copies of the information in our bodies and brains that make us who we are. Then we really will be immortal".

"Nanotechnology will extend our mental capacities to such an extent we will be able to write books within minutes.

"If we want to go into virtual-reality mode, nanobots will shut down brain signals and take us wherever we want to go. Virtual sex will become commonplace. And in our daily lives, hologram like figures will pop in our brain to explain what is happening," he said.

The scientist also predicts that humans in future will become cyborgs, with artificial limbs and organs.

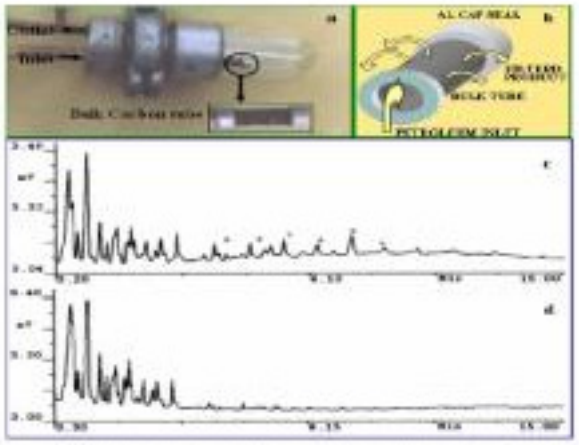
Water: Nano tube filter – water purification



Synthesis Methods

Structural characterization of macro tubes made from MWNT

Removal of bacteria using nano tube filter.



Petroleum filtration set-up using the Nano tube filter

They can remove 25-nanometer-sized polio viruses from water, as well as larger pathogens, such as E. coli and Staphylococcus aurous bacteria.

Filters adaptable to micro fluidics applications that separate chemicals in drug discovery.

Prof. A. SRIVASTAVA & team, Banaras Hindu University

CARBON NANOTUBES REINFORCED ADVANCED COMPOSITES

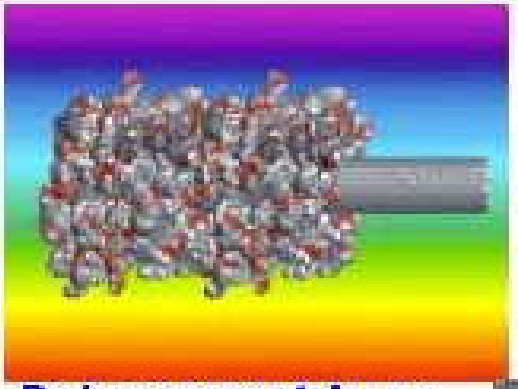
carbon nanofibre

Nanoreinforcement
- Process control
- Characterization

Matrix Selection
- Mechanical strength
- Compatibility

Acid based dispersion

Composite



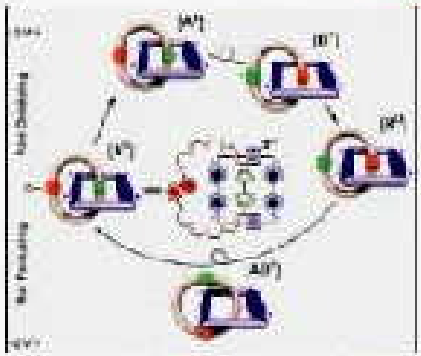
Polymer matrix on carbon nanotubes

Composite

- Reinforcements
- Light weight materials
- Conductive polymers
- Radar absorbing materials

NANO COMPUTERS

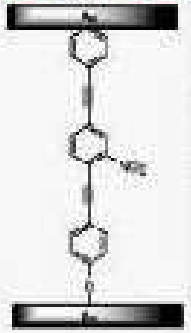
– THE NEXT GENERATION COMPUTERS

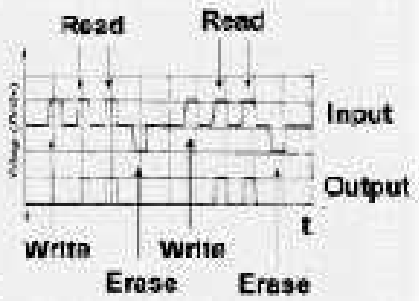


MOLECULAR SWITCH

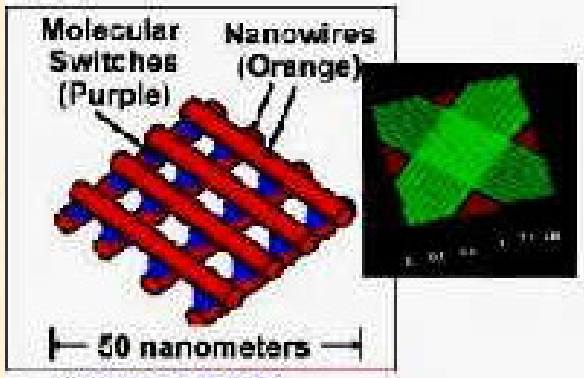
ADVANTAGES

- Low Power & Cost
- Long retention of molecular memory
- Excellent Elect. Performance

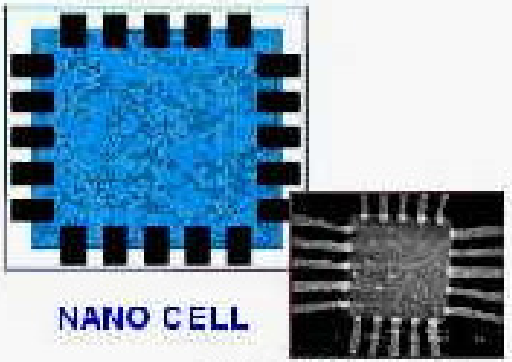




MOLECULAR CIRCUIT



"CROSS-BAR" MEMORY



NANO CELL

ULTRA-DENSE NANO COMPUTER MEMORY

RADICALLY FASTER & CHEAPER TO BUILD ASSEMBLY

Green nanotechnology

Curry Leaves

Methi

Mahua

Pudina

What is Green Nanotechnology?

- Green nanotechnology is the development of clean technologies, to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new nano-products that are more environmentally safe

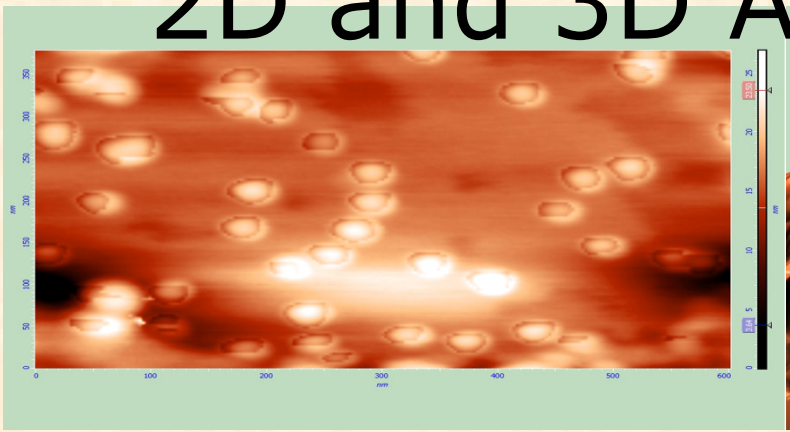
Inspiration

- Eco-friendly
- Less expensive and simple technique
- Water purification
- Antibacterial
- Non-toxic

Experimental procedure

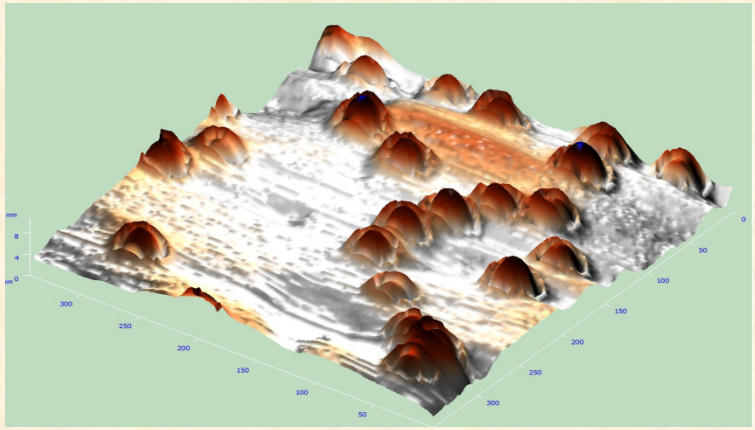
- **SOLUTION A**
  - Water based extract (5 mL)
    - Leaf sample
    - Deionized millipore water
    - Agate mortar and pestle set
    - Whatman filter paper
    - Centrifuge
- **SOLUTION B**
  - Silver nitrate solution (25 mL)
    - Millipore water
    - Fresh silver nitrate salt
- The prepared solution B was added drop-wise into solution A to make sample solution for investigation

2D and 3D AFM images

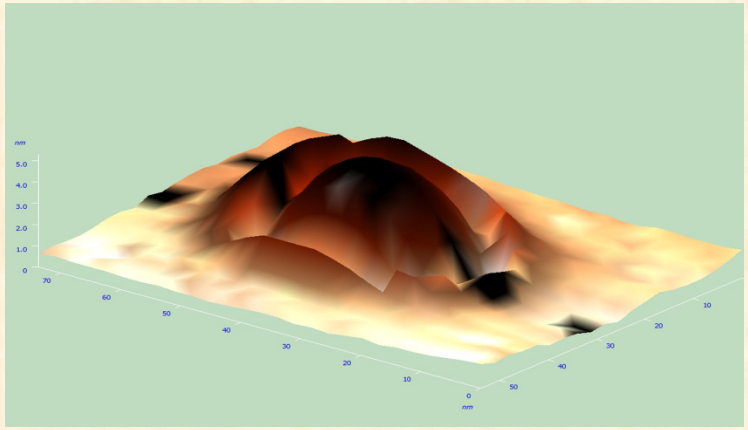


2D AFM image of fenugreek extract mediated Ag nanoparticles

3 D AFM image of fenugreek extract mediated Ag nanoparticles

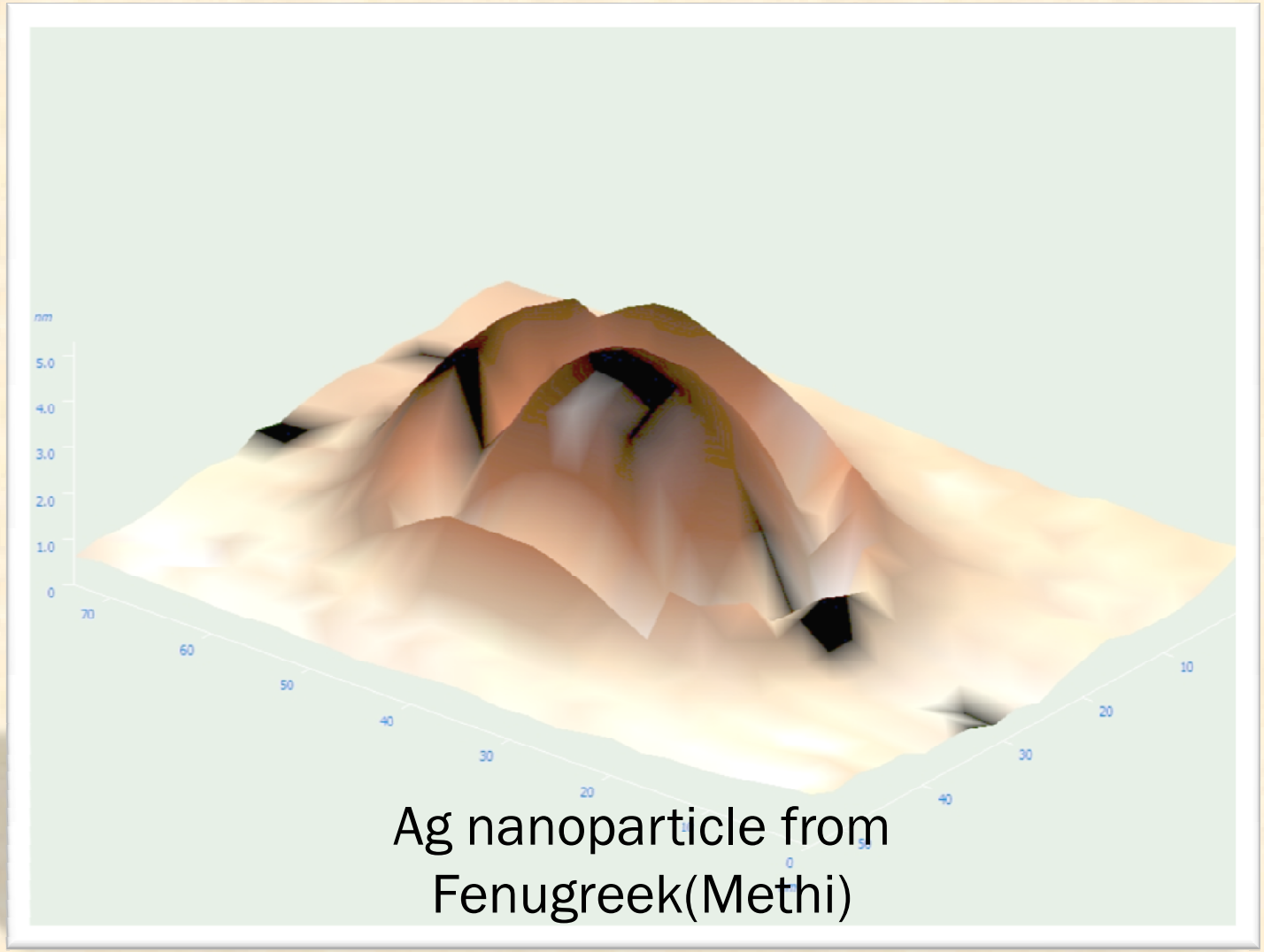


3 D AFM image of fenugreek extract mediated Ag nanoparticles (magnified)



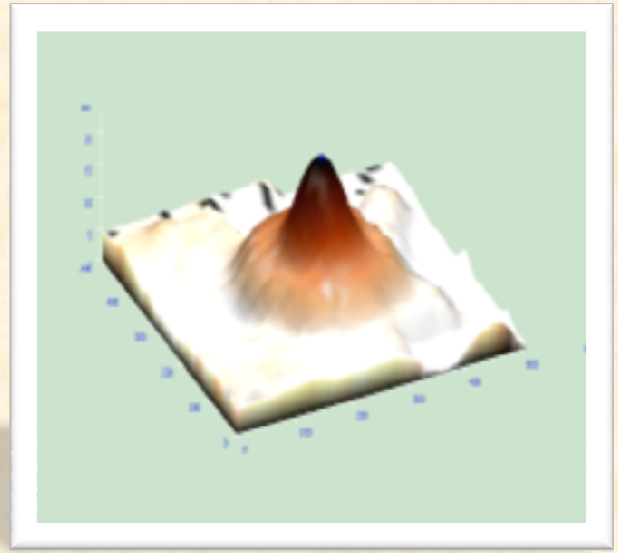
3 D AFM image of a Ag nanoparticle surrounded by phytochemical components of fenugreek extract

AFM IMAGE

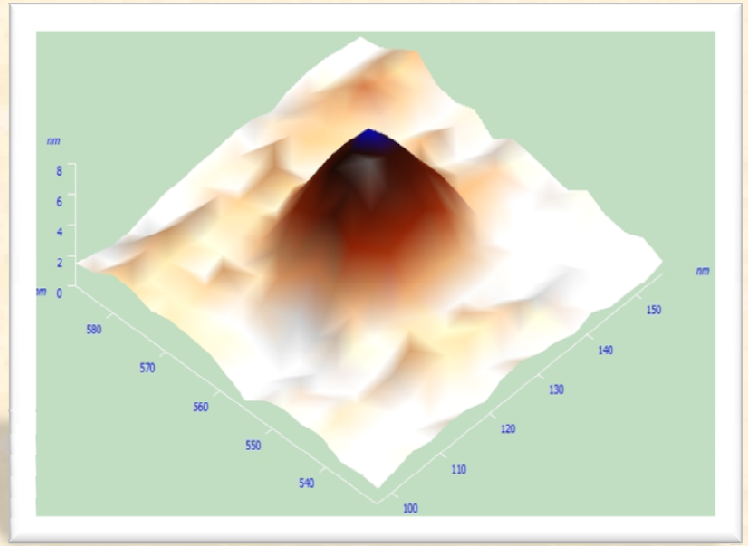


Ag nanoparticle from Fenugreek(Methi)

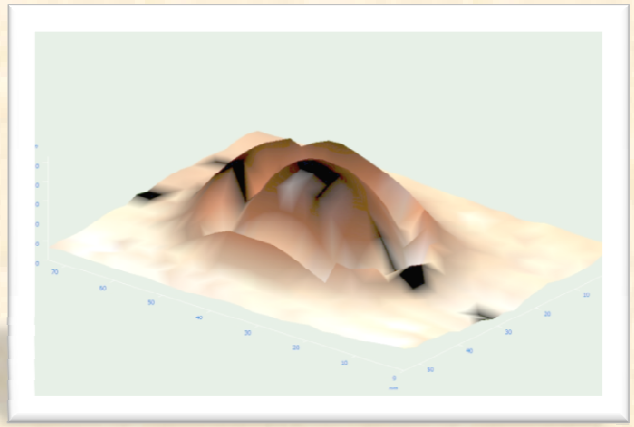
AFM images of ag nanoparticles from different leaf samples



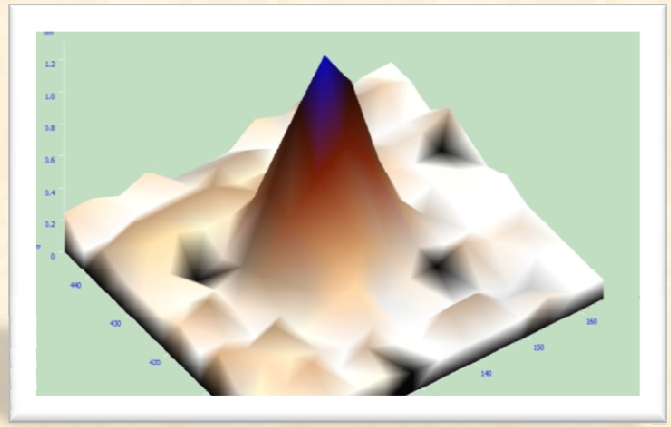
Mahua



Curry Leaves



Methi



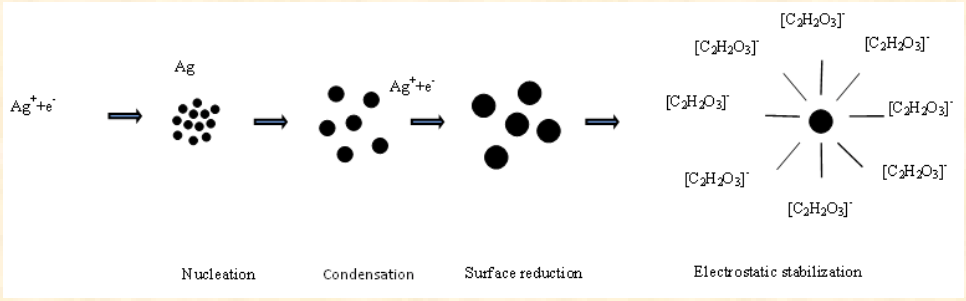
Pudina

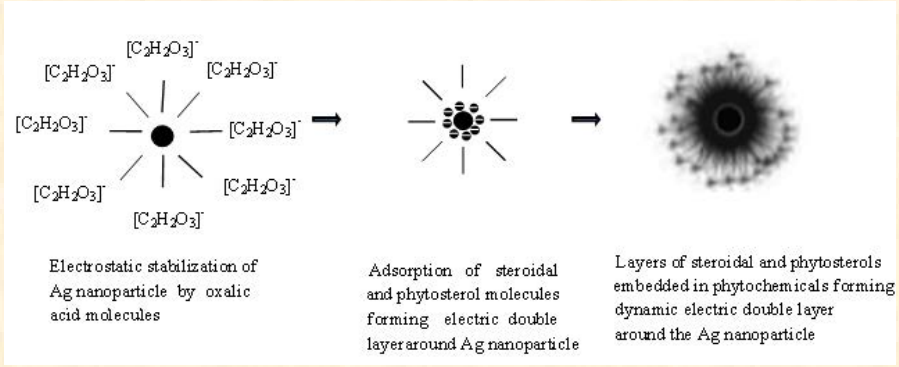
Schematic representation of mechanism of formation

In presence of water and oxygen, Ag nanoparticles release small amount of Ag^+ ions as follows:

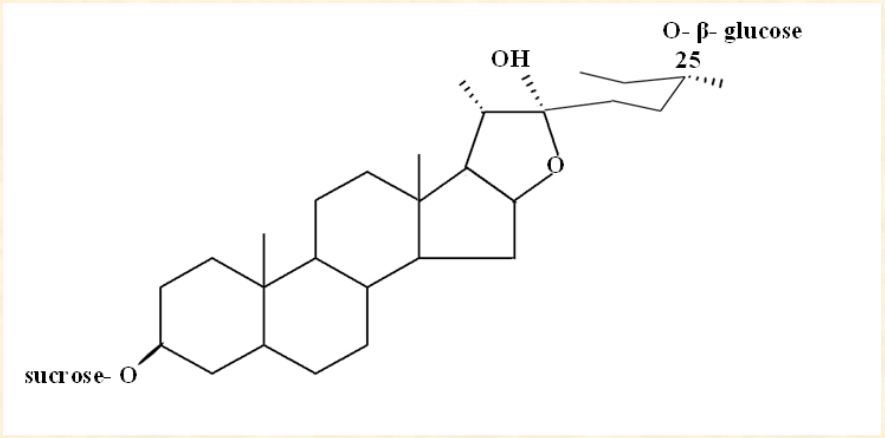
$$O_2(aq) + 4H_3O^+ + 4Ag(s) \rightarrow 4Ag^+(aq) + 6H_2O$$

This is followed by condensation, surface reduction and electrostatic stabilization by oxalic acid molecule layer as shown

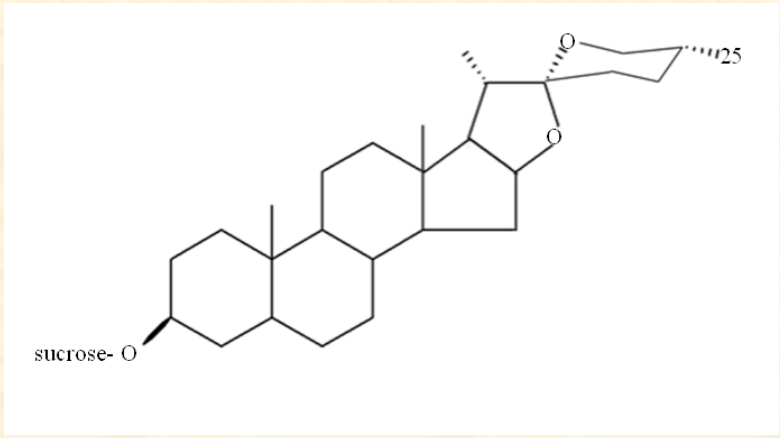




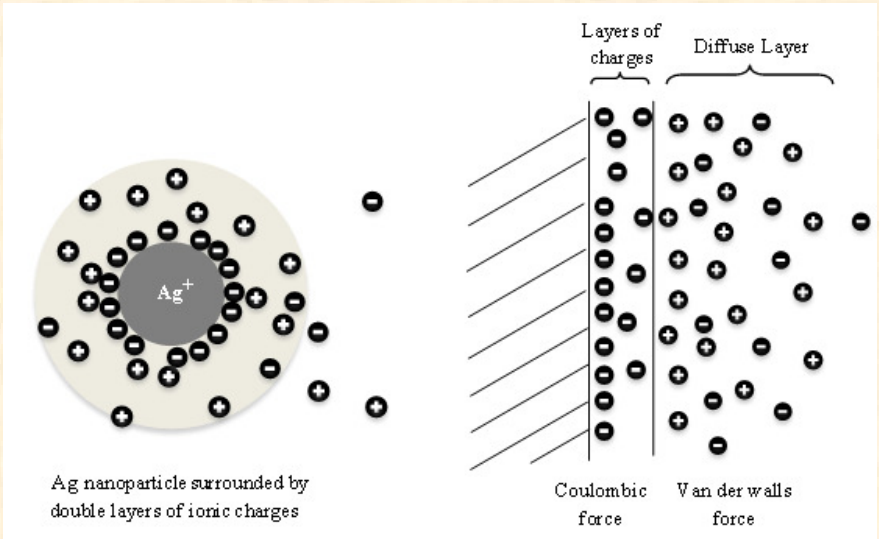
phytochemicals in methi extract for self-stabilization



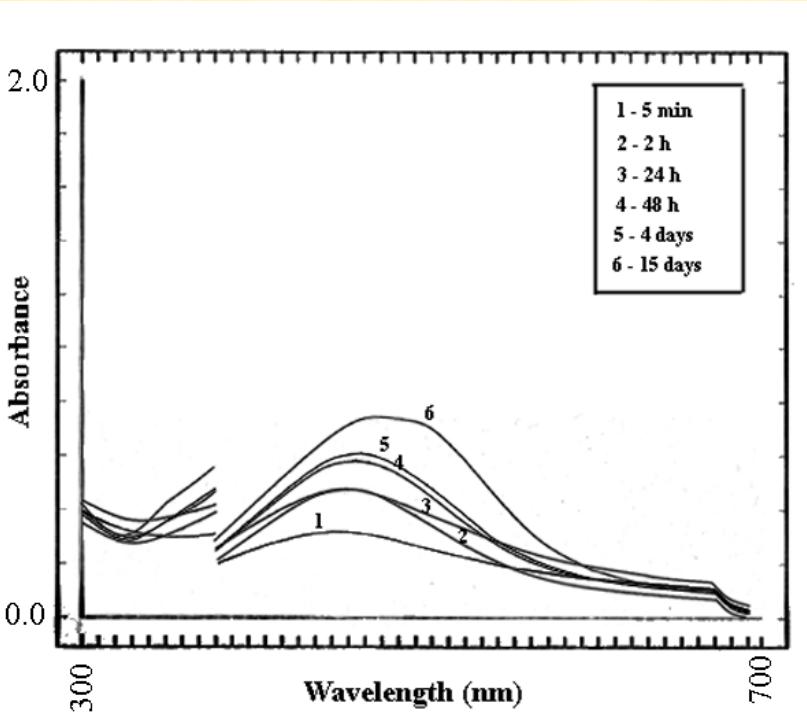
Furostanol Saponins



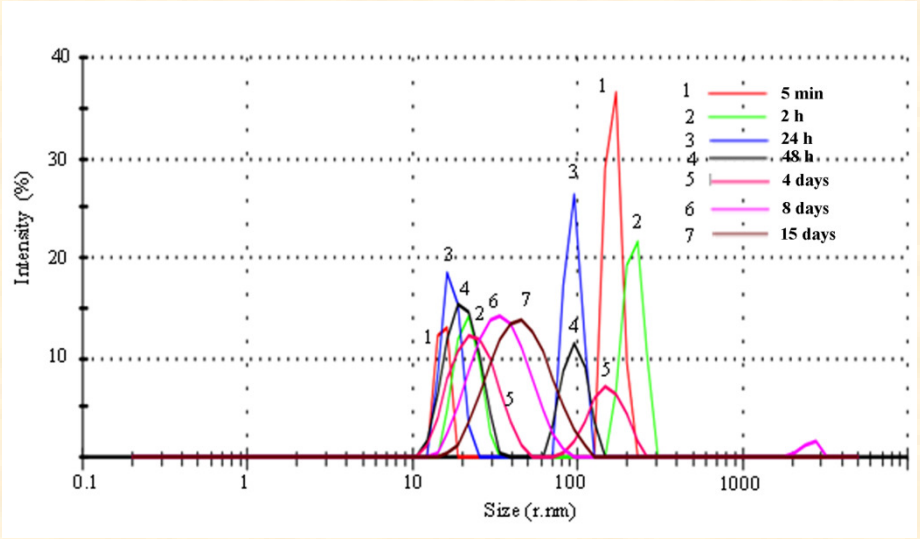
Spirostanol Saponins



UV vis and dls

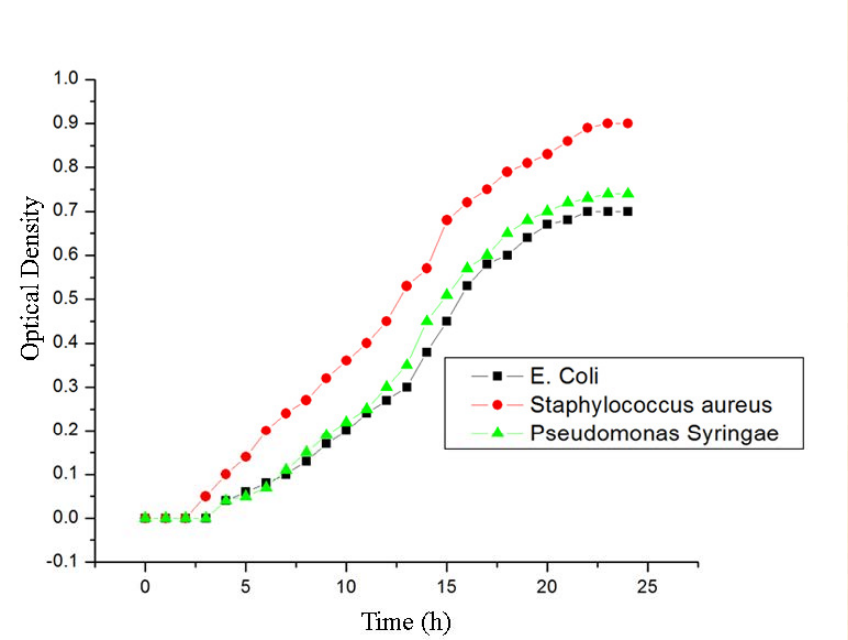


UV vis graphs of sample solutions at different times of reaction kinetics

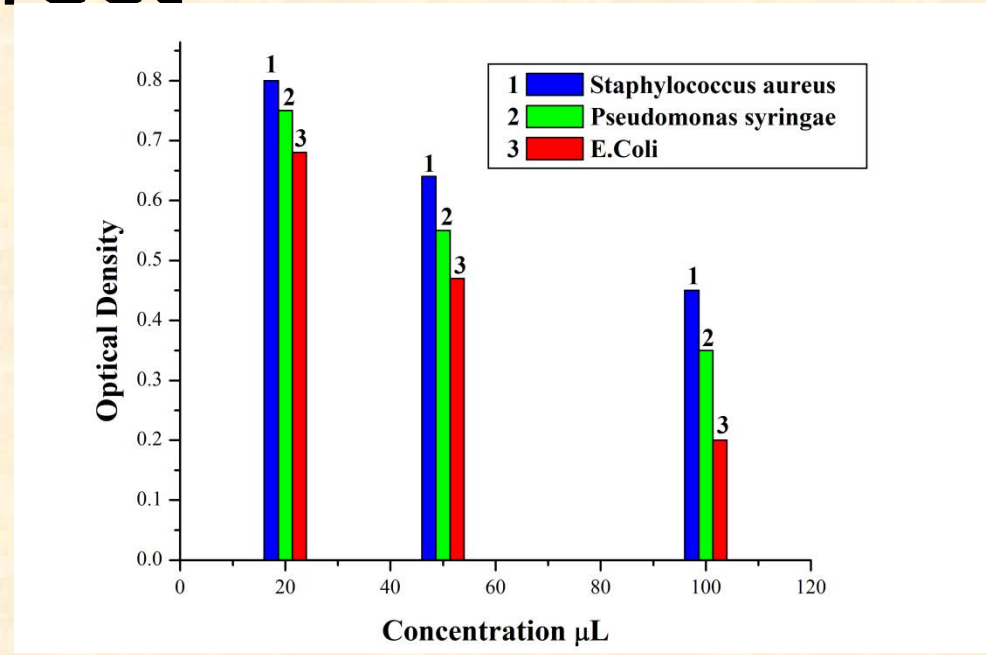


DLS graphs of sample solutions at different time of reaction kinetics

Antibacterial effect

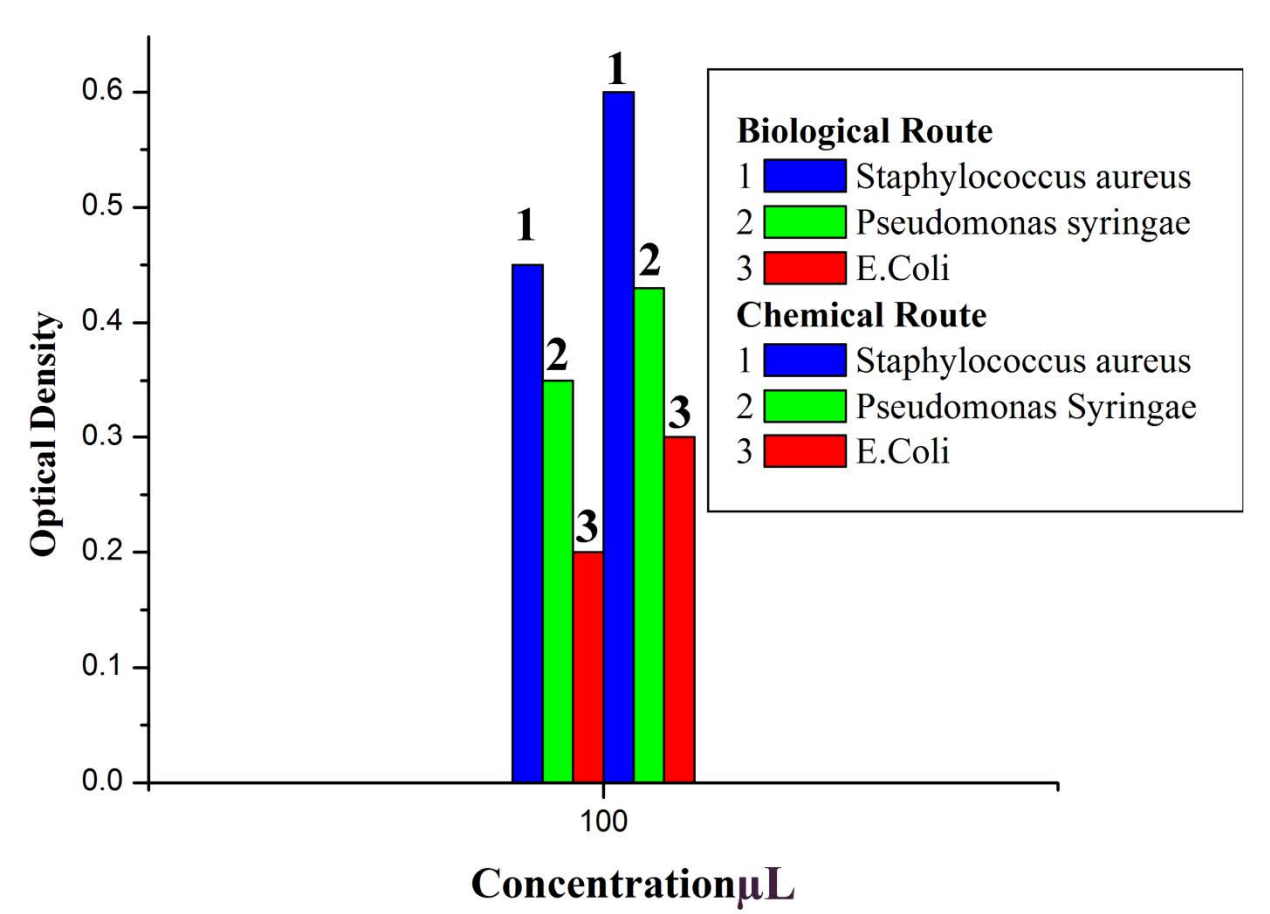


Graph of OD vs Time (h) for antibacterial growth of E. coli, Staphylococcus aureus and Pseudomonas syringae



Effect of Ag nanoparticles on three bacteria – E.Coli, Staphylococcus aureus and pseudomonas syringae

Antibacterial comparison of chemical vs biological route



Comparison of antibacterial effects of Ag nanoparticles (for 100 μL concentration) prepared by biological and chemical routes

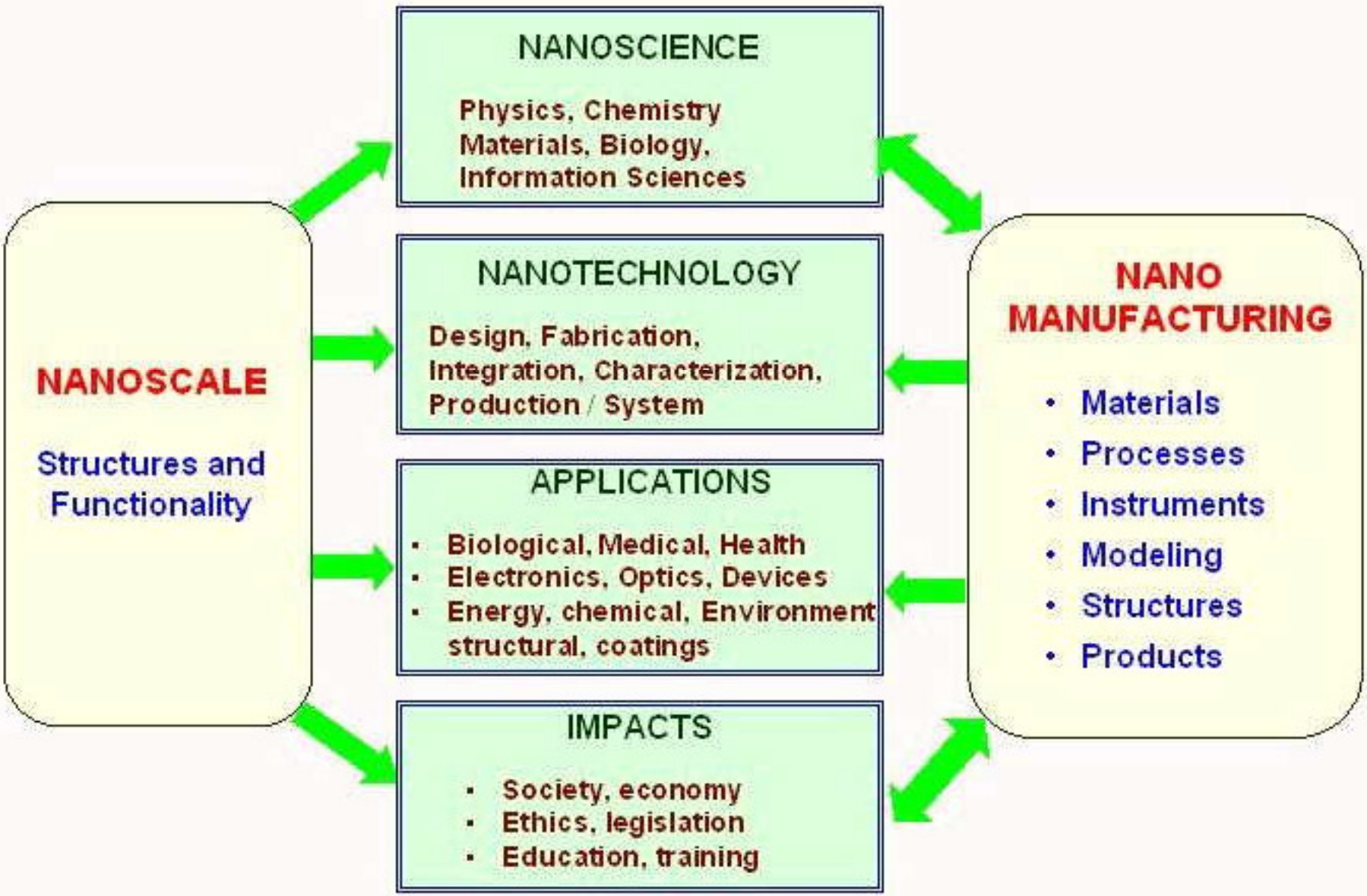
Summary

- The biological synthesis applied in the present investigation has advantage of being eco-friendly
- The technique is less-expensive of compound to chemical route
- Leaves of the plants are available everywhere in plenty
- The nanoparticles produced by biological methods are non-toxic.
- The antibacterial effect is more as compared to nanoparticles synthesized by chemical route and can be used for preventing the bacterial growth in dental, catheter and wounds.
- Nanoparticles are self-stabilized and there is no need of polymer for stability. The colloidal solution of the extract and silver nitrate which forms the nanoparticles through chemical reduction, can be used directly for filterations and separation of bacteria

Course programme

S. No	Course	Duration	Eligibility
1	B. Tech-Nanotechnology	4 years	Min. 60% aggregate in Class X & XII and PCM / PCB (min 60%)
2	B. Tech + M.Tech Nanotechnology (Dual degree)	5 Years (10 Semester)	Min 60% aggregate in Class X & XII and PCM /PCB (min 60%)
3	M.Tech-Nanotechnology	2 years (4 Semesters)	B.Tech/B.E./M.Sc. with Physics / Chemistry/ Biosciences/ Natural Science/ Electronic Science/ Instrumentation/ Mathematics (min 60%) & 10+2 (min 60%)
4	M.Sc-Nanoscience by Research	2 years (4 Semesters)	B.Sc or equivalent (min 60%) & 10+2 (min 60%)
5	M.Sc- Nanoscience by Research + M.Tech-Nanotechnology (Dual degree)	3 years	B.Sc. or equivalent (min 60%) & 10+2 (min 60%)
6	Ph.D – Nanoscience & Technology	Min 2 years	i) M.Tech (Nanotechnology)/ M.Sc (Nanoscience) with minimum 55% marks in aggregate OR ii) M.Tech/M.Sc(Physics/Chemistry/Biosciences/Material Science/Electronics Science/ Instrumentation) or equivalent with min 55% marks in aggregate

INTEGRATED APPROACH



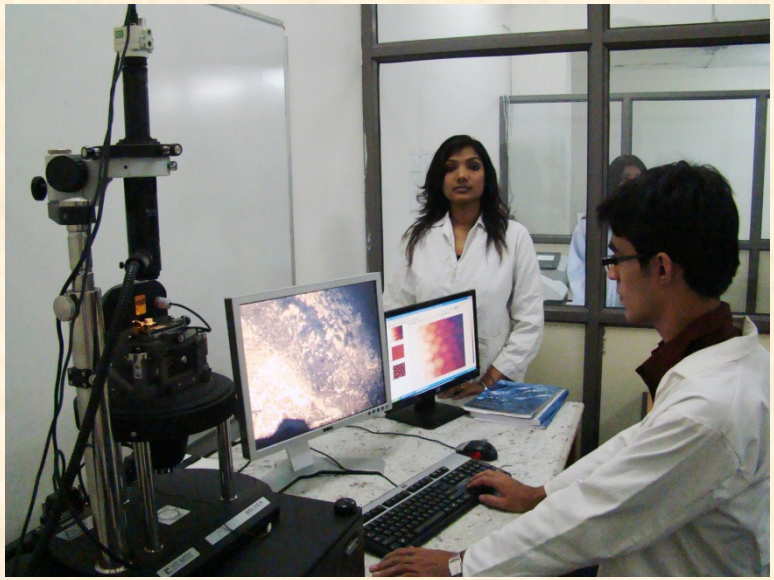
Research Programme

- Thrust areas
  - Semiconductor nanomaterials
  - Polymer based nanocomposites
  - Nano Biosensors and drug delivery systems
  - Green Nanotechnology
  - Carbon Nanotubes and applications in gas and humidity sensor
  - Nano solar cell

Research outcome

Total no. of students	400
Publications in international journals	50
No. of patents	12
6 months dissertation abroad in 20 countries	150 students
No. of Ph.D students abroad after MTech/MSc	90% students
PhD students in AINT	5
Foreign examiners comments	* Every student secured 80-100% marks in dissertation projects. * 80 % secured 9.5/10 * 1 student secured 10/10 with the remarks that “the student did outstanding work. I award 10/10, if 10 is the greatest academic achievement in India”

Characterization lab




THANK YOU