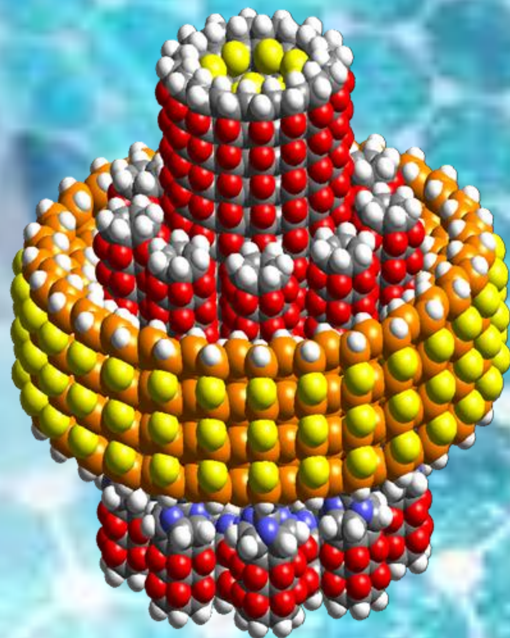
W E L C O M E



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Nanotechnology and its Applications in Computer Science

Outline

- Introduction
- Nano Scale
- History of nanotechnology
- Nanocomputer
- Applications
- Conclusion

What is Nanotechnology?

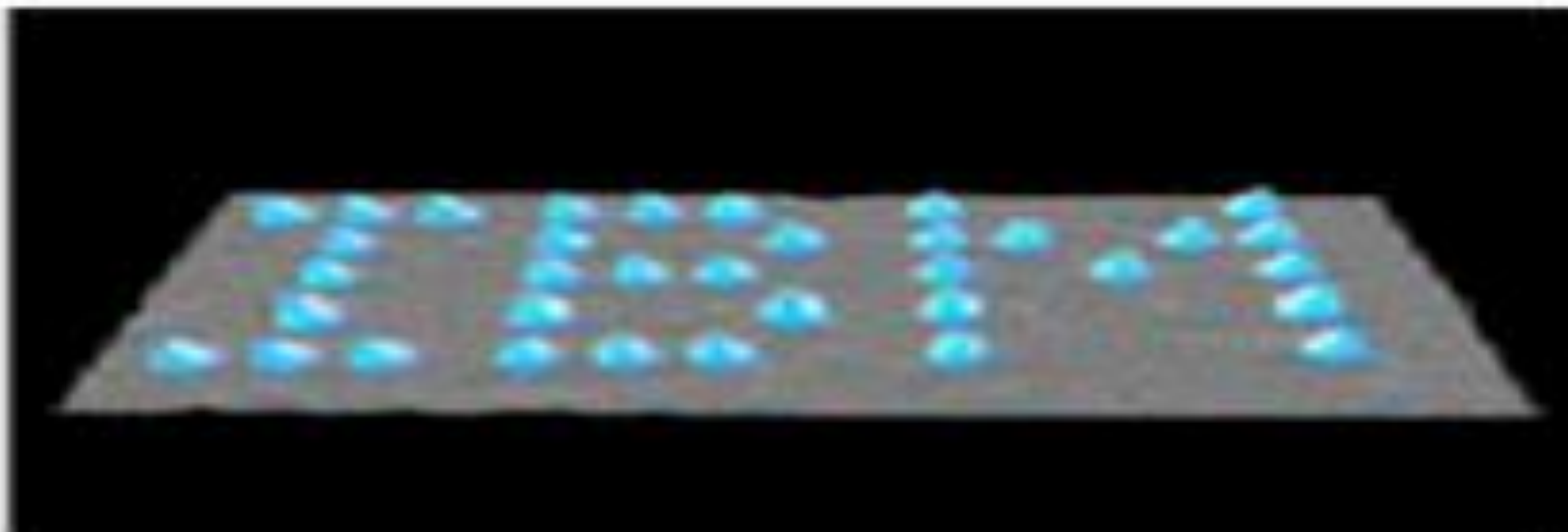
The making of useful devices or machines where in at least one dimension the fabrication is controlled in the nanometer scale

Definition:

"Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications". Nanotechnology involves imaging, measuring, modeling, and manipulating matter at nano length scale."

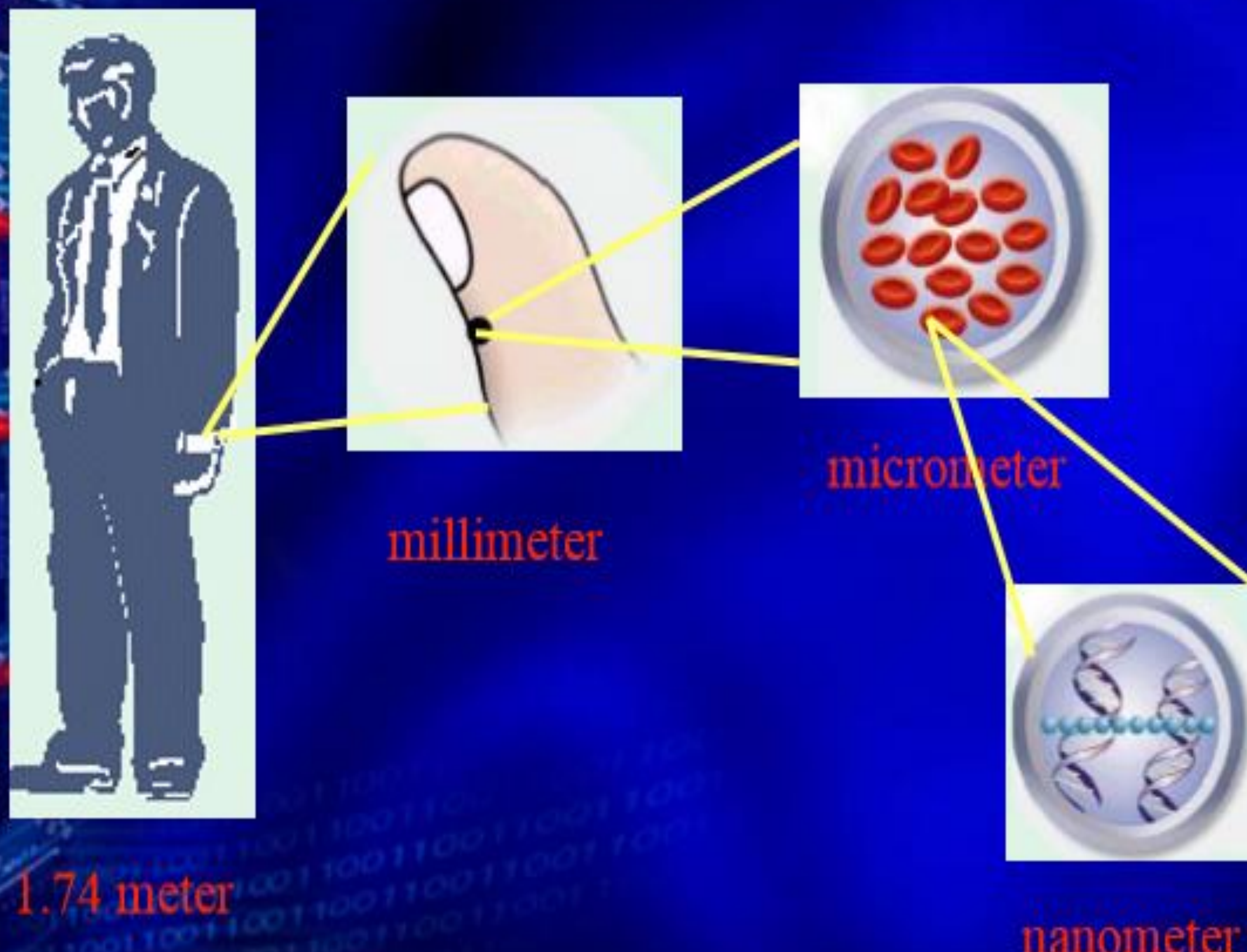
-National Nanotechnology Initiative

"Capability to manipulate, control, assemble, produce and manufacture things at atomic precision"



IBM logo spelled out with 35 atoms of xenon, 1989

Nanometer = 1/1,000,000,000 meter

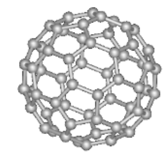


What is Nanoscale?

12,756 Km

22 cm

Fullerenes C_{60}



0.7 nm

www.physics.ucr.edu

1.27×10^{7} m

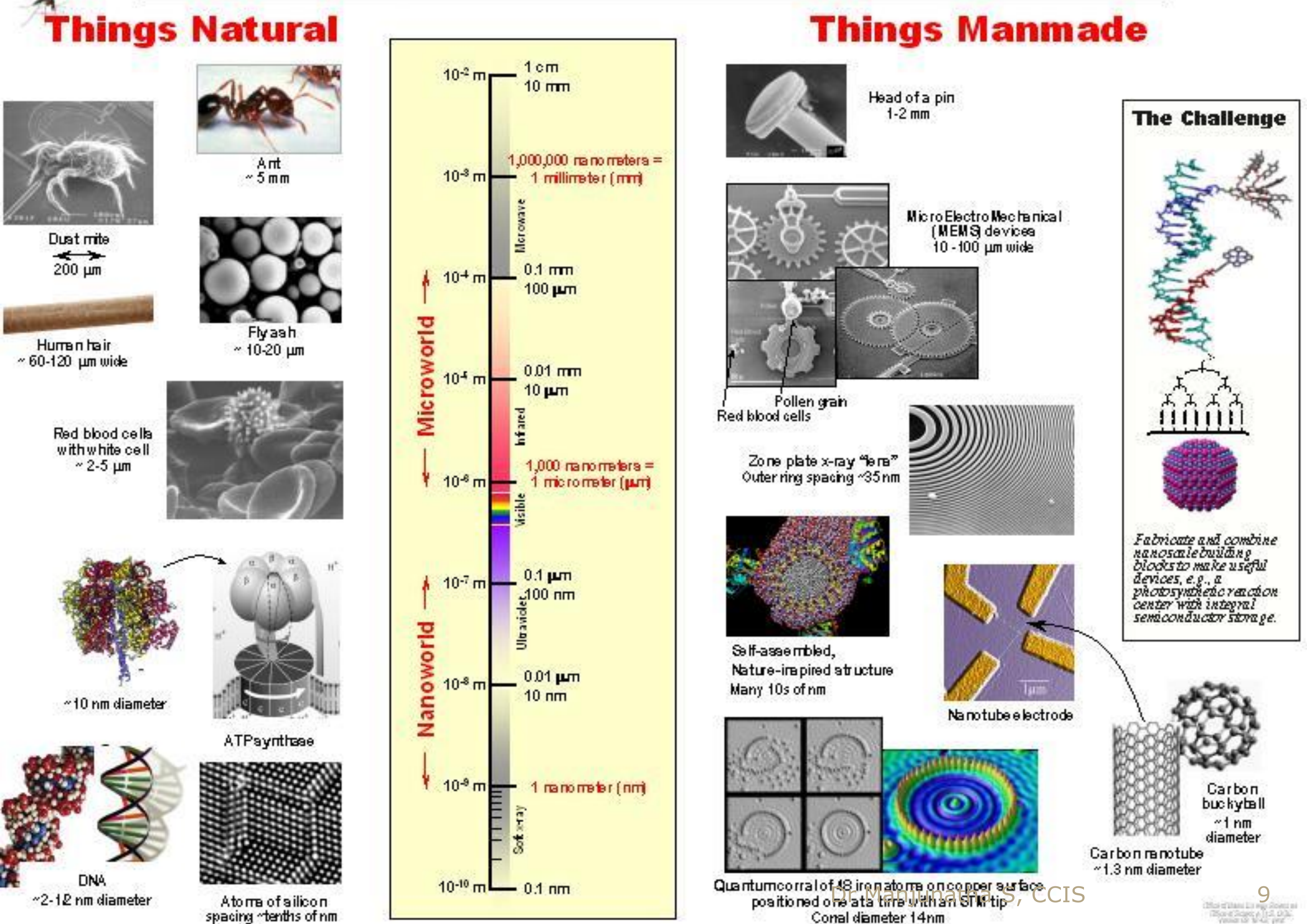
0.22 m

0.7×10^{-9} m

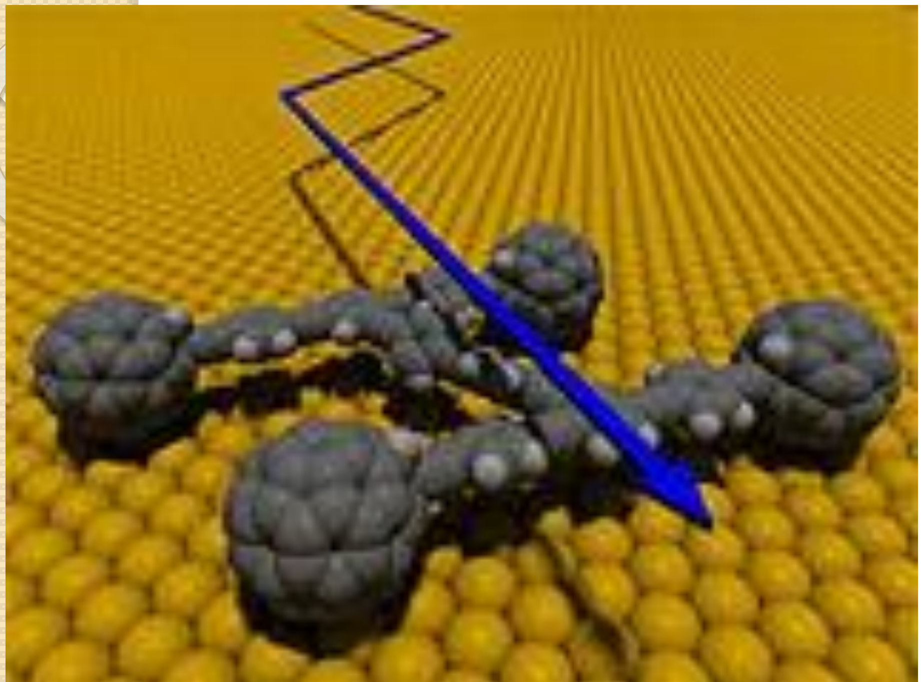
10 millions times smaller

1 billion times smaller

The Scale of Things – Nanometers and More



Emergence

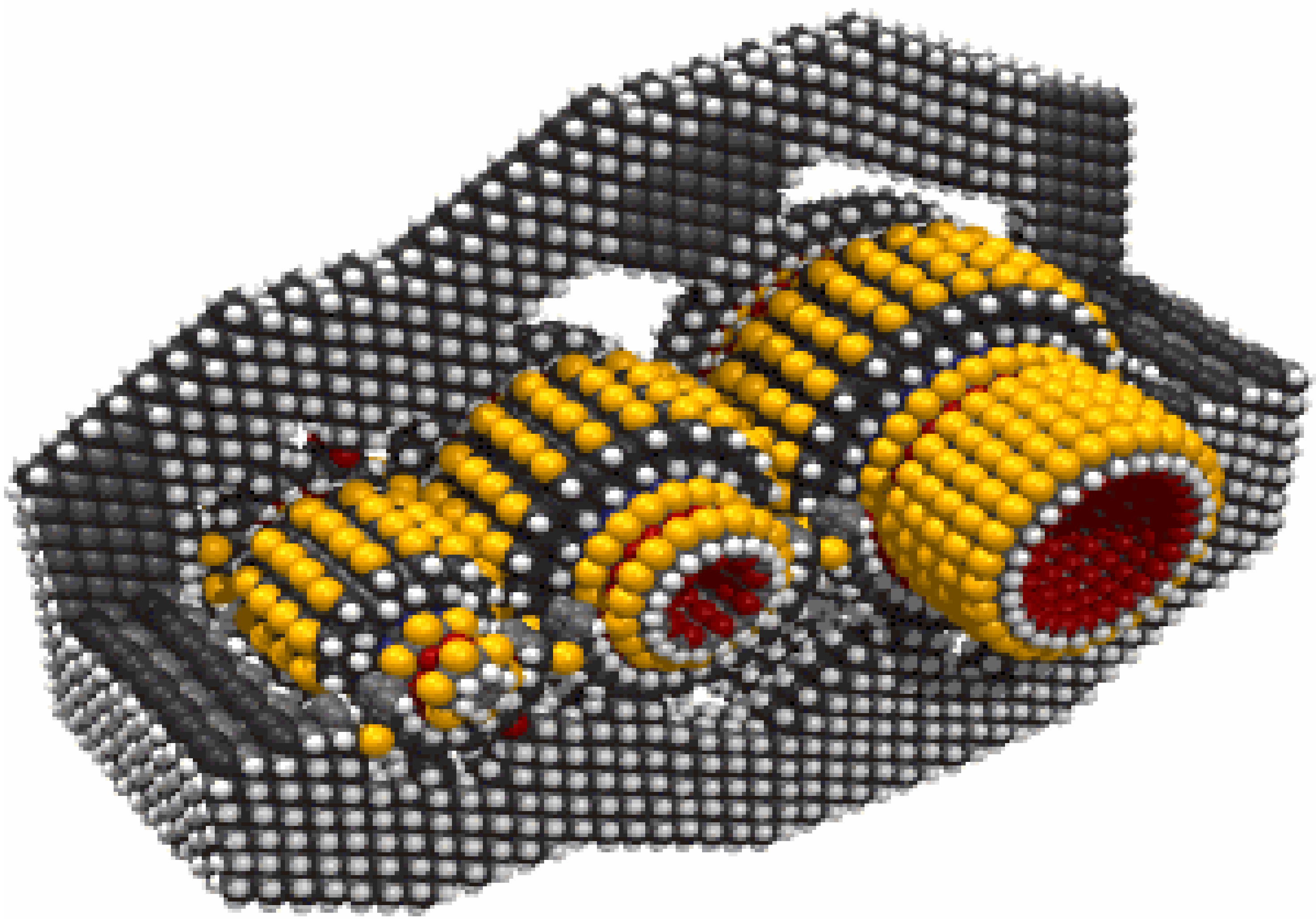


A nanocar made from a single molecule.

"...its arsenal includes nanotechnological transjectors...It can control other machines."

Arnold Schwarzenegger's character mentions nanotechnology in "The Terminator 3" movie.

With 15,342 atoms, this parallel-shaft speed reducer gear is one of the largest nano-mechanical devices ever modeled in atomic detail.



Why Now?

- New tools for atomic-scale characterization
- New capabilities for single atom/molecule manipulation
- Computational access to large systems of atoms and long time scales as a result miniature of machine.
- Convergence of scientific-disciplines at the Nanoscale

What's the BIG deal about something so SMALL?

"Atoms on a small scale

behave like

nothing on a large scale"

- Richard Feynman

Materials behave differently at this size scale.

It's not just about miniaturization.

At this scale---it's all about INTERFACES

Size Matters!

Color depends on particle size

Quantum dots 3.2 nm in diameter have blue emission

Quantum dots 5 nm in diameter have red emission

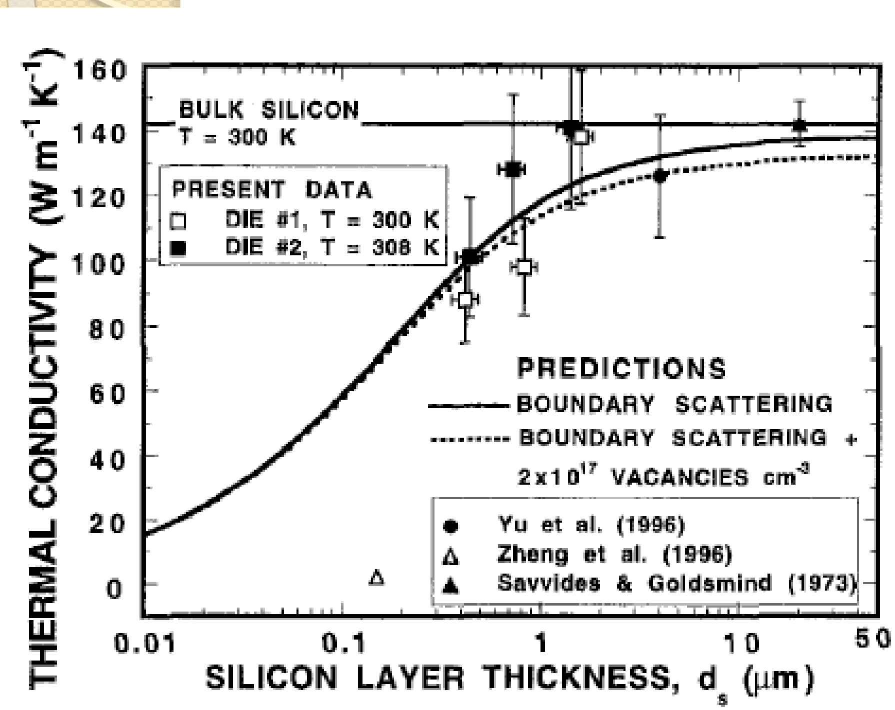
Size dependent properties of cadmium selenide:

Colour of nanophase materials vary according to the size of their constituent grains, or clusters.

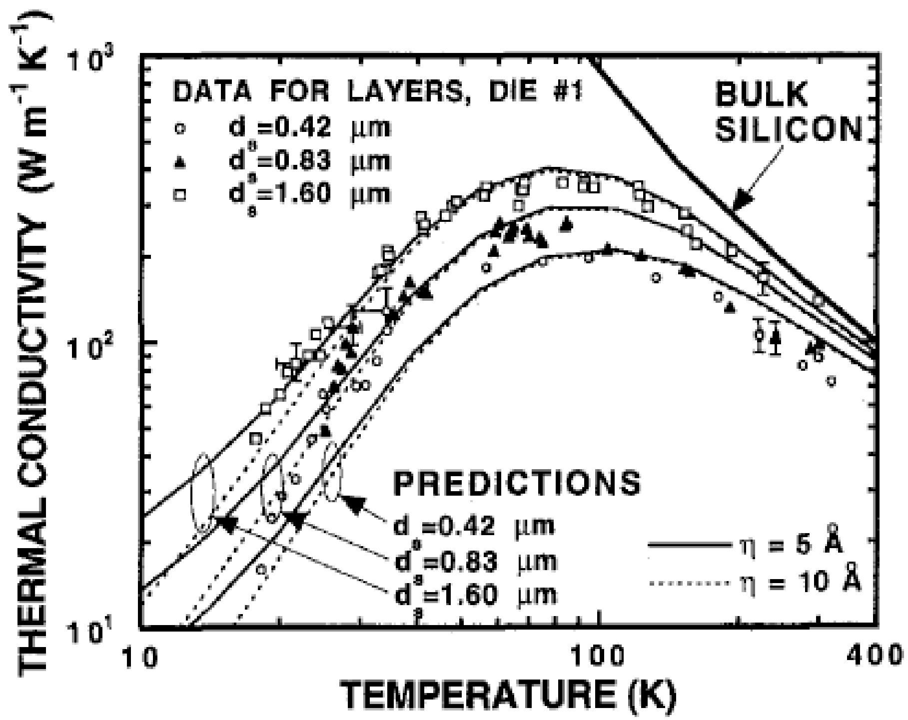
white light (*left*) and ultraviolet light (right).

Thermal Conductivity

Si phonon thermal conductivity: Bulk vs. Micro scale



Room-temperature thermal conductivity data for silicon layers as a function of their thickness.



Thermal conductivities of the silicon device layers with thicknesses 0.42, 0.83, and 1.6 μm.

Asheghi, A., Touzelbaev, M.N., Goodson, K.E., Leung, Y.K., and Wong, S.S., 1998, "Temperature-Dependent Thermal Conductivity of Single-Crystal Silicon Layers in SOI Substrates," ASME *Journal of Heat Transfer*, **120**, 30-36.

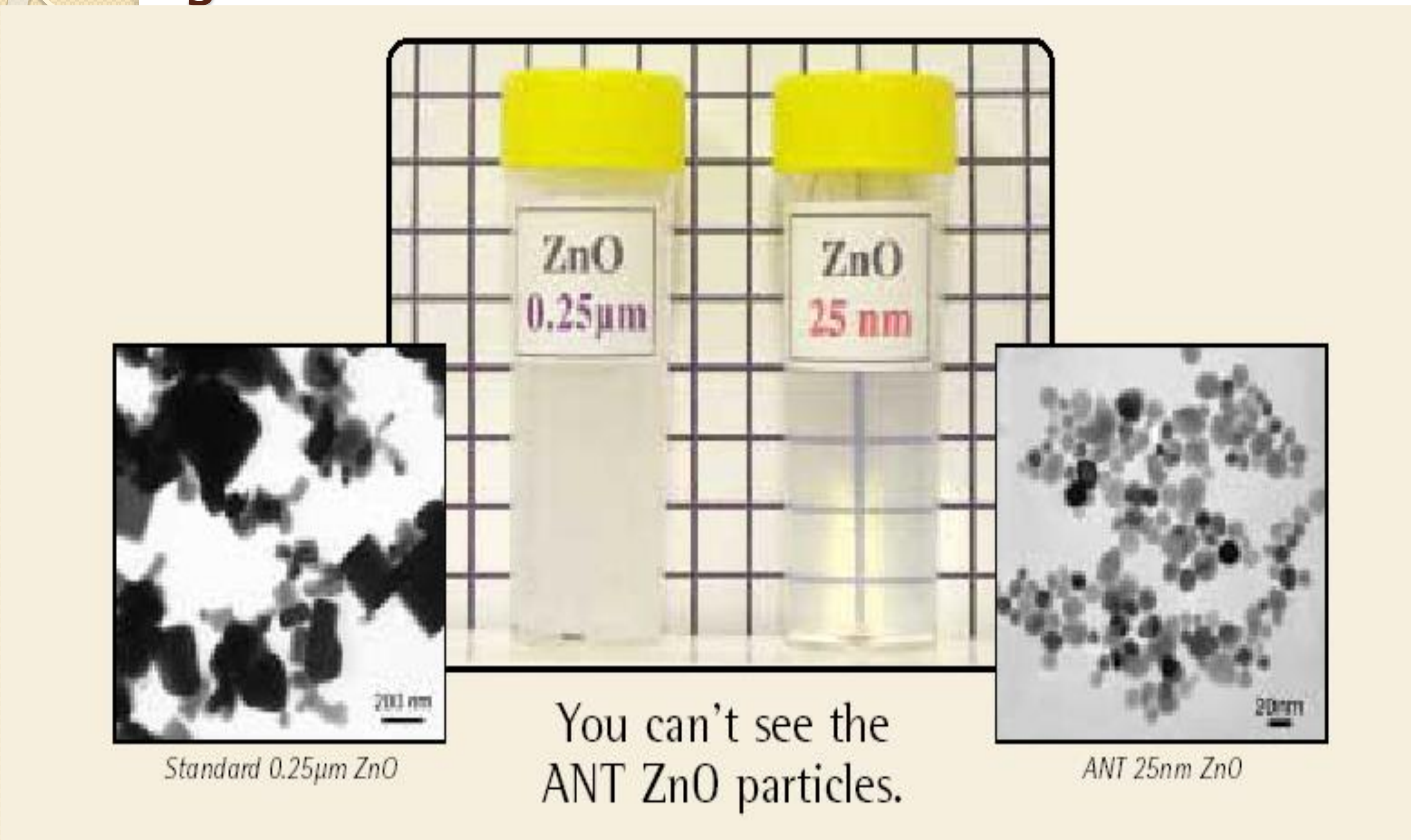
Nanoscale Size Effect

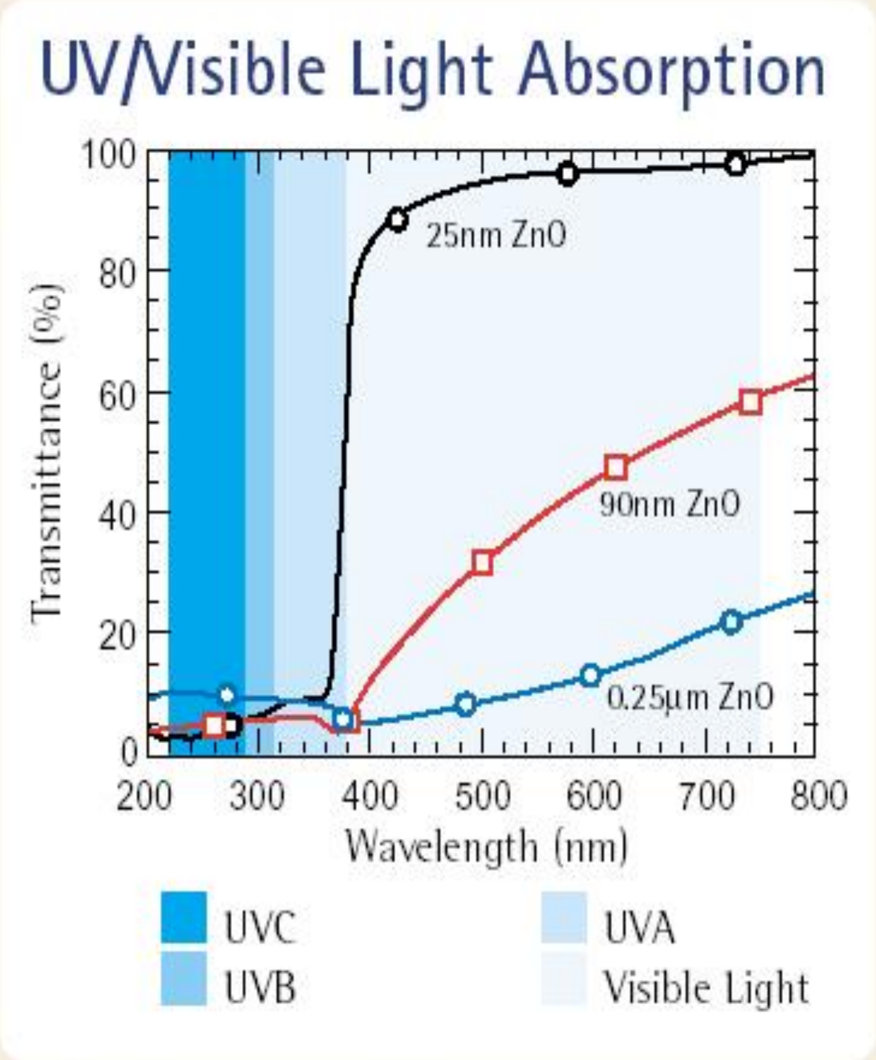
- Attainment of high surface area to volume ratio
- Change in properties, including changes in:
  - Physical Properties (e.g. melting point)
  - Chemical Properties (e.g. reactivity)
  - Electrical Properties (e.g. conductivity)
  - Mechanical Properties (e.g. strength)
  - Optical Properties (e.g. light emission)

…Nanoscale Size Effect

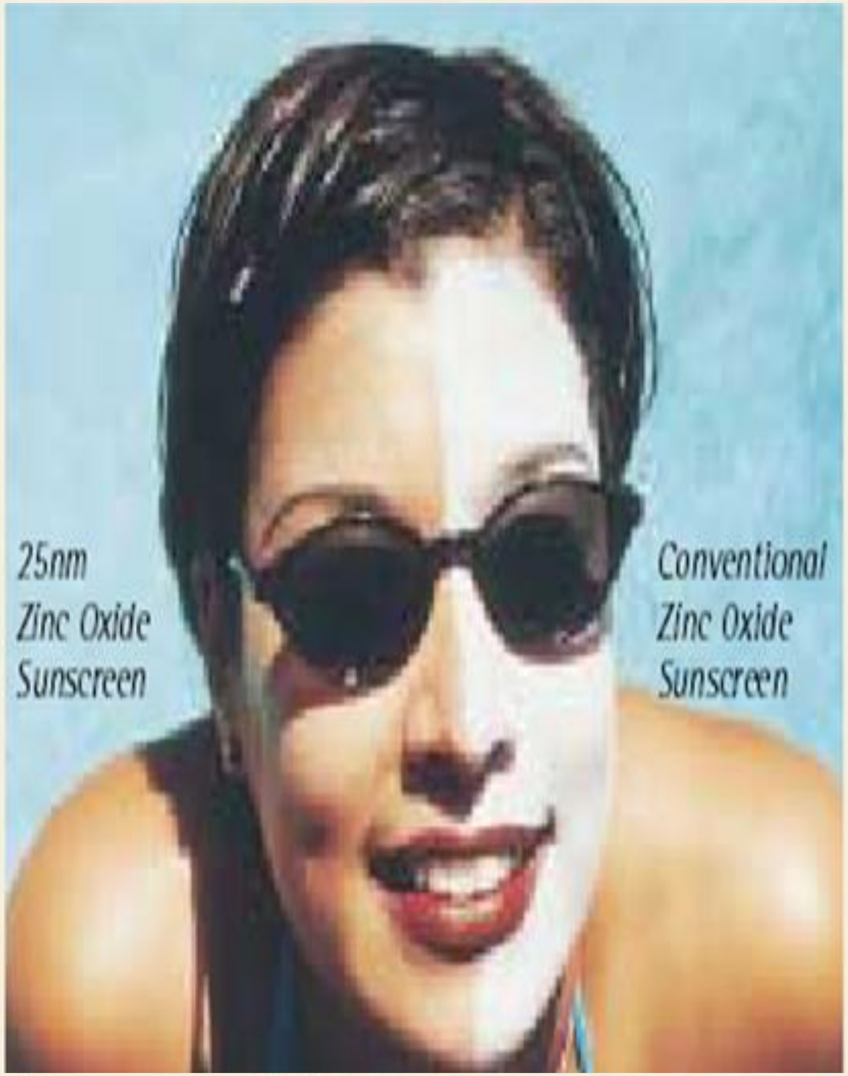
- Magnetic materials like iron loses its magnetism at nano-size.
- Gold shines as a metal and non-reactive. At nano, chemically reactive.
- Melting point of solid changes with size of particle.

Nanopowder are transparent to visible light.





As ZnO absorbs UV radiation[1], ZnO nanopowders will function as a transparent UV absorber.



As opposed to conventional inorganic based sunscreens, you can't see the ANT NanoPowder based sunscreen.

Benefits of Nanotechnology

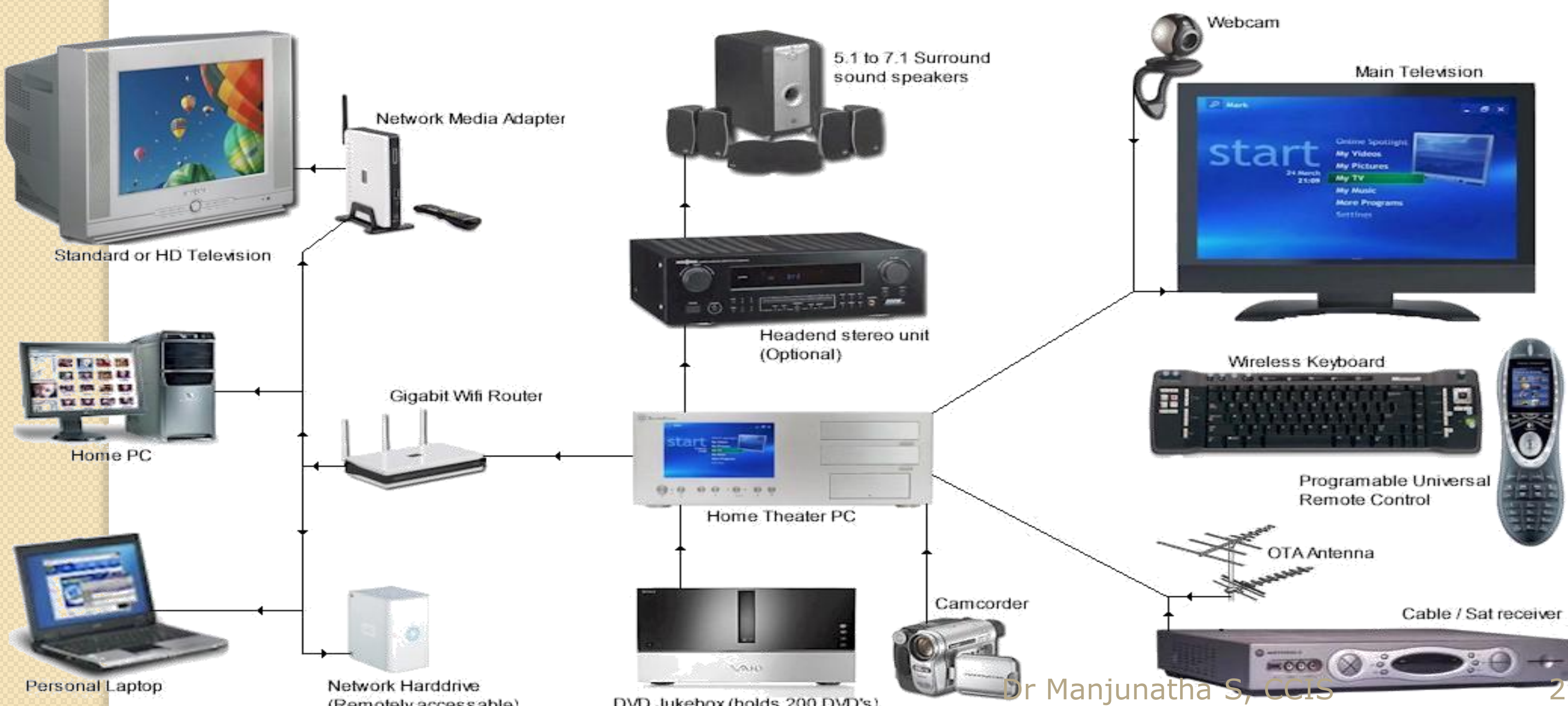
"The power of nanotechnology is rooted in its potential to transform and revolutionize multiple technology and industry sectors, including aerospace, agriculture, biotechnology, homeland security and national defense, energy, environmental improvement, information and computer technology, medicine, and transportation. Discovery in some of these areas has advanced to the point where it is now possible to identify applications that will impact the world we live in."

-National Nanotechnology Initiative

How can Nanotechnology help us?

Nanotechnology will help us :

1. **Develop new manufacturing technology**
2. **Help us build computer systems inexpensively with mole quantities**



Recycling: Reverse Engineering

- Over the next three years, 250 million computers are expected to become obsolete.

[According to the Environmental Protection Agency]

- Old PCs can quickly become quickly obsolete. A typical computer monitor, for example, contains between 2 and 4 pounds of lead, which can leach into the groundwater in a landfill.

Nanotechnology known only

in the 20th century!!

HISTORY OF NANOTECHNOLOGY

- ~ **2000 Years Ago** – Sulfide nanocrystals used by Greeks and Romans to dye hair,
- Egyptian were known to preparation of nano – gold

The Diamond Sutra of Gautama Buddha

~1000 Years Ago (Middle Ages) – Gold nanoparticles of different sizes used to produce different colors on stained glass windows.

Milan - Duomo

Dichroic Glass Cup-collidal gold silver, 4th century

In Diffused light

In focussed light

Damascus Steel was a super-strong Middle Eastern forged metal used from roughly 1100 A.D. to 1700 A.D. It was said to be able to cut through rocks and other people's swords, olden steel smiths used nanotechnology (carbon nanotubes).

Stained Glasses

Dr. Juen-Kai Wang

Reynard the Fox
early 15-th century, *Holy Cross Church*

The Ascent of Elijah
c.1863, *Trinity Methodist Church*

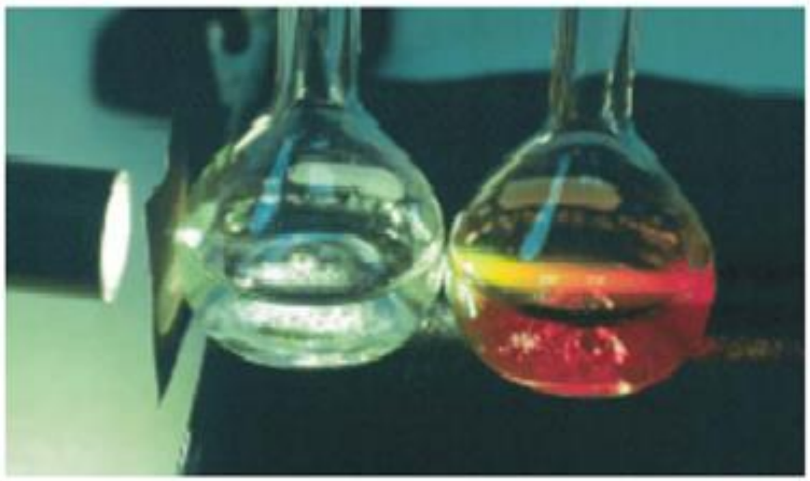
The stained Glass Museum *(www.stainedglassmuseum.org*

In 1857, Faraday reported the formation of deep red solution of an aqueous solution of Chloroaurate (Au Cl_{4-}) using phosphorous is $Cs_{2.}$

Faraday's works on Au nanoparticles

Dr. Juen-Kai Wang

Faraday-Tyndall Effect

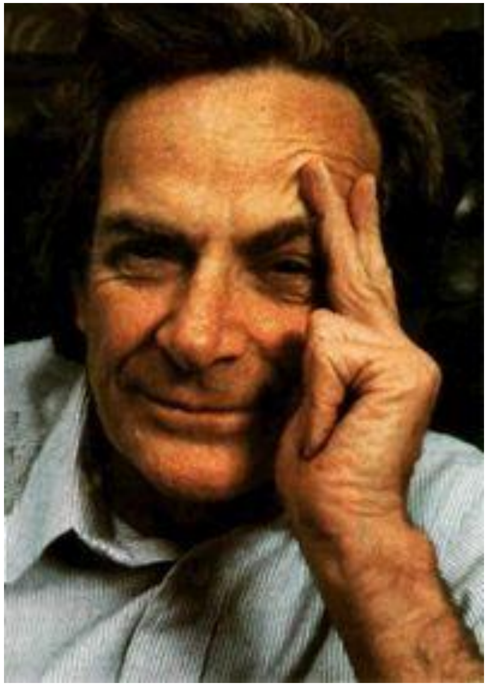


A solution of gold chloride   Gold colloids

Faraday's slides
Prepared in 1856, in conjunction with Faraday's research on finely-divided gold
(The Royal Institution of Great Britain)

M. Faraday, Philos. Trans. R. Soc. London ***147****, 145 (1857).*
R. D. Tweney, Department of Psychology, Bowling Green State University, USA (personal.bgsu.edu/_tweney)

1959 –Dr. Richard Feynman, one of America's most notable physicists (1965 Nobel Prize in Physics).



"Why cannot we write the

entire 24 volumes of the

Encyclopedia Britannica

on the head of a pin?"

"There is plenty of room

at the bottom"

1974 – Taniguchi, Professor of Tokyo Science University

Taniguchi used the word Nanotechnology”

for the first time to describe the science and technology of processing or building parts with nanometric tolerances.

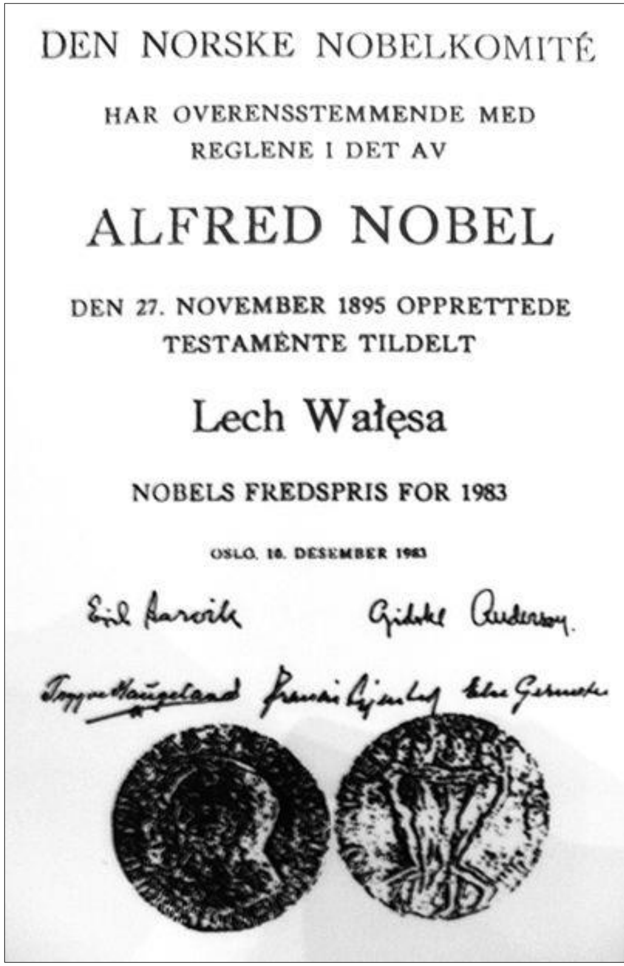
1985 – "Bucky ball" - Scientists at Rice University and University of Sussex discover C_{60}

Harold Kroto from the University of Sussex,

Robert Curl and Richard Smalley from Rice University

Awarded the Nobel Prize in Chemistry in 1996 for their discovery of a new composition of carbon, Carbon 60.

Carbon-60 buckyball is shaped like a soccer ball.



DEN NORSKE NOBELKOMITÉ

HAR OVERENSSTEMMENDE MED REGLENE I DET AV

ALFRED NOBEL

DEN 27. NOVEMBER 1895 OPPRETTEDE TESTAMENTE TILDELT

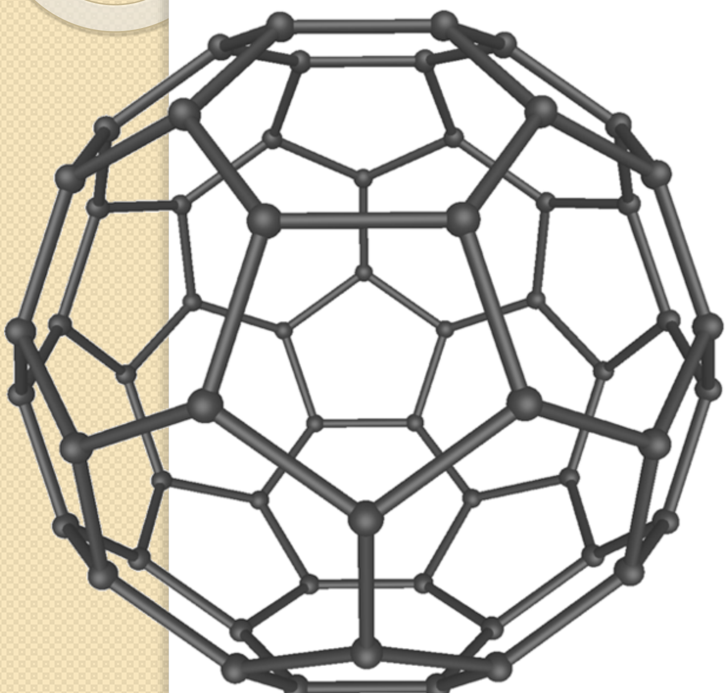
Lech Wałęsa

NOBELS FREDSPRIS FOR 1983

OSLO, 10. DESEMBER 1983

Nobel prize diploma.

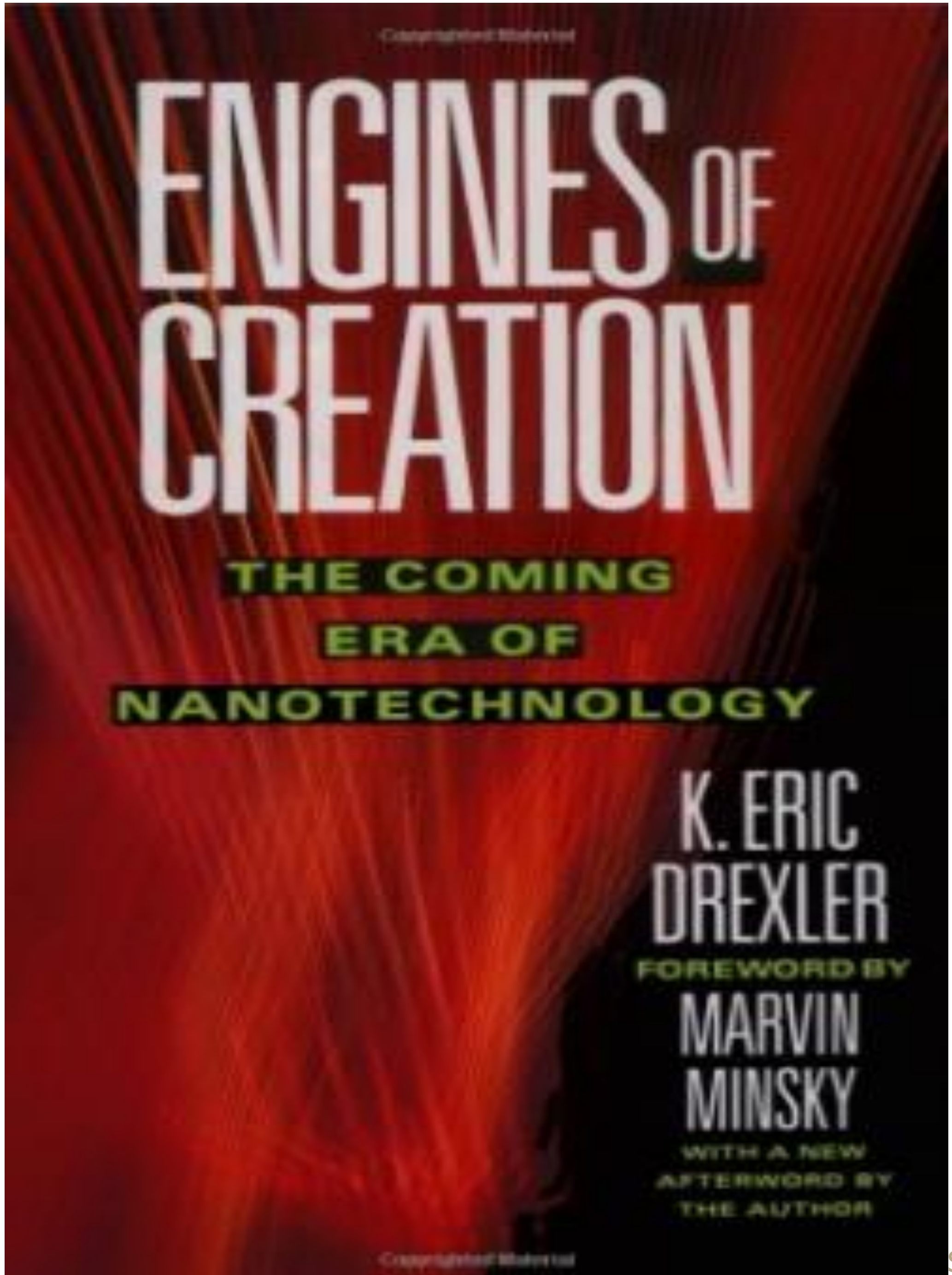
Carbon 60 was named after Richard Buckminster Fuller, who called by the nickname "Bucky."
Fullerenes



A "Bucky ball."

Dome over Biosphere in Montreal.

- **1981** – IBM develops Scanning Tunneling Microscope
- **1986** – "Engines of Creation" - First book on nanotechnology by K. Eric Drexler. Atomic Force Microscope invented by Binnig, Quate and Gerbe
- **1989** – IBM logo made with individual atoms
- **1991** – Carbon nanotube discovered by S. Iijima
- **1999** – "Nanomedicine" – 1st nanomedicine book by R. Freitas
- **2000** – "National Nanotechnology Initiative" launched

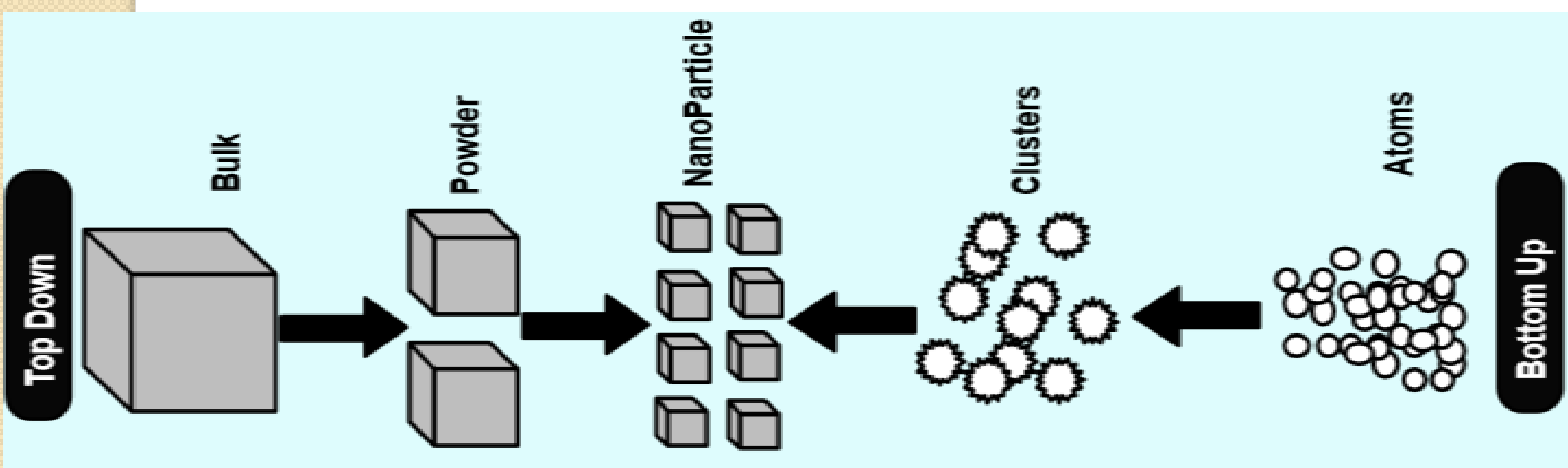

ENGINES OF CREATION
THE COMING ERA OF NANOTECHNOLOGY
K. ERIC DREXLER
FOREWORD BY
MARVIN MINSKY
WITH A NEW AFTERWORD BY THE AUTHOR

Nanomaterials and Fabrication

Two approaches used in producing nanomaterial.

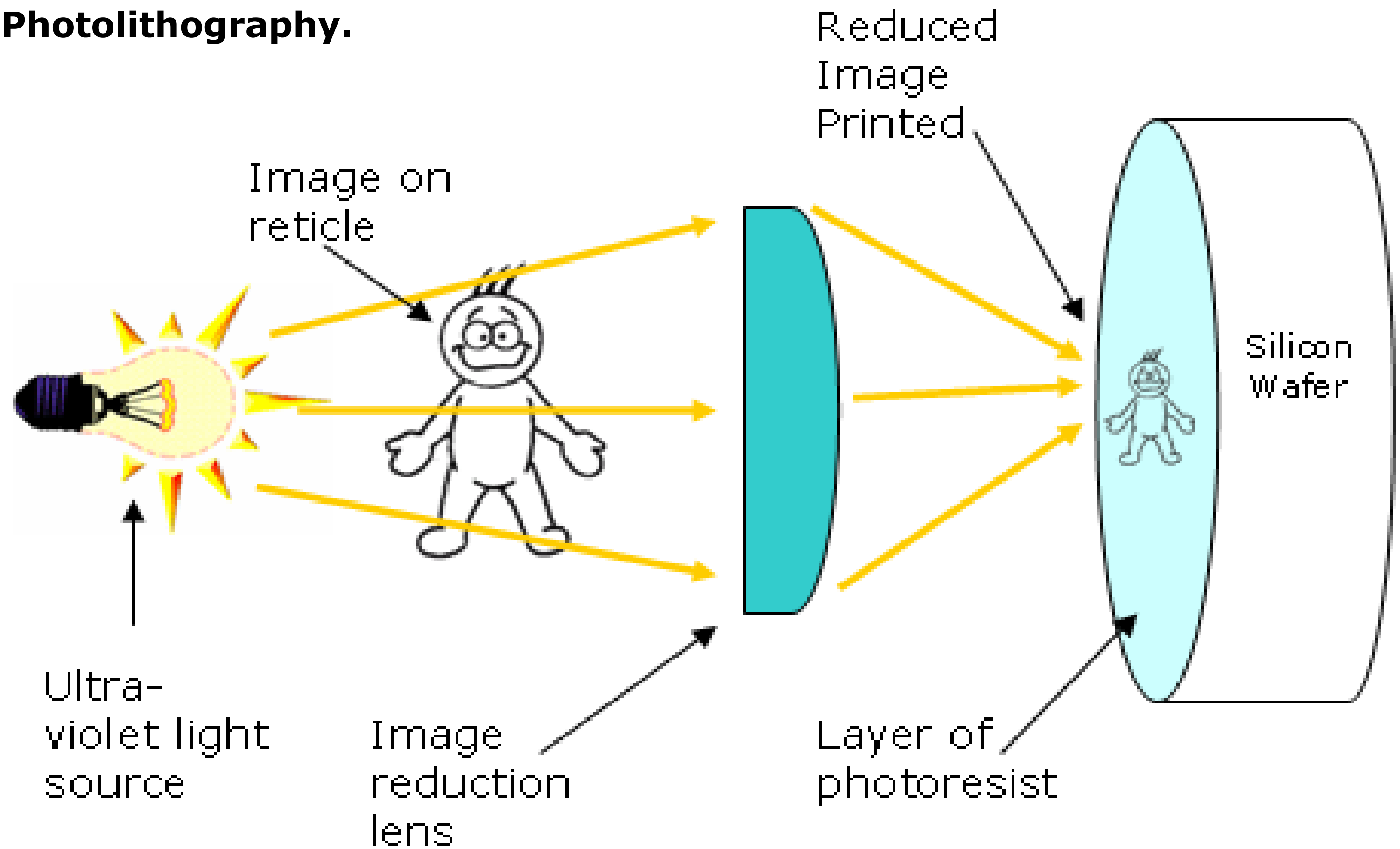
1. Top-down method

2. Bottom-up method



1. Top-Down Approach – broken up into smaller particles using grinder, laser etc

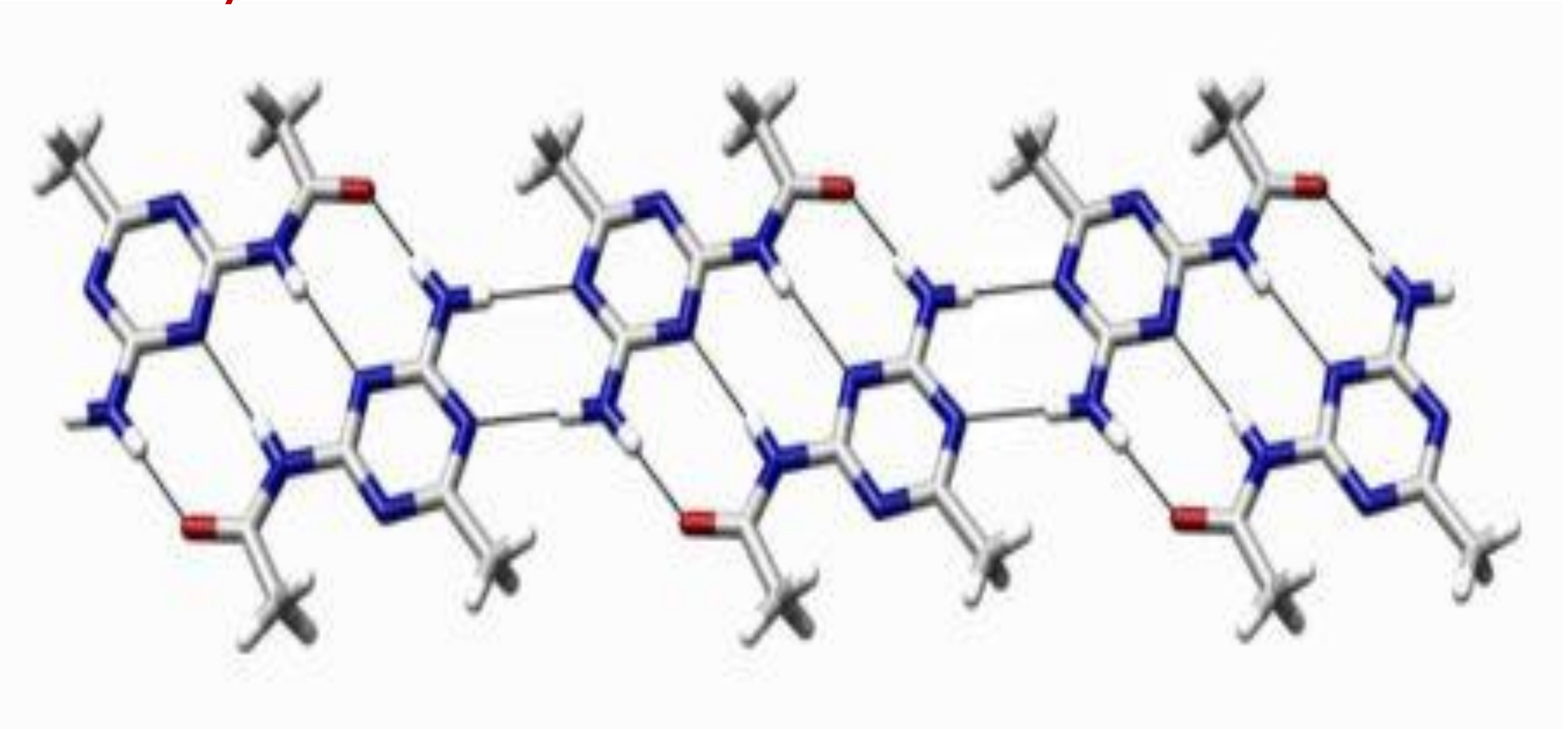
Photolithography.



Top-down method is used by computer chip manufacturers.

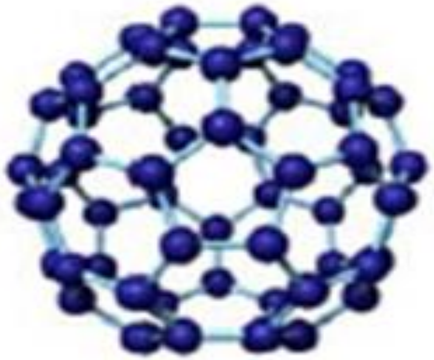
2. Bottom-Up Approach

Bottom-up approach- larger structures are built atom by atom



Example: A molecular self assembly through hydrogen bonds, forming well defined structure of DNA

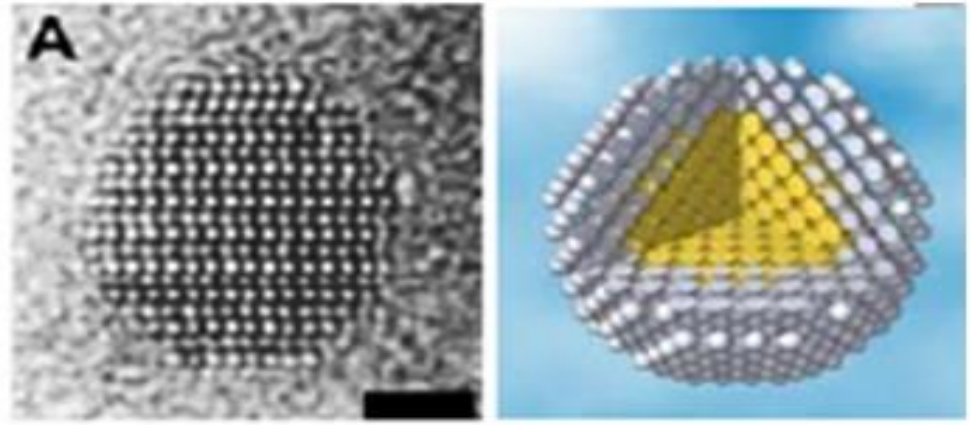
Building blocks



Nanoclusters

Magic #'s of atoms

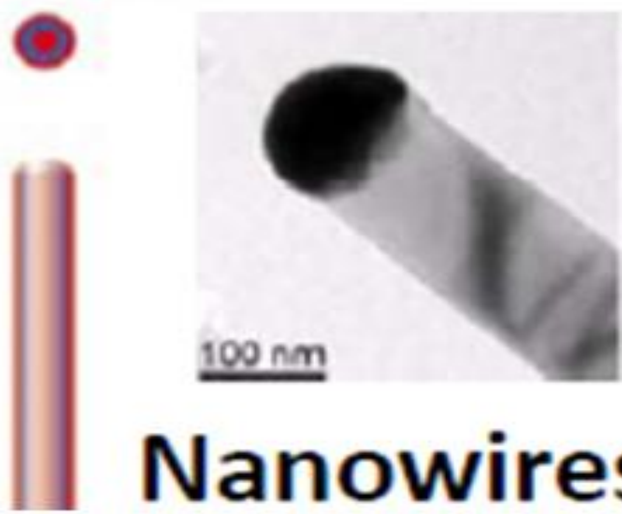
≤1 nm size



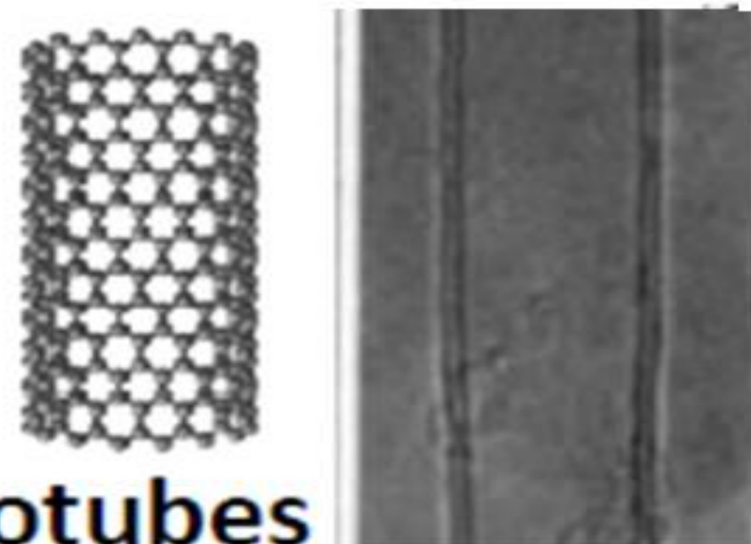
Nanoparticles

100s-1000s of atoms

~1-100 nm diameter



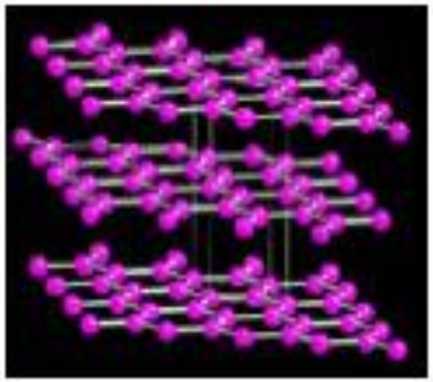
Nanowires



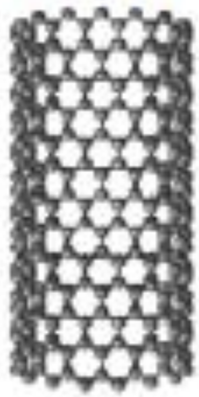
Nanotubes

Nanostructured carbons

Graphite
sp^2

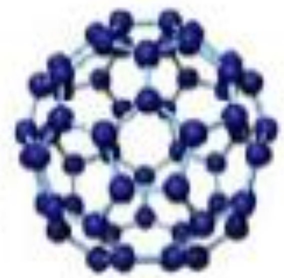


Single-wall CNT (SWNT)
D = 0.4-3 nm

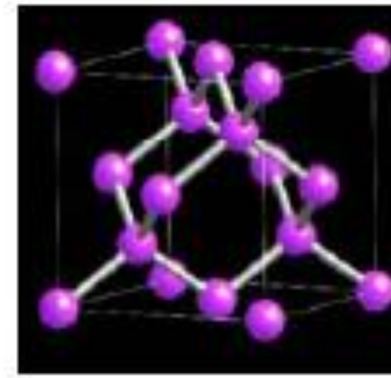


Multi-wall CNT (MWNT)
D = 3-100 nm

Fullerene
D = 0.4-3 nm



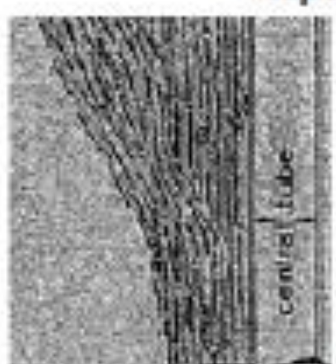
Diamond
sp^3



Carbon "nanofibers" → **Carbon fibers**

Carbon "nanofibers"
D = 10 nm – 1 mm

D = 10 nm – 1 mm
Vapor-grown



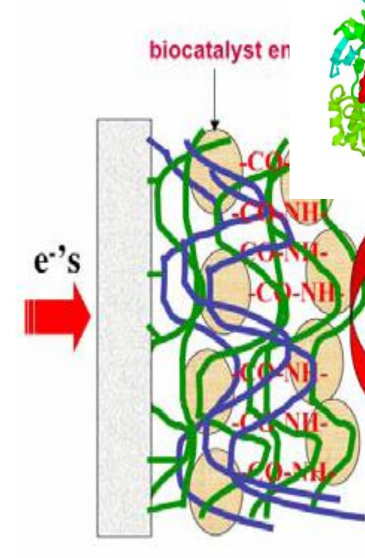
Core is a SWNT

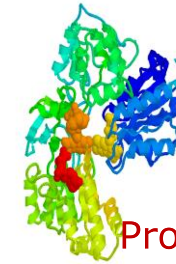
Carbon fibers
D = 1–10 mm
Melt-spun

> 50,000 tons/yr

Compiled from many sources

Nanoscale Materials



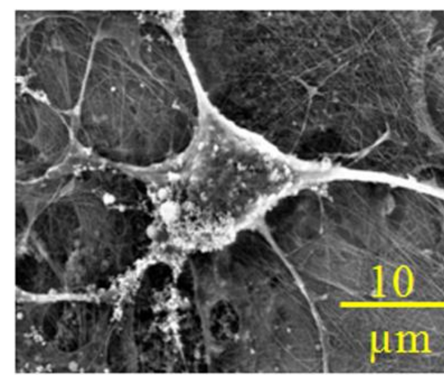


Protein

Cross-linked enzymes used as catalyst *– Univ. of Connecticut, Storrs , 2007*

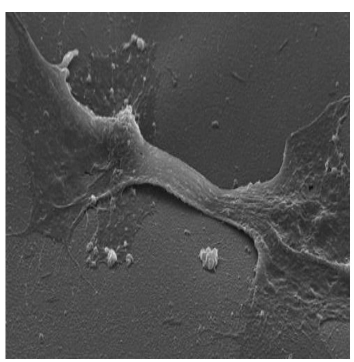
Bionanomaterials

1) Biological materials utilized in nanotechnology
   - Proteins, enzymes, DNA, RNA, peptides
1) Synthetic nanomaterials utilized in biomedical applications
   - Polymers, porous silicon, carbon nanotubes

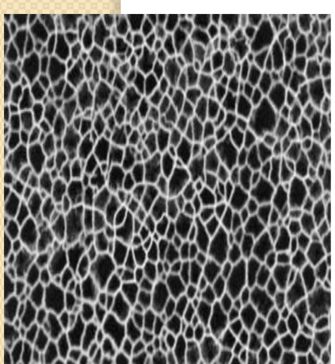


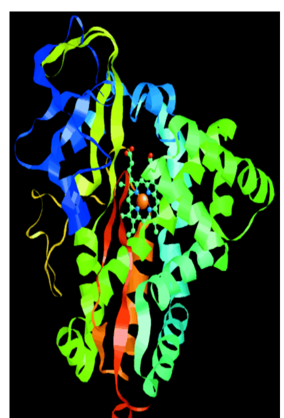
Bone cell on porous silicon *– Univ. of Rochester, 2007*

Human cell on PSi



Porous silicon (PSi)





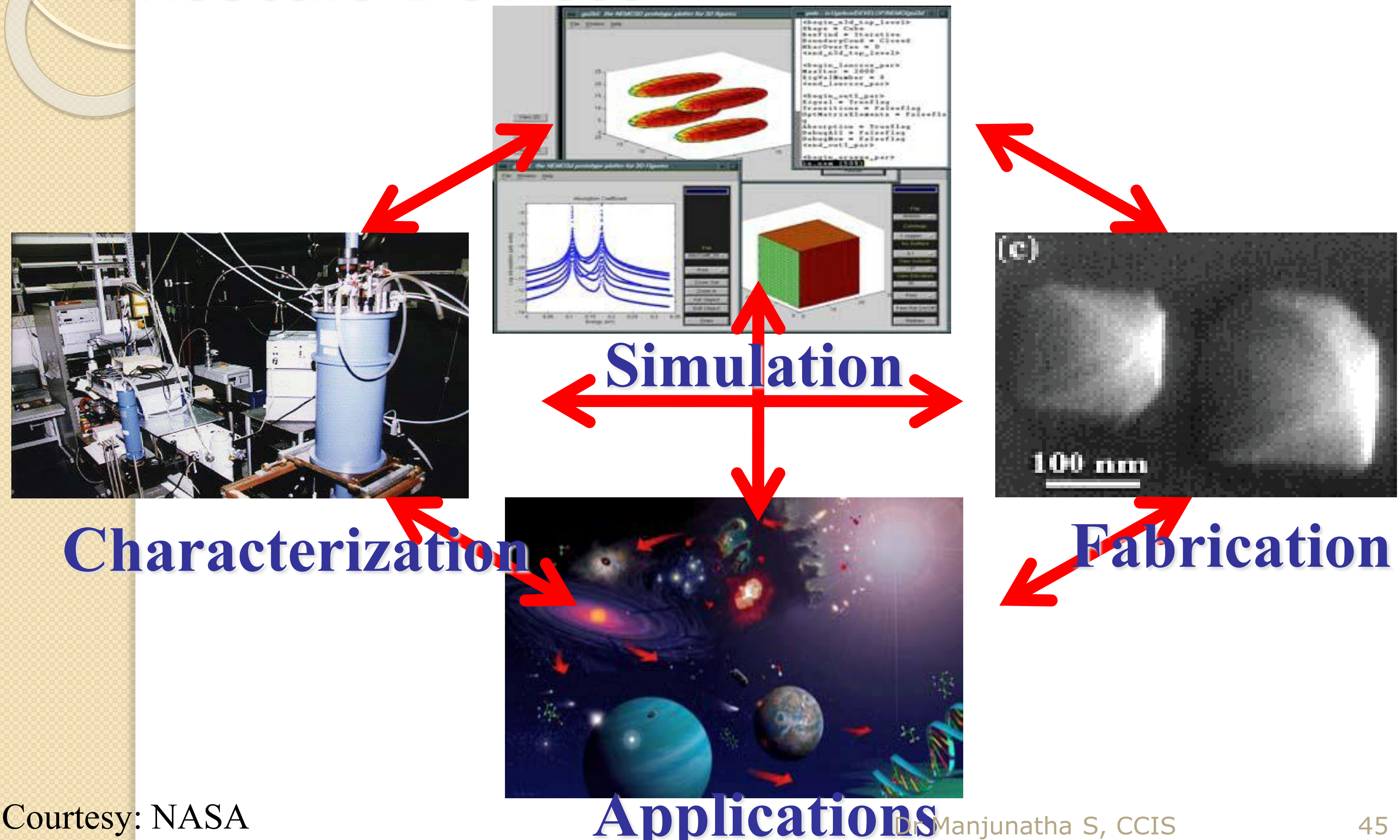
Enzymes are used as oxidation catalysts

DEVELOPMENT

OF

NANOTECHNOLOGY

Modeling, Characterization and Fabrication are important tools for Nanoscale Devices



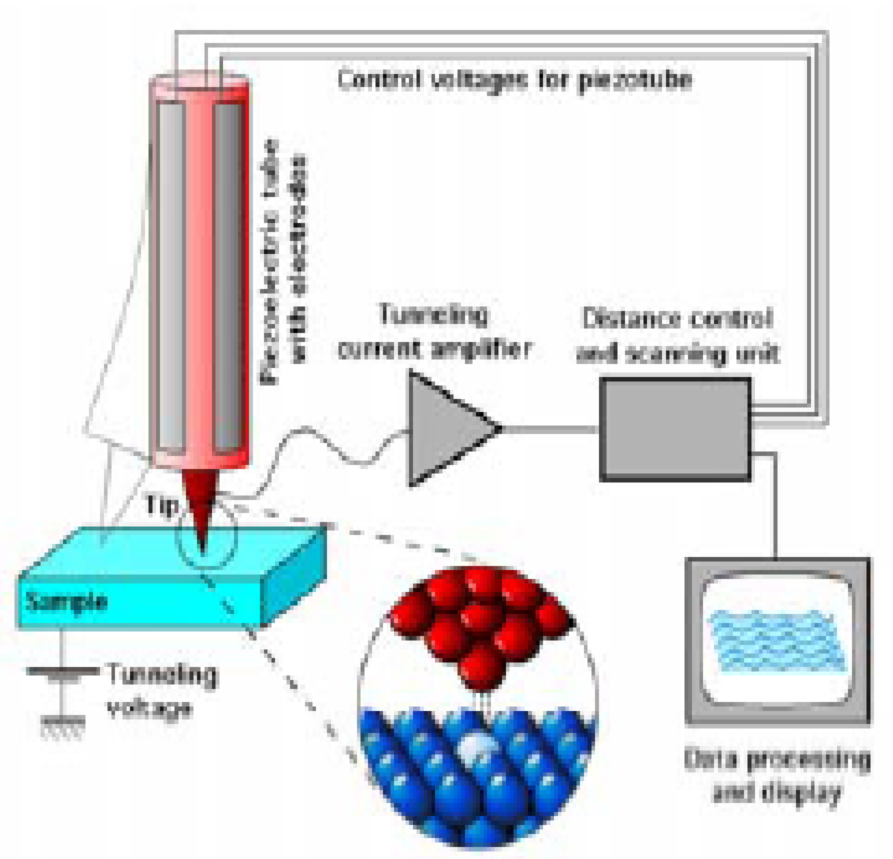
Courtesy: NASA

MICROSCOPES

Measurement of equipment is the cornerstone of nanotechnology.

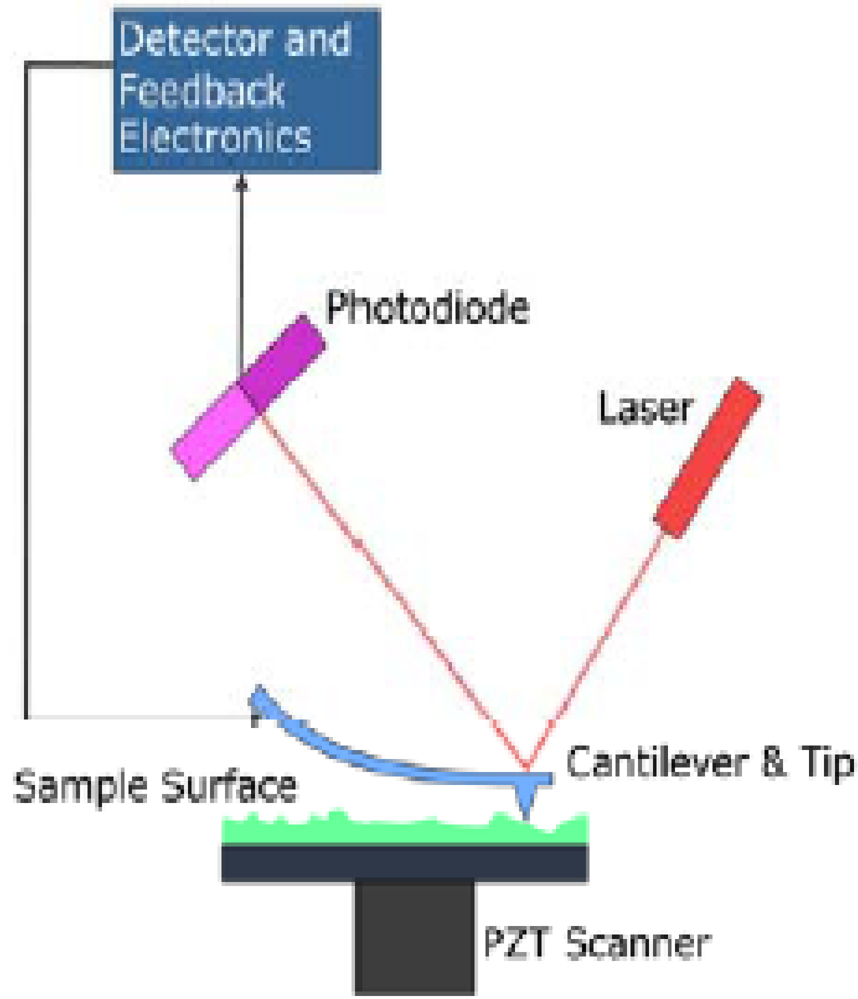
- Scanning Tunneling Microscope (STM)
- Scanning Probe Microscope (SPM)
- Atomic Force Microscope (AFM)
- Scanning Electron Microscope (SEM)
- Transmission Electron Microscope (TEM)

Scanning tunneling microscope (STM)



invented by Young and colleagues, NIST, 1972
Binnig and Rohrer, Nobel Prize, 1986

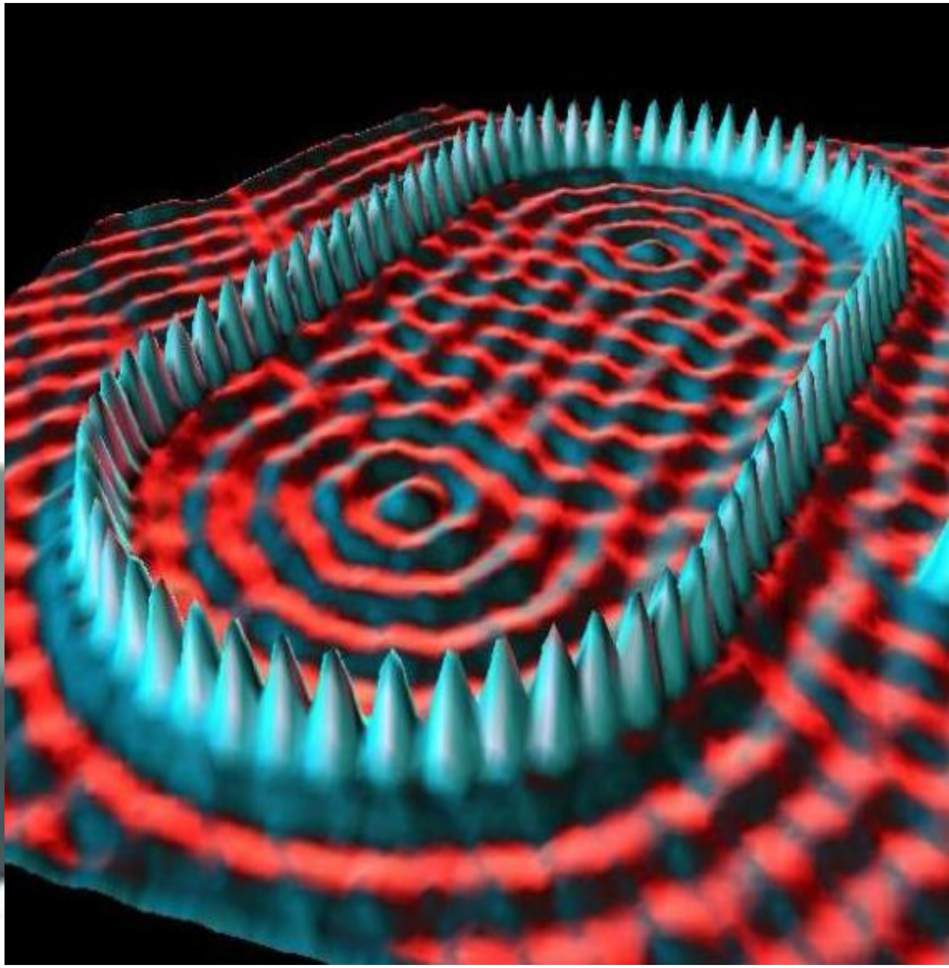
Atomic force microscope (AFM)



Binnig, Quate, Gerber, 1986

Scanning Probe Microscope Systems (SPM).

Scanning Tunneling Microscope Image.



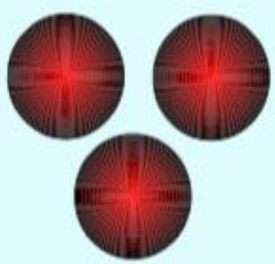
NANO FABRIFICATION

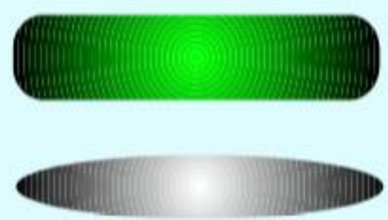
- Photo-lithography: Fabricate microprocessors, mask the surface of silicon wafer using UV light.
- Electron-lithography: Manipulation of nanoparticles on polymers with electron beam.

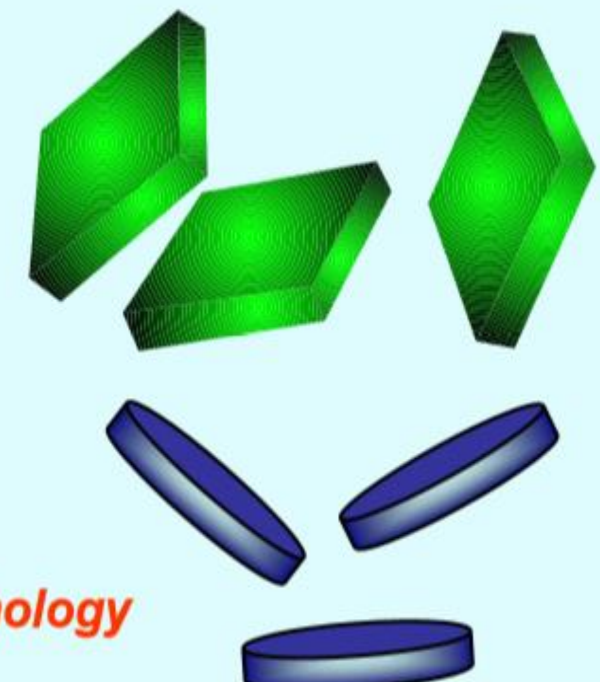
Nano Building Blocks

“ Nano Objects - Lego Fabrications”

1st generation nanoparticles

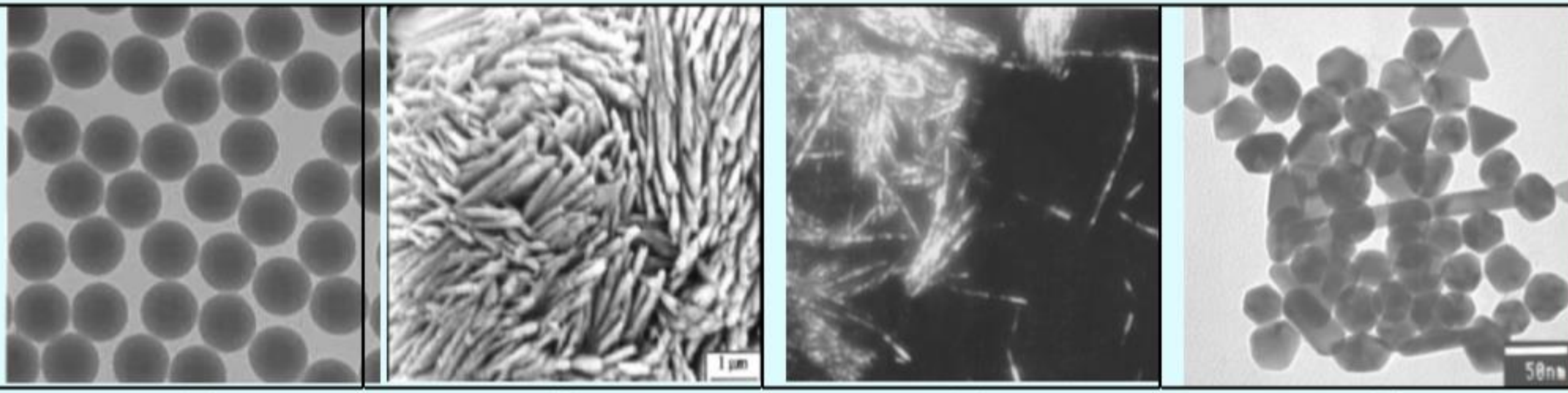






Size - Composition- Homogeniety - Morphology

EXAMPLES OF FIRST GENERATION NANOPARTICLES



(a) (b) (c) (d)

(a) TEM image of perfectly spherical polystyrene nanospheres,

(b) SEM image of ZnO precursor,

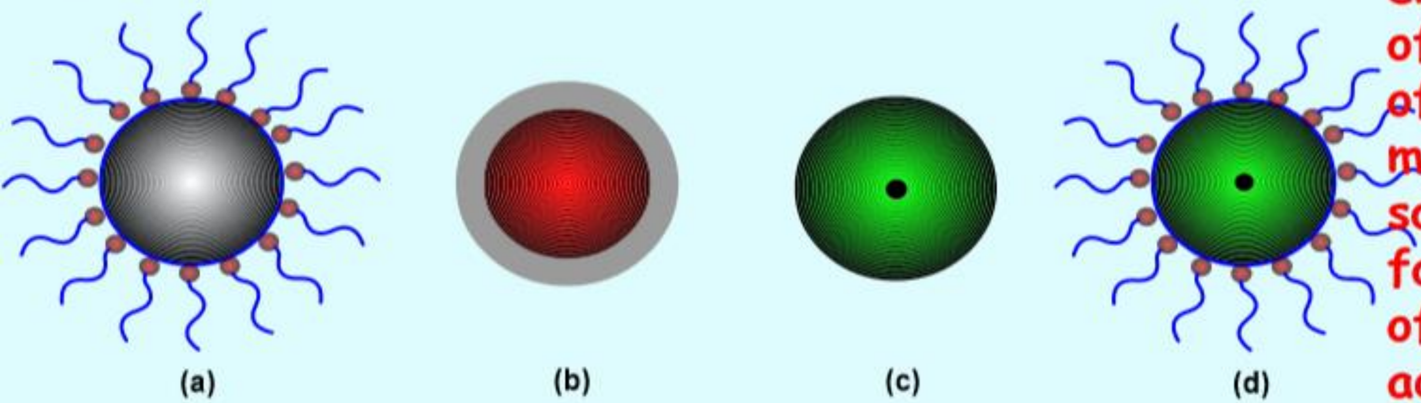
(c) Optical microscope image of Au nanowire with high aspect ratio and

(d) TEM image of Au nanoparticles with different morphologies.

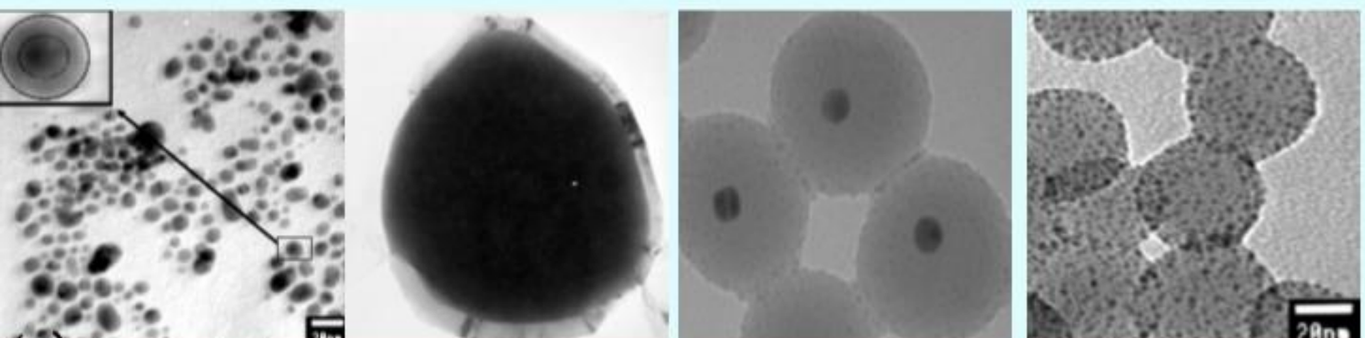
The "First Generation Nanoparticles" can be considered to be those particles obtained at the early stage of the development of nanostructured materials

EXAMPLES OF SECOND GENERATION NANOPARTICLES

Second generation nanoparticles have emerged as a result of increasing degree of complexity, multifunctionality and sophistication needed for the engineering of nanostructures for advanced applications



Evolution of second-generation nanoparticles. (a) Nanoparticles coated with surfactant for forming stable suspension, (b) Nanoparticle coated with thin metallic layer, (c) Small nanoparticle coated with porous ceramic layer and (d) dispersion of core-shell combination of (a) and (c) for stable suspension.



(a) Au coated magnetite nanoparticles prepared by sequential microemulsion processing

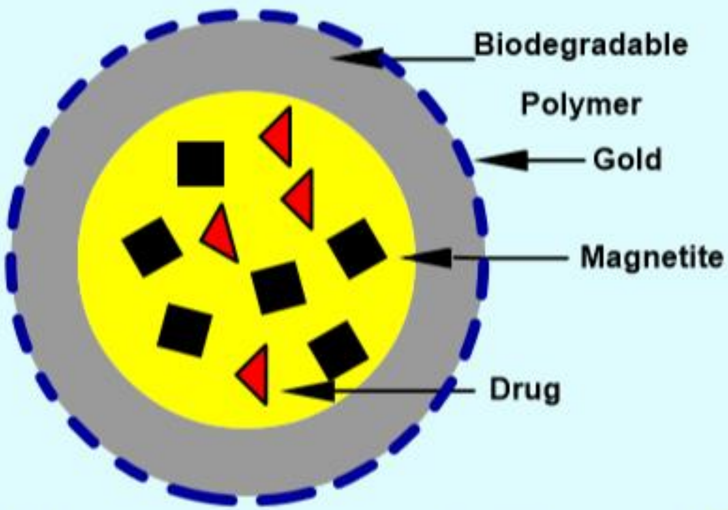
(b) Au coated SiO2,

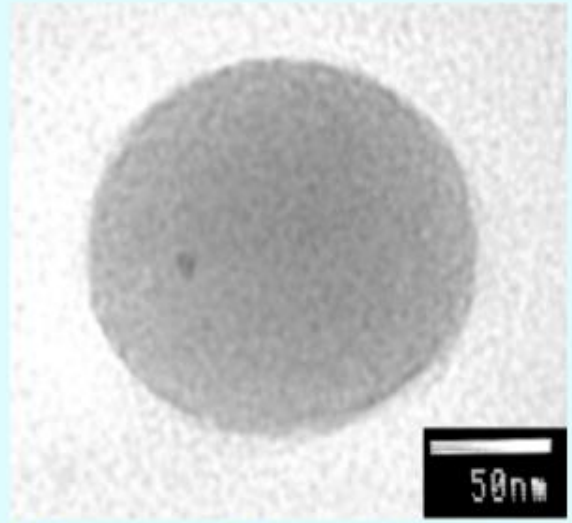
(c) SiO2 coated Au nanospheres prepared by sol-gel method,

(d) self-assembled Au nanoparticles on SiO2 nanospheres

TEM images of second-generation nanoparticles.

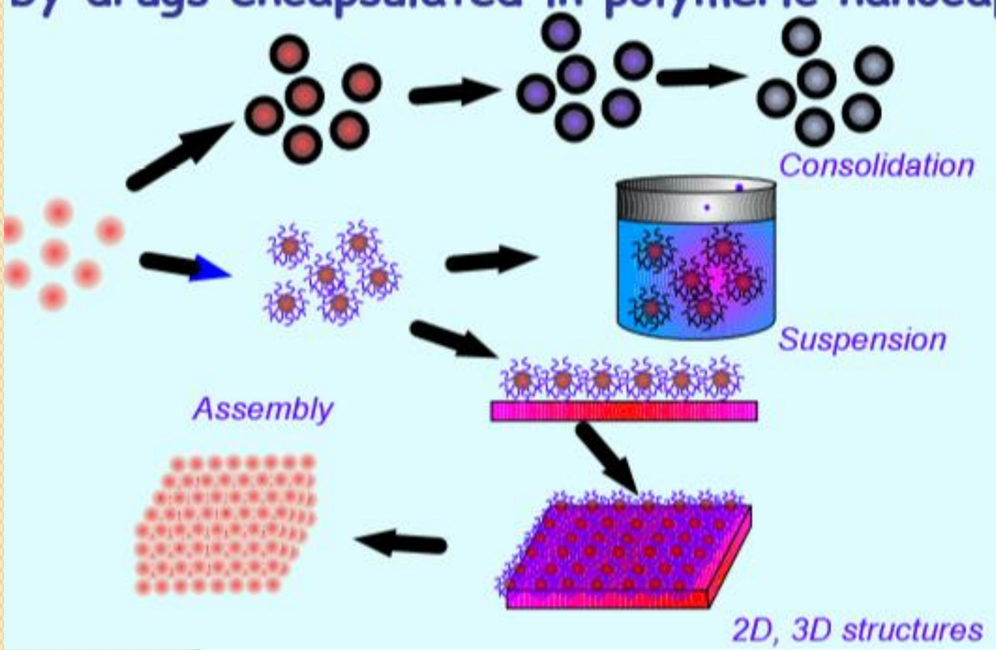
EXAMPLES OF ADVANCED GENERATION NANOPARTICLES





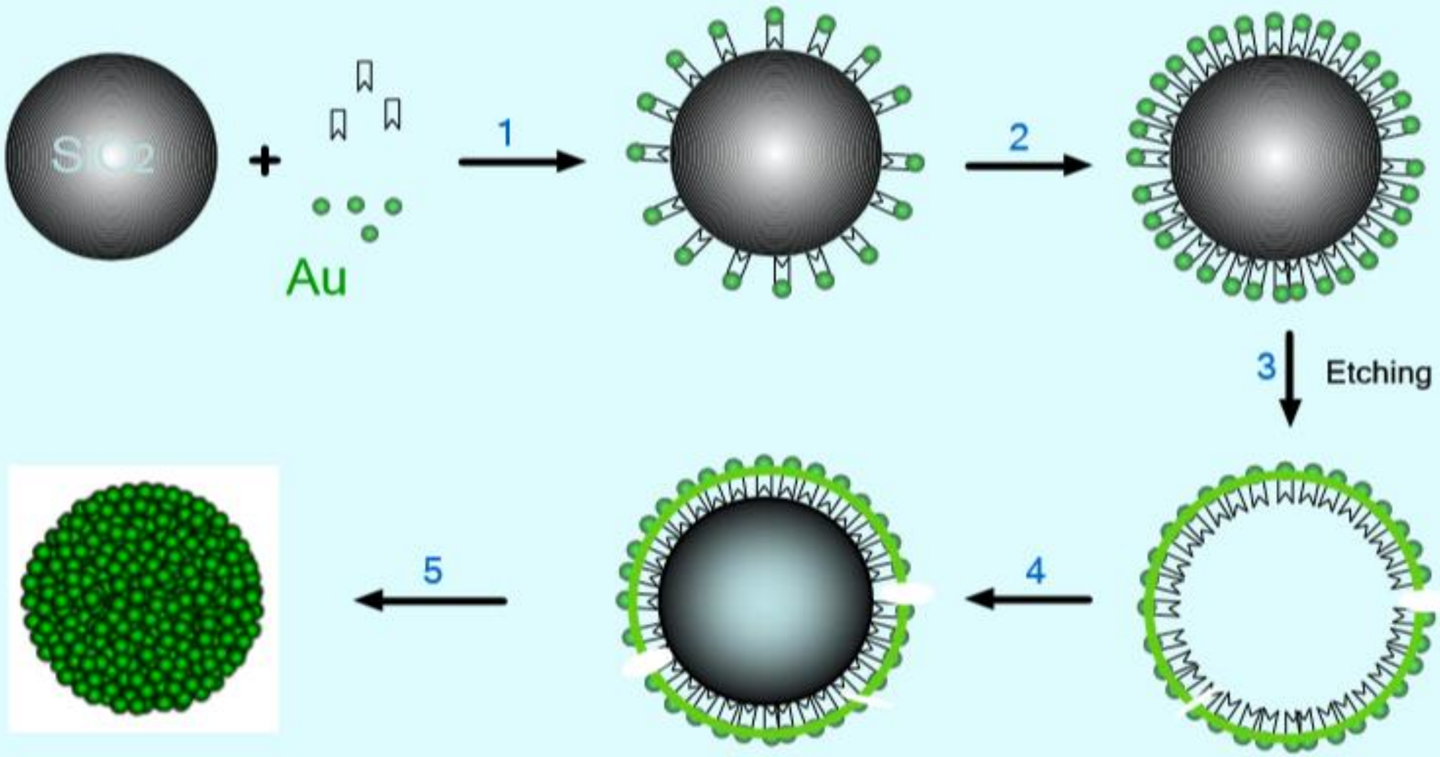
Advanced generation nanoparticles engineering and use in nanotechnology has recently emerged as the need for the fabrication of nanoparticles with highest degree of complexity.

Schematic representation and TEM image of target-oriented drug release by drugs encapsulated in polymeric nanocapsule.



A general overview of the construction of 2D and 3D nanostructures with nanoparticles as building blocks.

Rutgers The State University of New Jersey



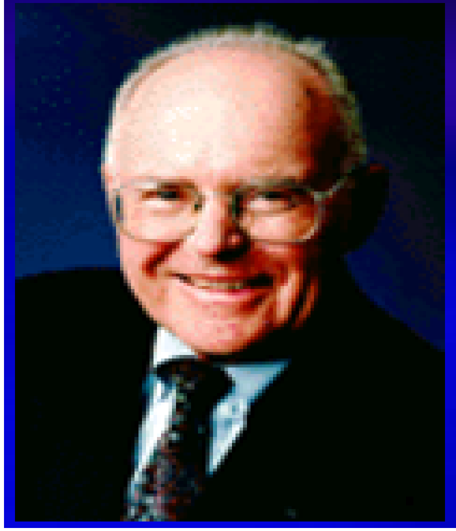
Fabrication of Complex structures via Self assembly and Templating

Prospective

for

Nanocomputer

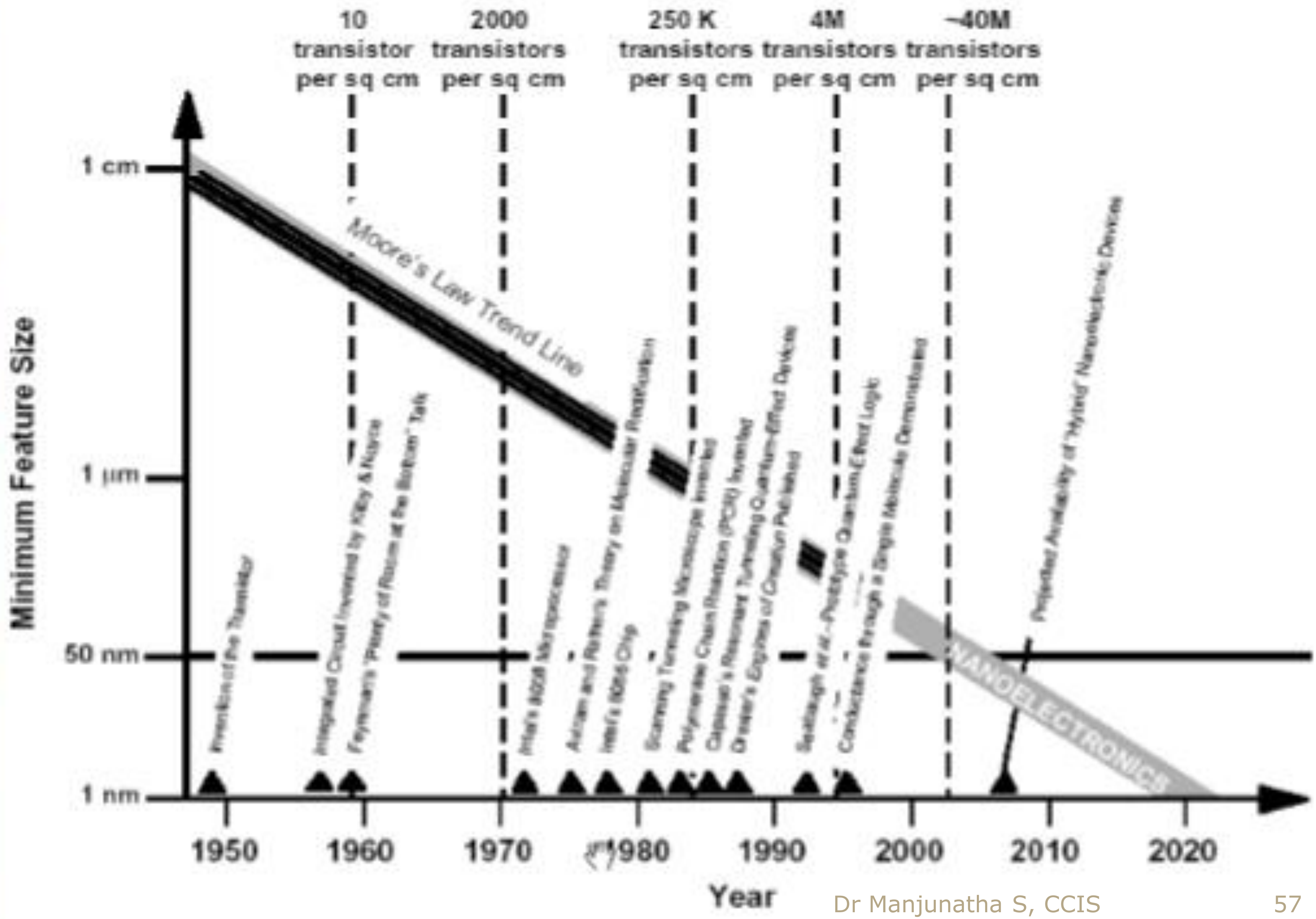
Moore's Law



Gorden Moore
Co-Founder of Intel Corp

- CPU is doubled in performance every 18 months.
- The size of semiconductor chip is decreasing by a factor of 2 every 1.5 years.
- The no. of transistors the industry would be able to place on a computer chip would double every 1.5 years.
- Cost of constructing a new Fabs will double every 3 years.

Living on the Moore's Curve



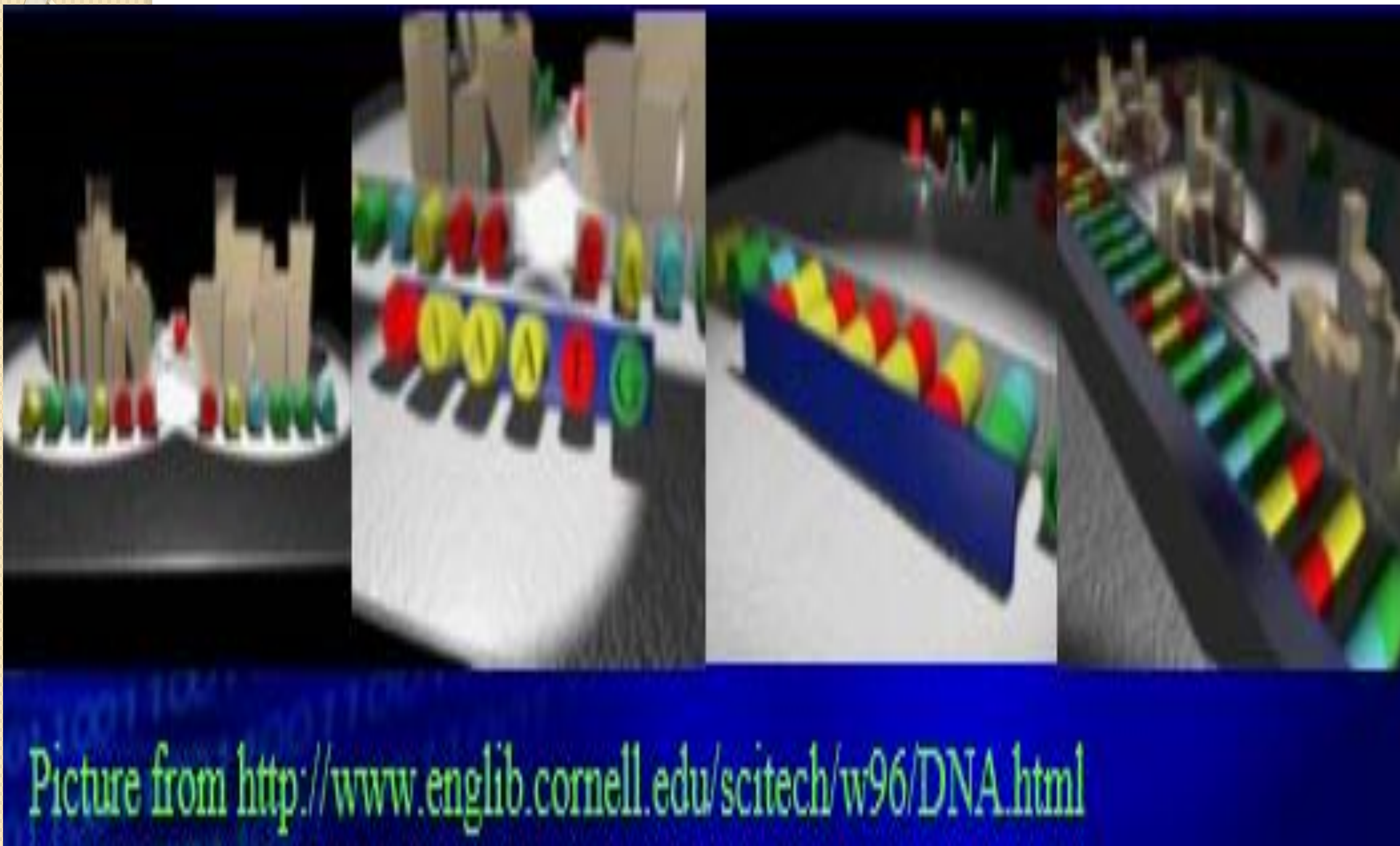
- Averin and Likkharev (1985), later 1987, first achievements in nanocomputer research was development of single electron tunneling (SET) transistor.
- Technique developed in nanofabrication created transistor, diodes, relays and logic gates from carbon nanotubes.
- Research is going on different types of nanowires (semiconductor nanowire) and how to interconnect and integrate components to build a computer processor.
- Recently, semiconductor industry has succeed to built 70 mega bit memory chip containing half billion transistors. Shortly, we can expect silicon based nanocomputer into reality.

A tiny diamond wire, taking to the next generation of computing devices.

Scientists have been looking at spin, or "spintronics." Spin in electrons is either up or down, and could store bits of information the way that a flow of electrons being on or off does.

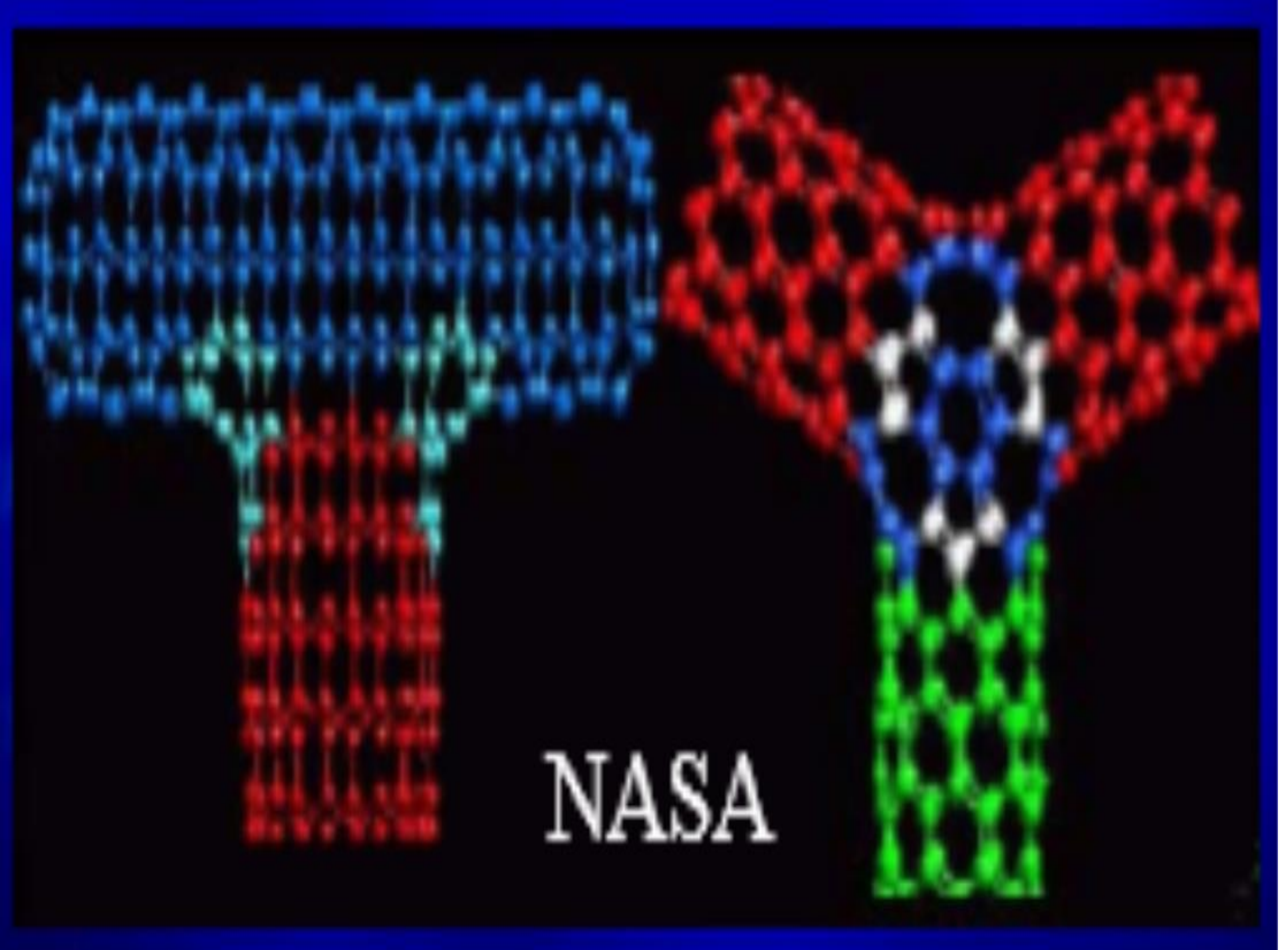
Such devices would emit less heat as they don't rely on current, allowing for smaller circuits.

DNA Computing



Nanocomputer using DNA computing.

- Adleman (1994), introduced idea of solving complex mathematical problem, travelling salesman problem by DNA (Deoxyribo-Nucleic Acid). Hamilton's path problem
- DNA molecule can store more information than conventional memory chip and parallel computations makes area small.
- Researcher at univ.(1997) of Rochester built DNA logic gates, another step towards DNA computer.


NASA

Quantum computer

The Next Generation of Computing Devices?

Quantum Computer

- In 1982, Feynmanin, Bennett and Deutsch, proposed to build a Quantum Computer.
- A computer that uses quantum mechanical phenomena to perform operations on data through devices such as superposition and entanglement.
- Use quantum bit (qubit) from the physical properties of materials, i.e. spin state, polarization.

- Harnesses the power of atoms and molecules to perform memory and processing tasks
- Parallel Processing – millions of operations at a time, 30-qubit quantum computer equals the processing power of conventional computer that running at 10 teraflops (trillions of floating-point operations per second).
- Quantum Bit (Qubit)
  - 2 Basic states –
    ket 0, ket 1:
  - Superposition of both states (not continuous in nature)

Pure Quibit State:

$$\Psi = a|0\rangle + b|1\rangle$$

where $a, b \in$ □

$$\text{s.t. } 1 = \sqrt{|a|^2 + |b|^2}$$

$\therefore$ 8 Possible States per Qubit

Classical vs Quantum Bits

- Classical Bit
  - 2 Basic states – off or on: 0, 1
  - Mutually exclusive
    - Quantum entanglement
      - 2 or more objects must be described in reference to one another
      - Entanglement is a non-local property that allows a set of qubits to express superpositions of different binary strings (01010 and 11111, for example) simultaneously

$$|0\rangle, \ |1\rangle$$

Pure Quibit State:

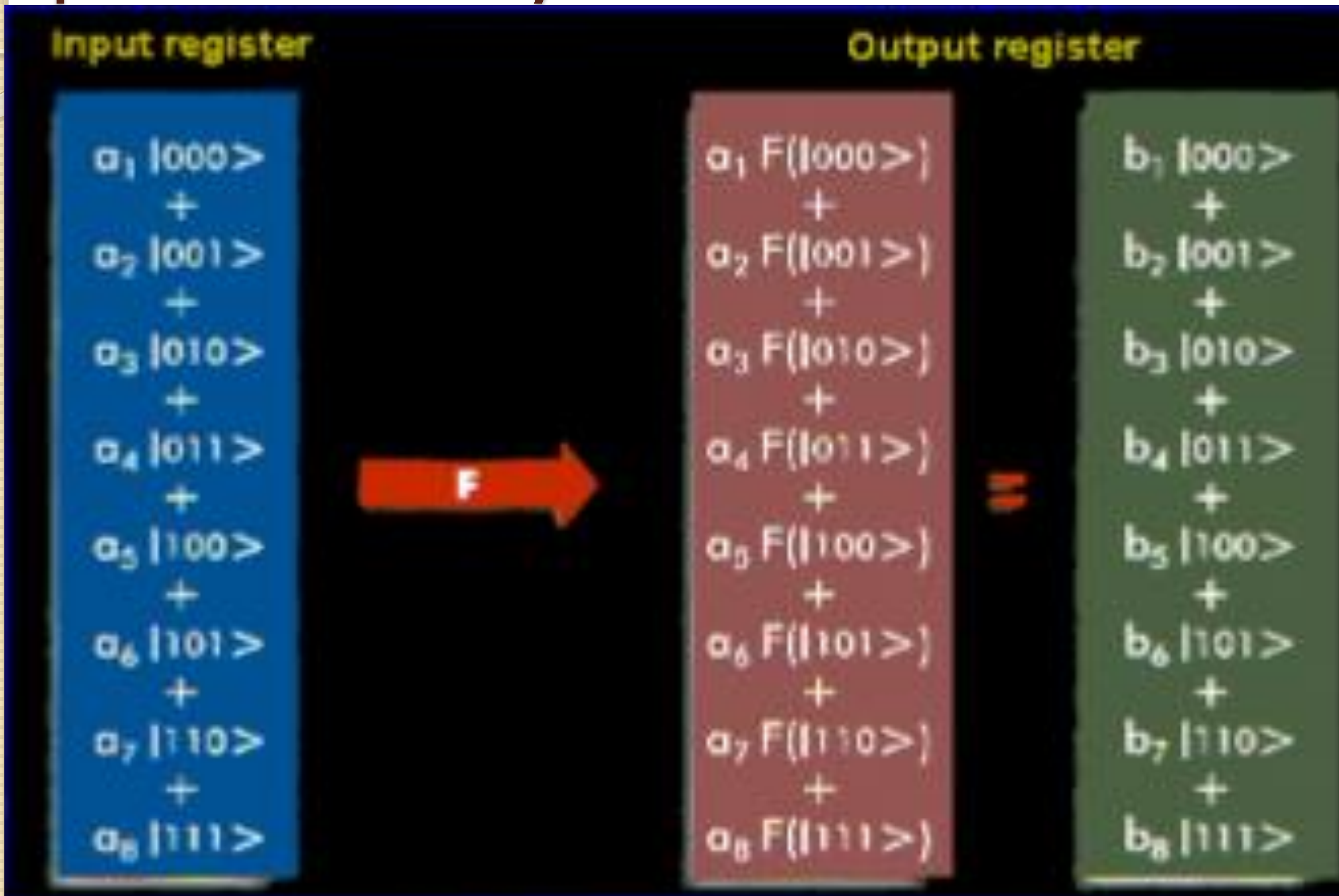
$$\Psi = a\,|0\rangle + b\,|1\rangle$$

where $a, b \in$ □

$$\text{s.t. } 1 = \sqrt{|a|^2 + |b|^2}$$

$\therefore$ 8 Possible States per Qubit

Based on the principles of quantum Physics

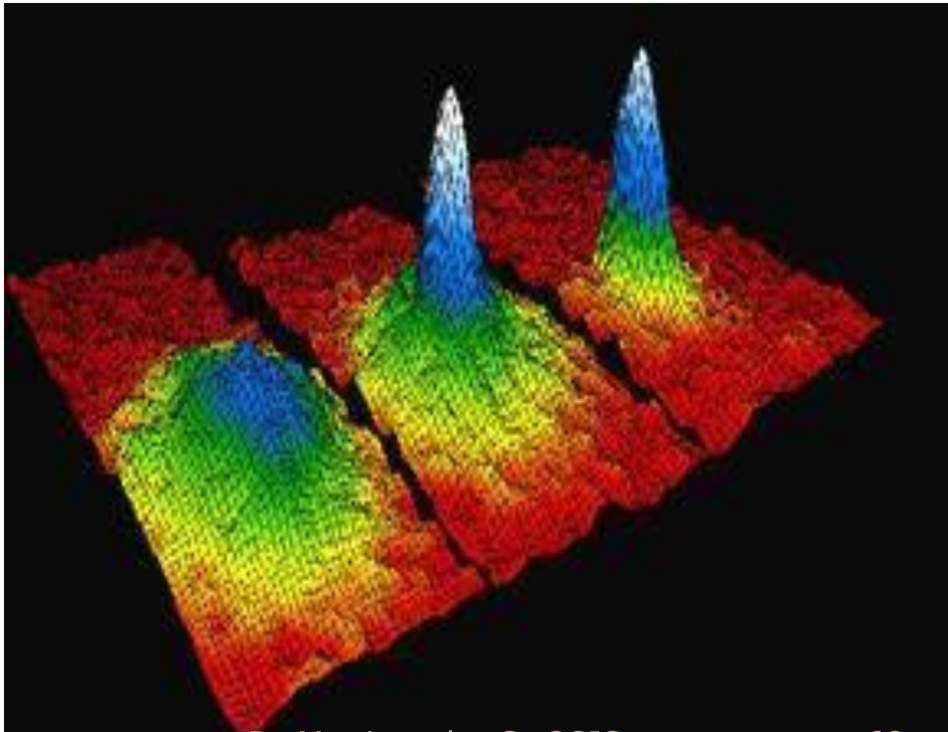


Earth Simulator

Supercomputer:
40 T flop/s (4×10^{12} flop/sec)
–

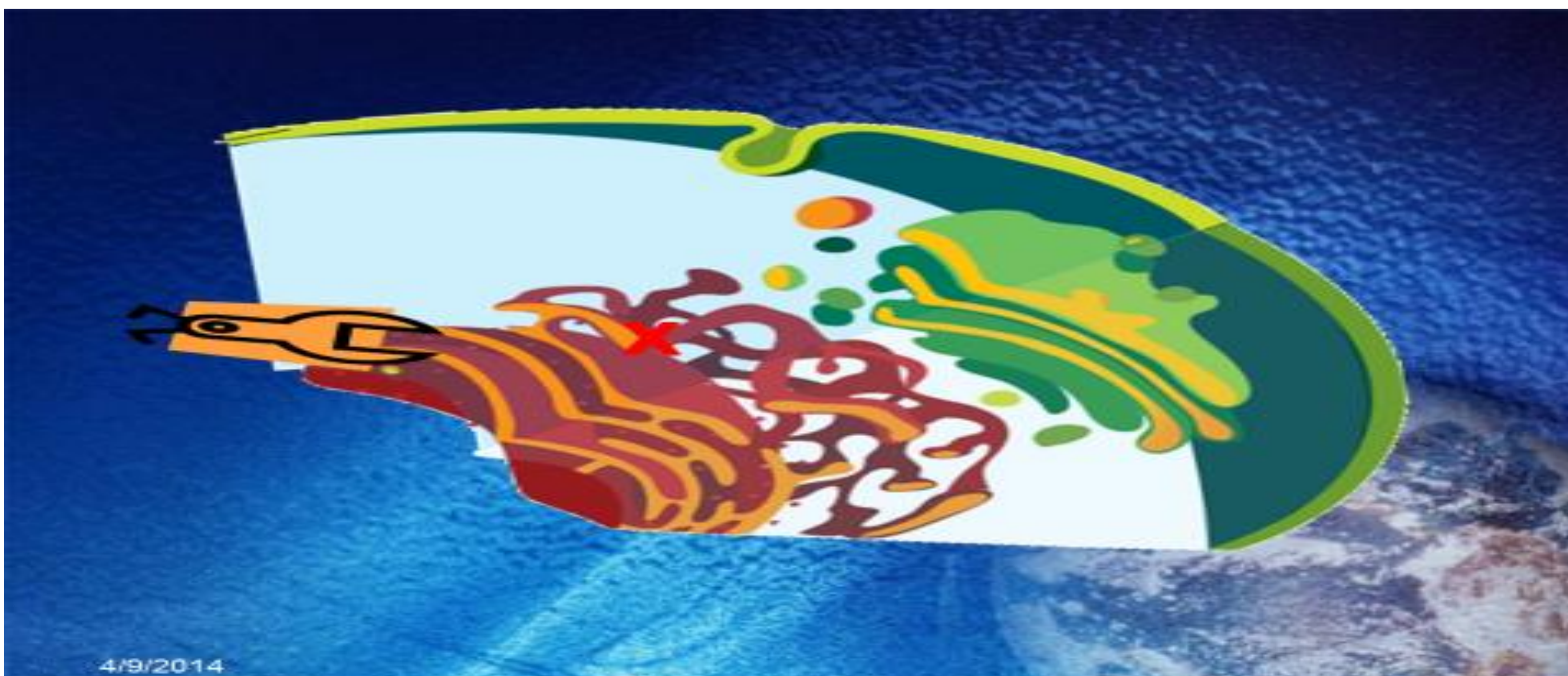
Quantum Computer and security

Telephone hacking
Computer virus
Network hacking



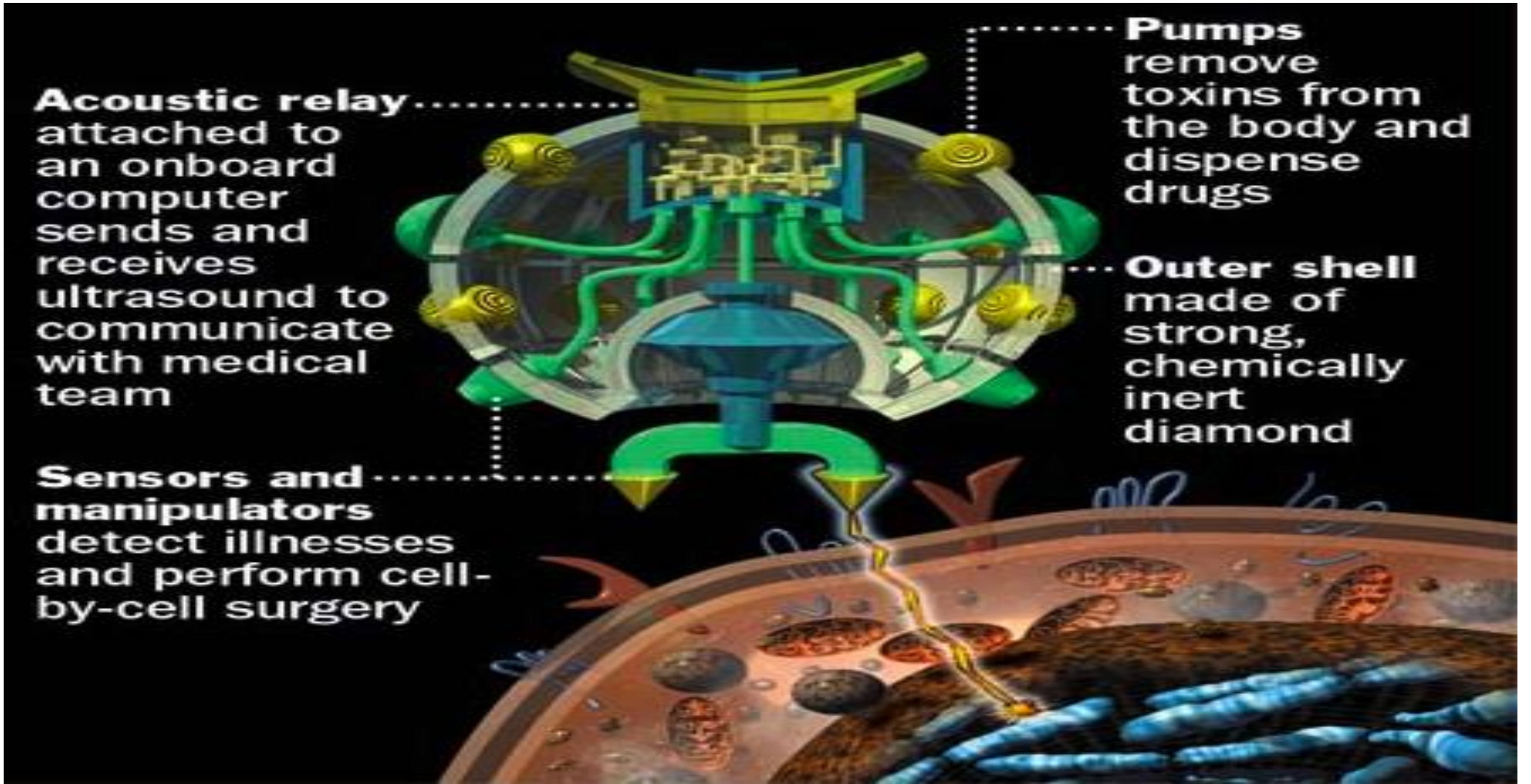
Nano Robot

Device with robotic arms, motors, sensors and computers to control the behavior at nanoscale.

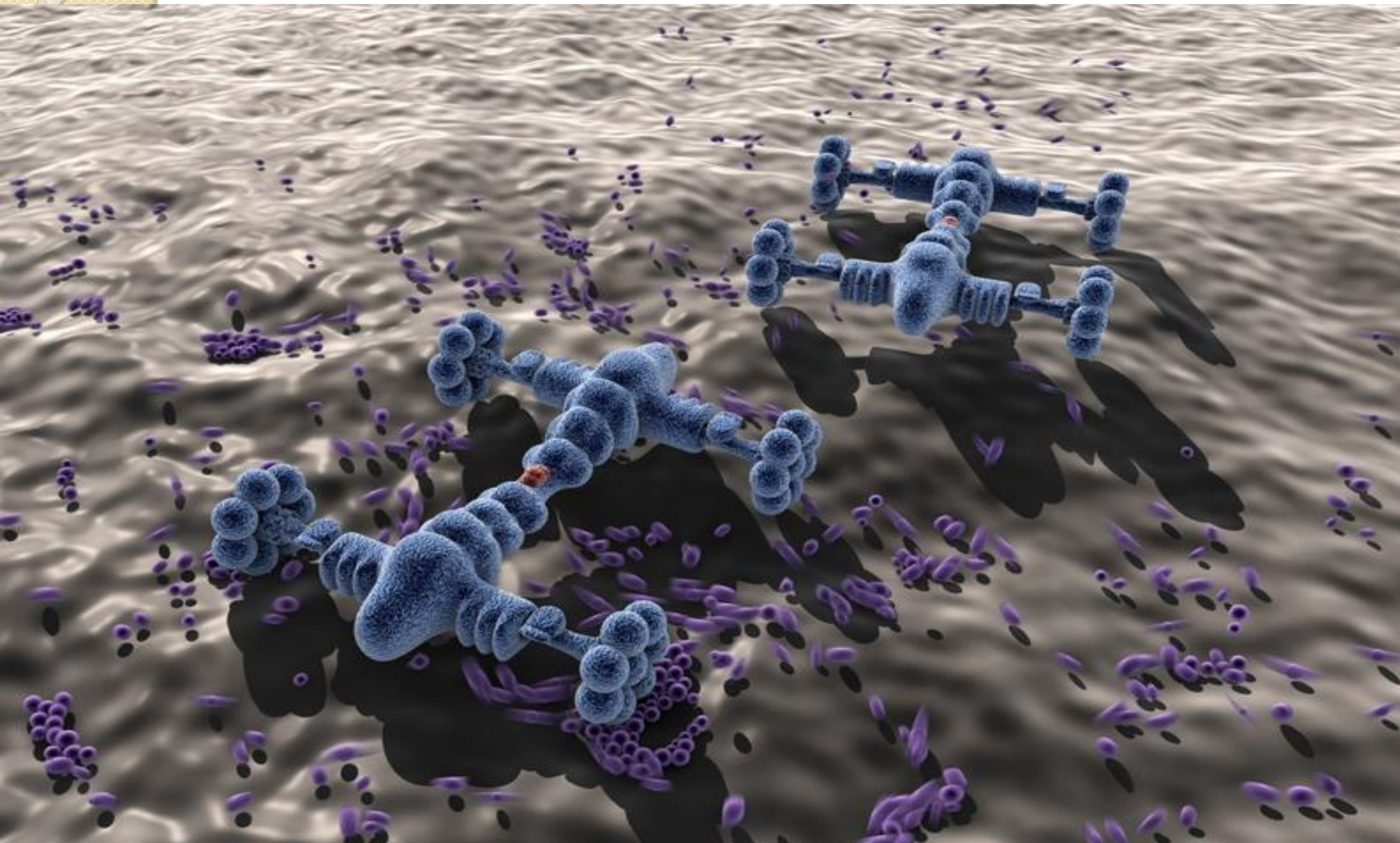


Nano robots are imaginary, but nano sized delivery systems could…

Break apart kidney stones, clear plaque from blood vessels, ferry drugs to tumor cells



Jesse Emspak, Live Science Contributor , April 09, 2014 09:10am, reported nanorobot, the ability to follow specific instructions, making them programmable. Such tiny robots could do everything from target tumors to repair tissue damage.



The programmable DNA nanorobot

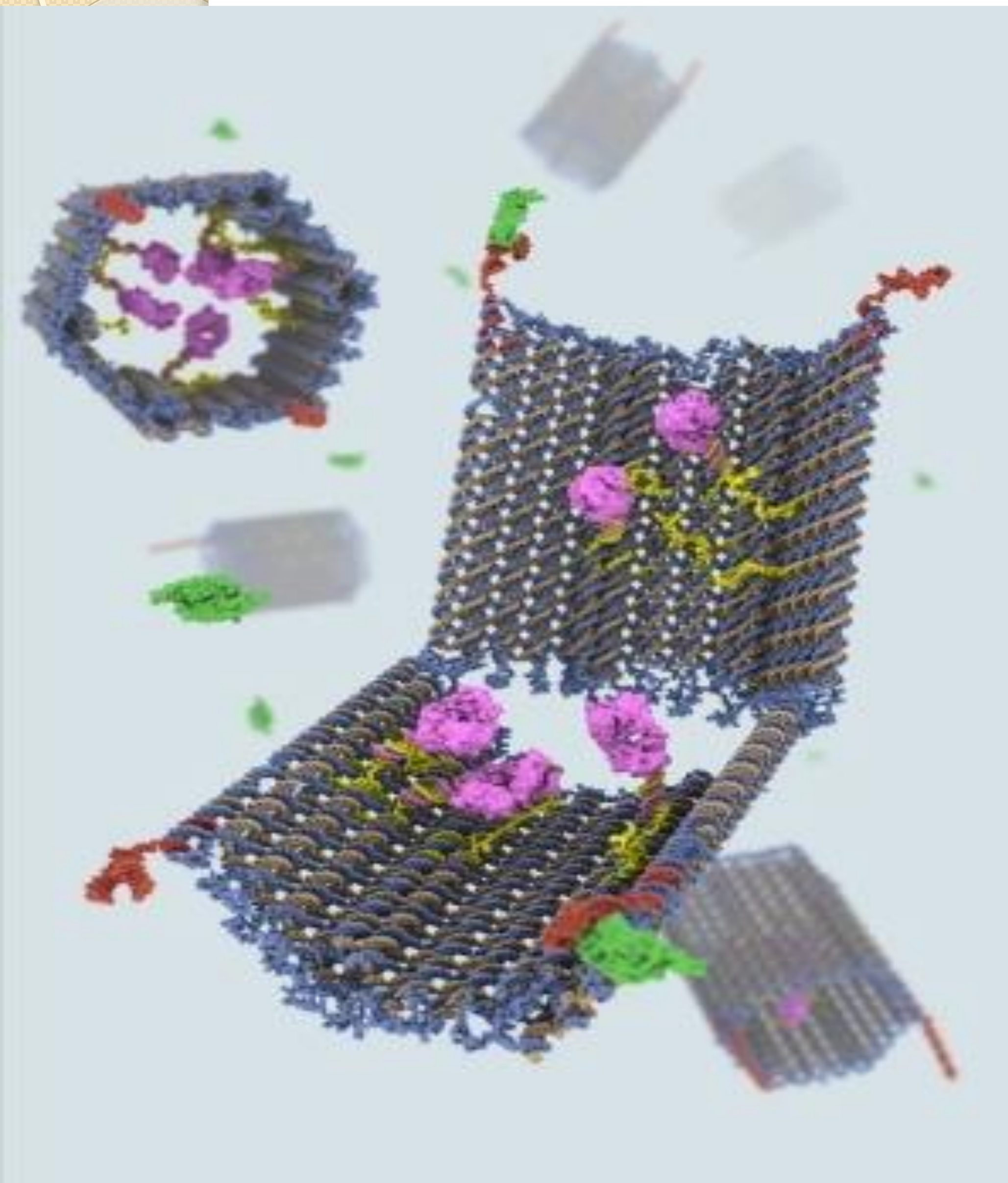
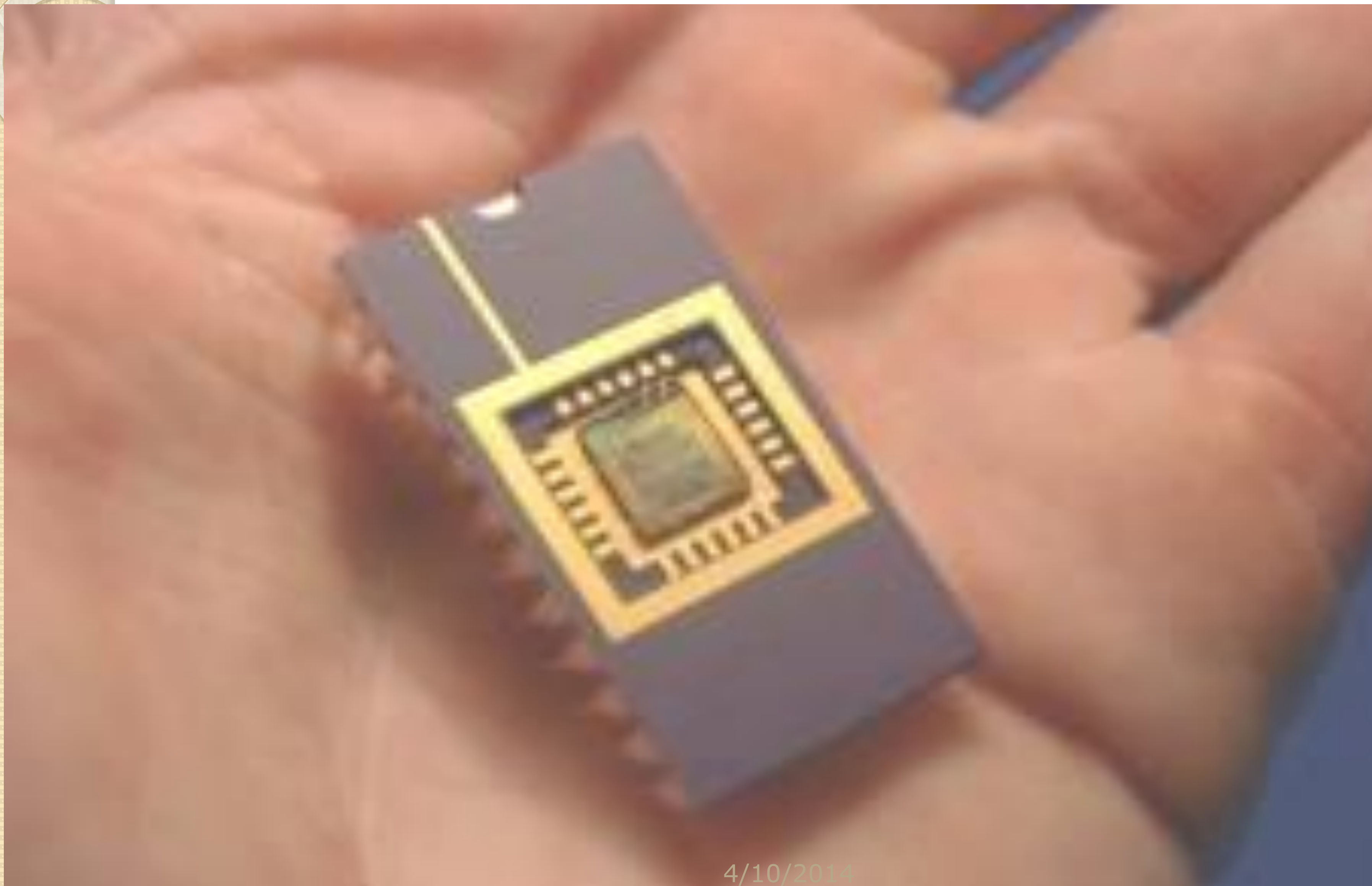


Image created by Campbell Strong, Shawn Douglas, and Gaël McGill using Molecular Maya and cadnano.

Courtesy : Wyss Institute for Biologically Inspired Engineering at Harvard University

Health Care: Biosensors



Benefits of Computer Science for Nanotechnology:

- Recently, M. C. Roco of the National Nanotechnology Initiative (NNI), an organisation officially founded in 2001 to initiate the coordination among agencies of nanometre-scale science and technology in the USA, gave a timeline for nanotechnology to reach commercialization

- The first generation, which just ended in 2004, involved the development of passive nanostructures such as coatings, nanoparticles, nanostructured metals, polymers and ceramics.

- The second generation, 2004-2010, could able to manufacture active nanostructures including transistors, amplifiers, targeted drugs, and adaptive structures.

- The third generation started from 2010. It is estimated nanosystems. For example: guided molecular assembling systems, 3D networking and new system architectures, robotics and supramolecular devices, would be developed.

- The fourth generation of nanotechnology (from 2020) should be the generation of molecular nanosystems, which would use molecules as devices or components at atomic levels.

- Other current uses of computer science for nanotechnology include developing software systems for design and simulation.

- A research group at NASA has been developing a software system, called NanoDesign, for investigating fullerene nanotechnology and designing complex simulated molecular machines.

Intelligent Systems (IS)

- Research in IS involves the understanding and development of intelligent computing techniques as well as the application of these techniques for real- world tasks

- PACE-Programmable Artificial Cell Evolution, a project aims to create "nano-scale artificial protocell able to self-replicate and evolve under controlled conditions". Protocell (like nano robot) which is simplest technically feasible elementary living cell.

- In addition to this work, computer modelling of embryogenesis and developmental systems is becoming increasingly popular in computer science

Swarm Intelligence

- The new emerging technique, Swarm Intelligence, which is inspired by the collective intelligence in social animals such as birds, ants, fish and termites (require no leader and may not be intelligent).
- Collective behaviours emerge from interactions among individuals, in a process known as self-organization. Together they perform complex collaborative behaviours can use to solve various optimisation problems.
- Depend up on the problems, three main types of swarm intelligence techniques are used like Models of bird flocking, Ant colony optimisation (ACO) algorithm, and Particle swarm optimisation (PSO) algorithm.

Swarm Intelligence contd..

- Although still a young field of computer science, swarm intelligence is becoming established as a significant method for parallel processing and simultaneous control in order to produce a desired emergent outcome.
- Researchers (Santa Fe Institute) developed a multi-agent software platform, called Swarm, inspired by collaborative intelligence in social insects, for simulating complex adaptive systems.
- Likewise, BT’s Future Technologies Group developed a software platform known as EOS, for Evolutionary Algorithms (EAs) and ecosystem simulations and so on.

Swarm Intelligence contd..

- SI techniques used for complex adaptive, where no exact mathematical model of the system exists.
- The Autonomous Nanotechnology Swarm (ANTS) architecture for space exploration by NASA.
- In 1996, Holland and Melhuish investigated the abilities of single and multiple agents on a task with agents under similar circumstances as future nanorobots (minimal sensing, mobility, computation and environment).
- Recently, a new swarm algorithm proposed, the Perceptive Particle Swarm Optimisation (PPSO) algorithm, suitable for programming or controlling the agents of nanotechnology (whether nanorobots, nanocomputers or DNA computers)

Nanotechnology Applications

Information Technology

- Smaller, faster, more energy efficient and powerful computing and other IT-based systems

Energy

More efficient and cost effective technologies for energy production

- Solar cells
- Fuel cells
- Batteries
- Bio fuels

Medicine

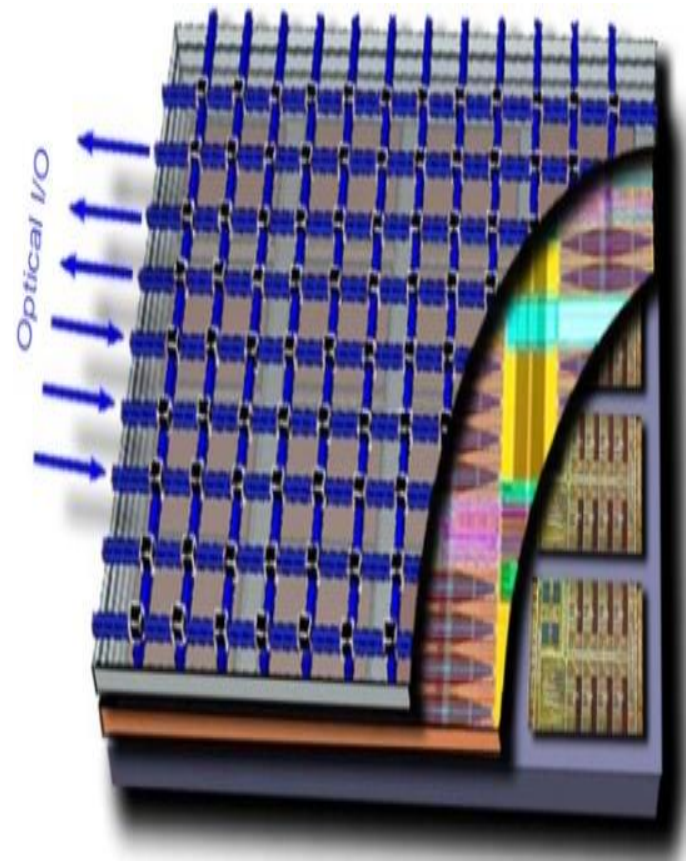
- Cancer treatment
- Bone treatment
- Drug delivery
- Appetite control
- Drug development
- Medical tools
- Diagnostic tests
- Imaging

Consumer Goods

- Foods and beverages
  - Advanced packaging materials, sensors, and lab-on-chips for food quality testing
- Appliances and textiles
  - Stain proof, water proof and wrinkle free textiles
- Household and cosmetics
  - Self-cleaning and scratch free products, paints, and better cosmetics

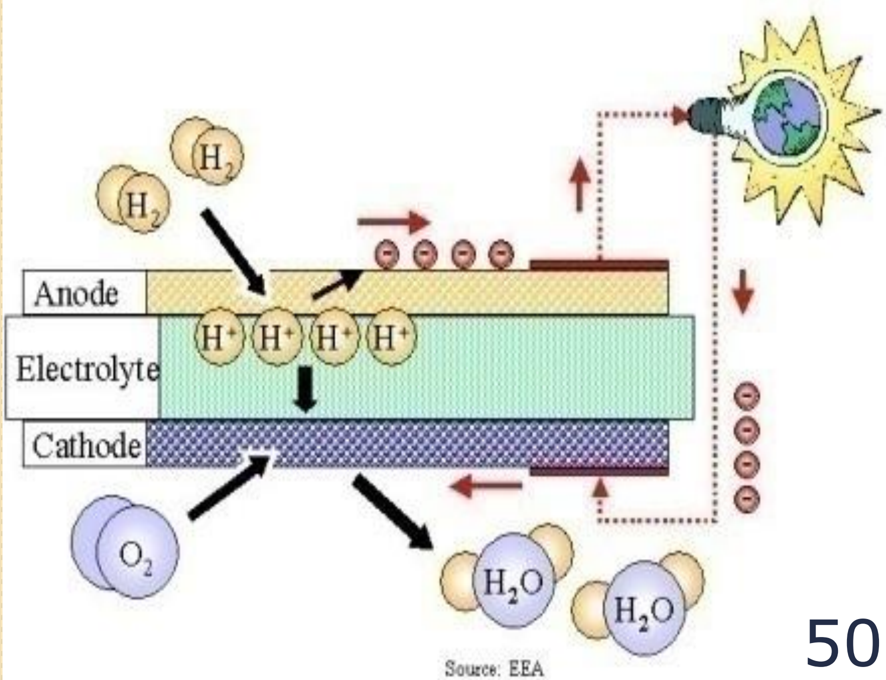
Nanophotonic Systems

- Nanophotonic systems work with light signals vs. electrical signals in electronic systems
- Enable parallel processing that means higher computing capability in a smaller chip
- Enable realization of optical systems on semiconductor chip



Fuel Cells

- Fuel cells use hydrogen and air as fuels and produce water as by product
- The technology uses a nanomaterial membrane to produce electricity



500 W fuel cell

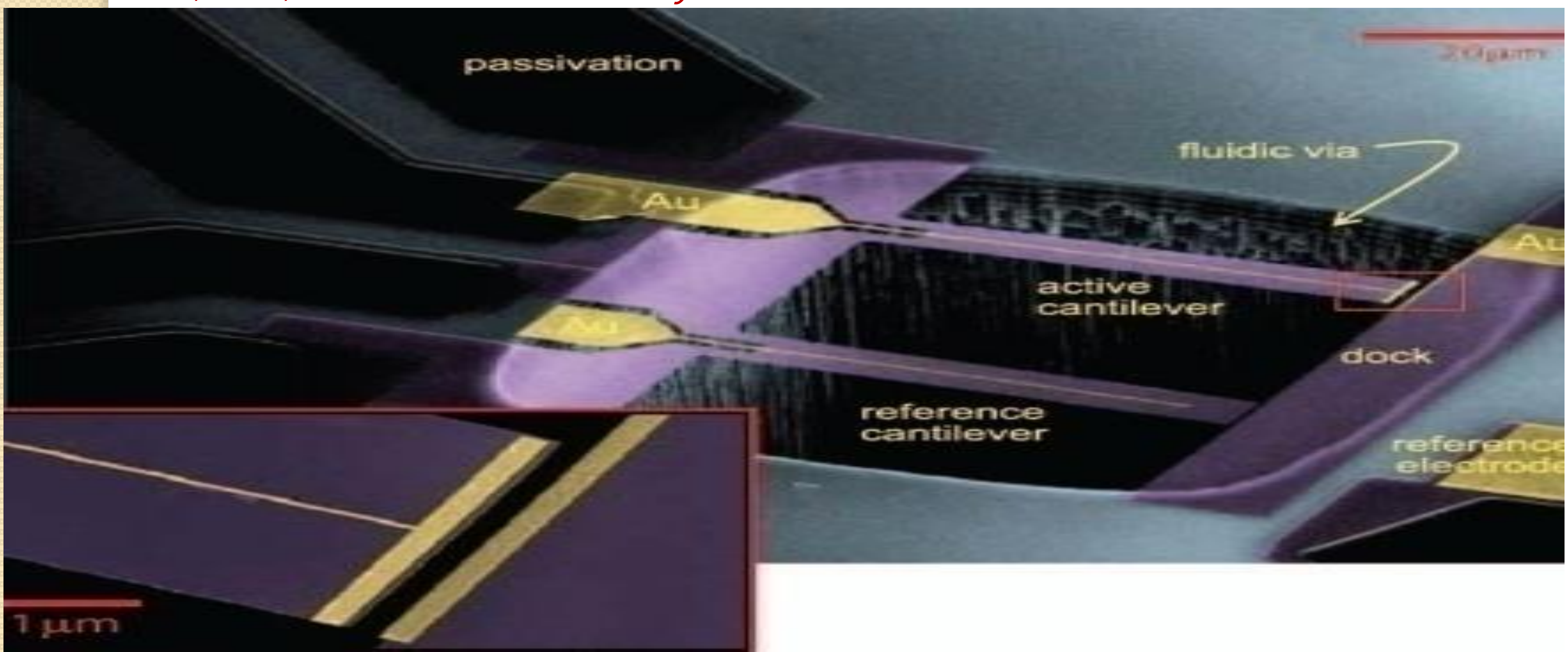
Futurist and inventor Ray Kurzweil, predicts solar power will scale up to produce all the energy needs of Earth's in 20 years.

Nanoelectromechanical System (NEMS) Sensors

- NEMS technology enables creation of ultra small and highly sensitive sensors for various applications
- The NEMS force sensor is applicable in pathogenic bacteria detection

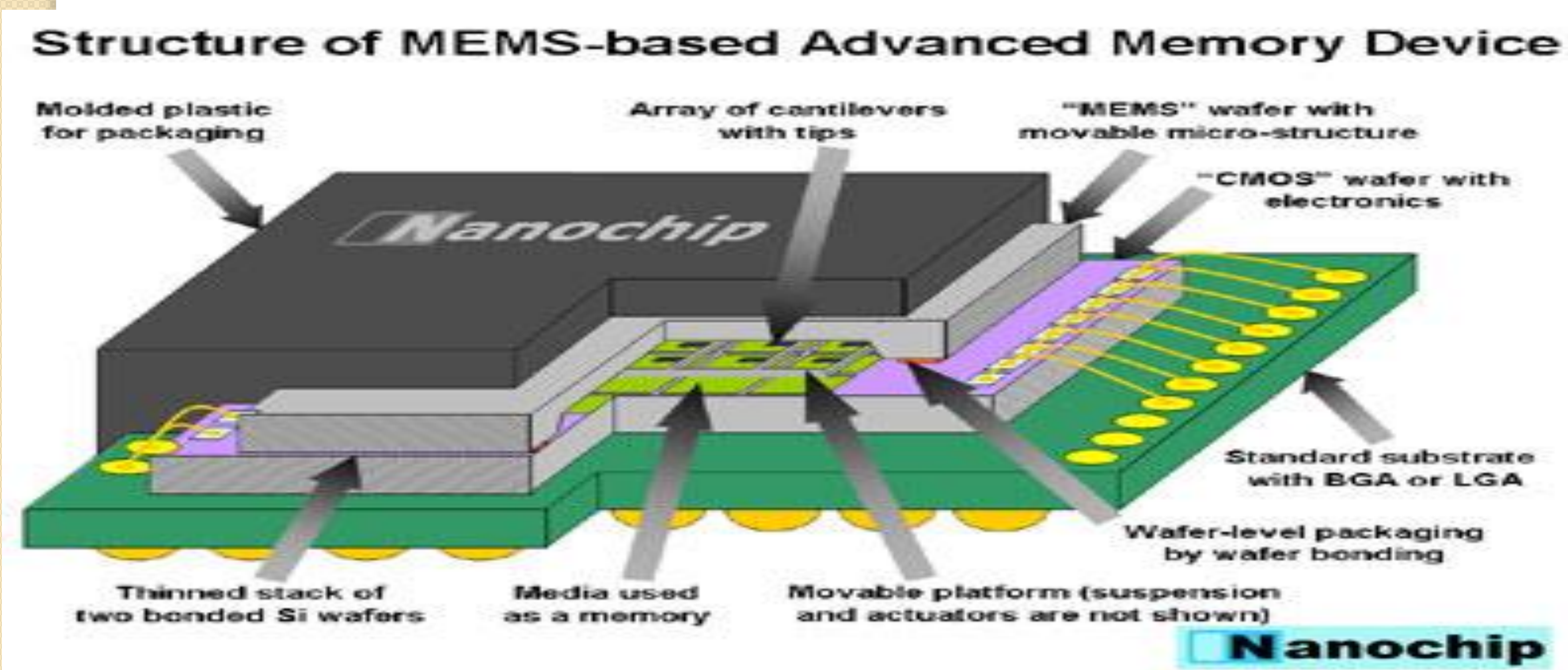
A NEMS bacteria sensor

– Nano Lett., 2006, DOI: 10.1021/nl060275y

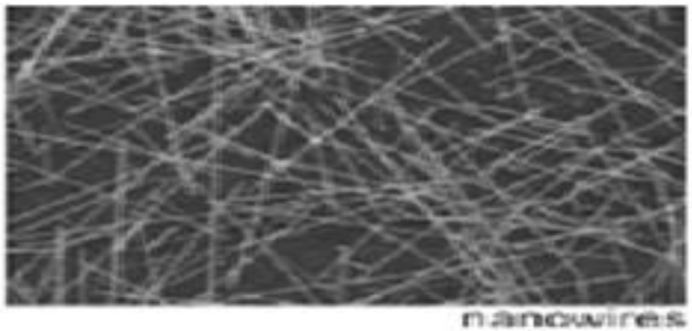


Nanochip

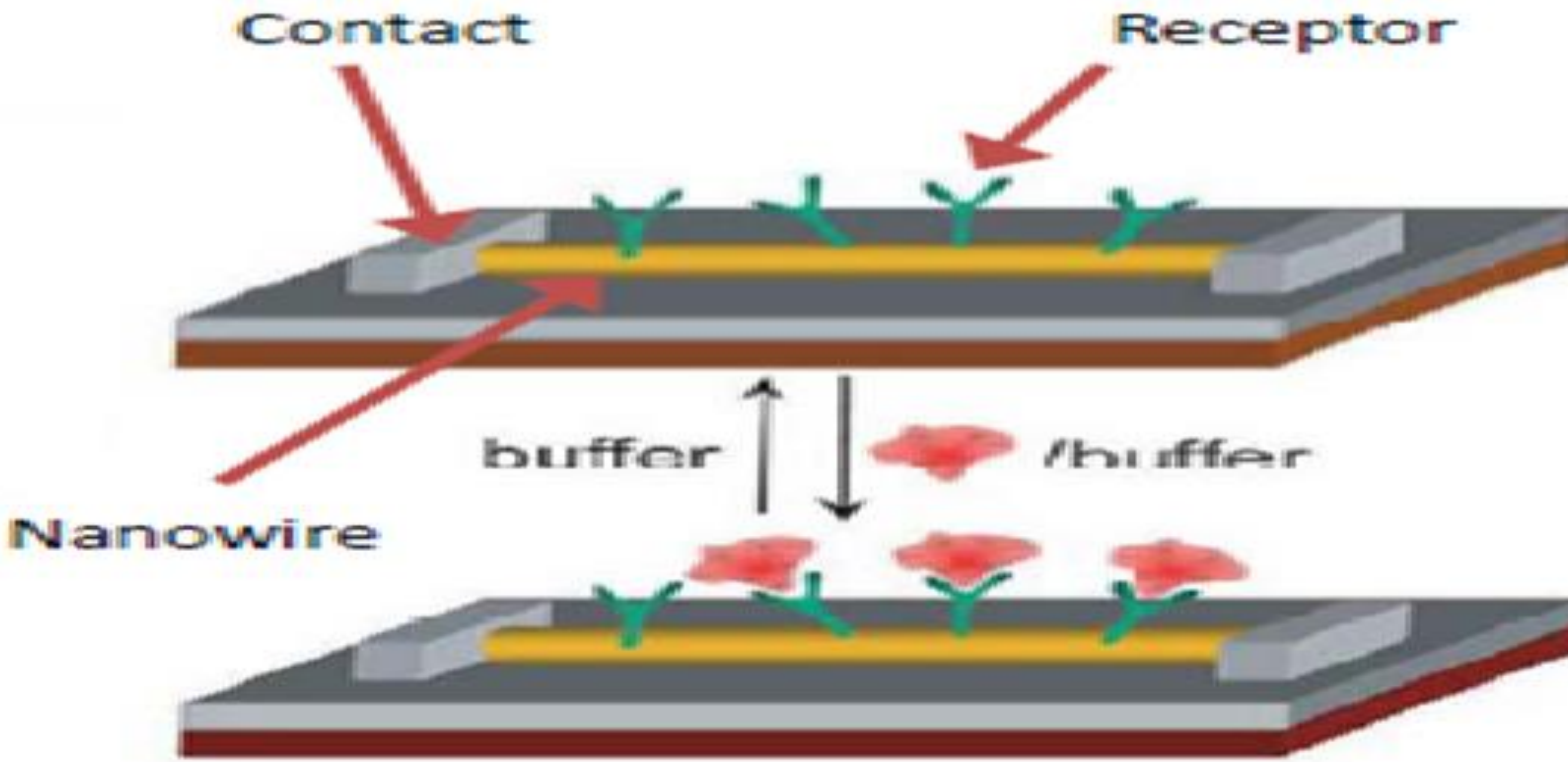
- Currently available microprocessors use resolutions as small as 32 nm
- Houses up to a billion transistors in a single chip
- MEMS based nanochips have future capability of 2 nm cell leading to 1TB memory per chip



Nanowire chemical sensors

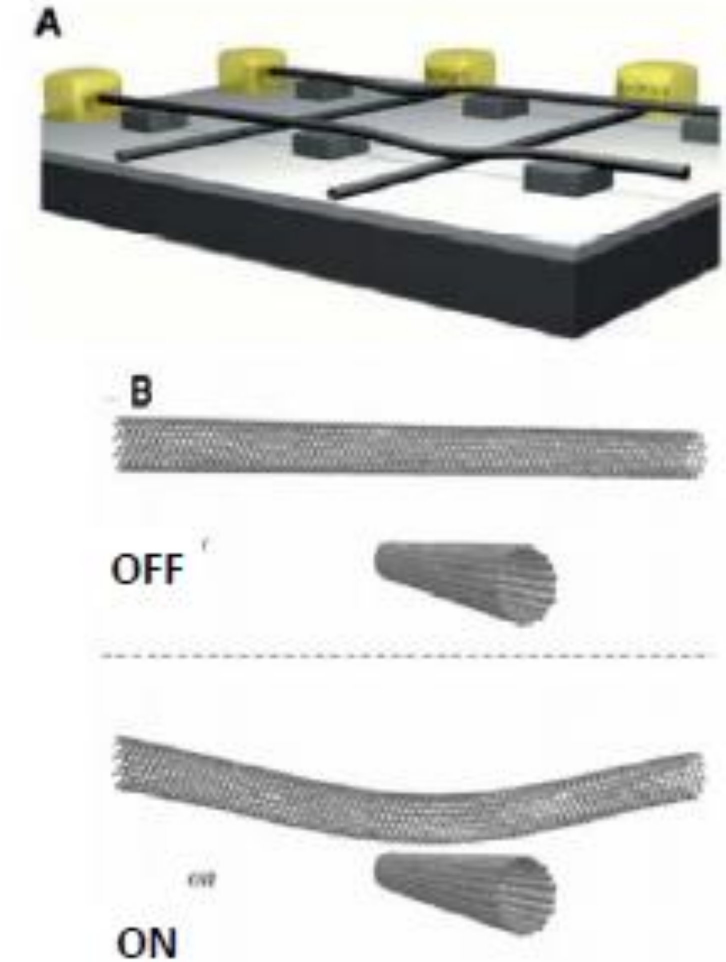


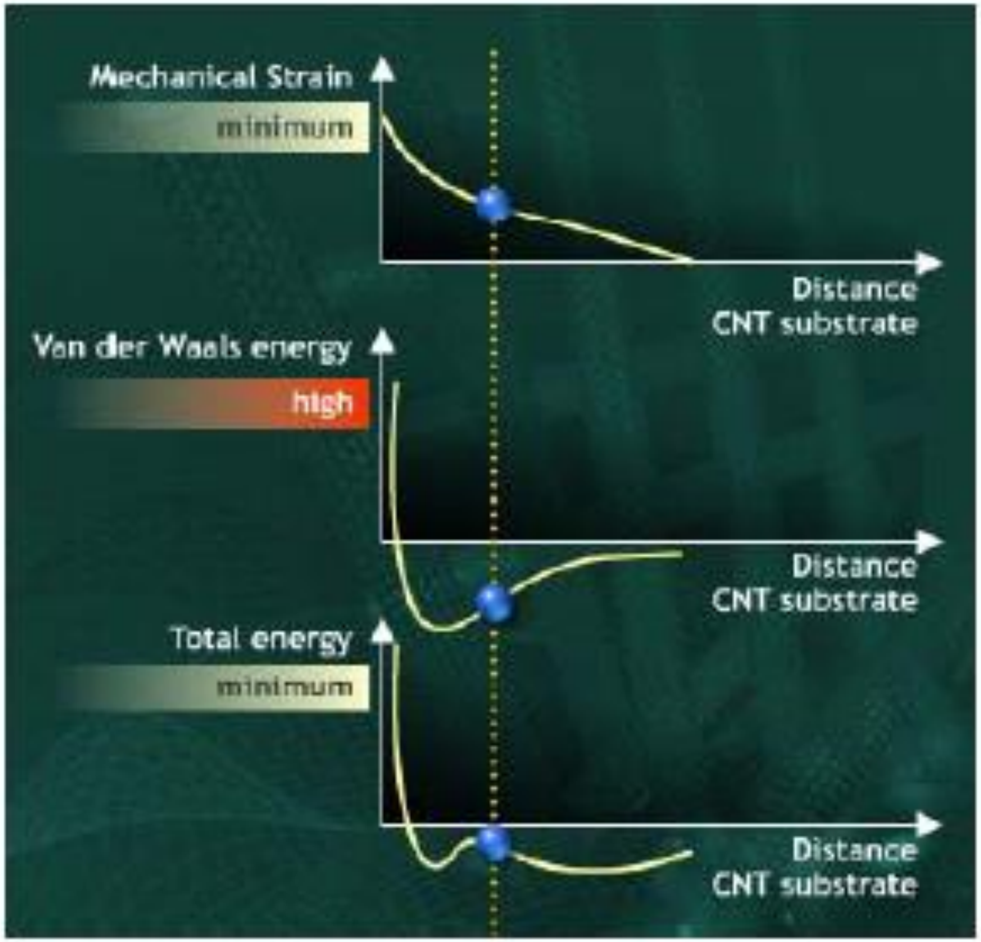
Reversible binding of biomolecules



CNT-based memory (Nantero, Inc.)

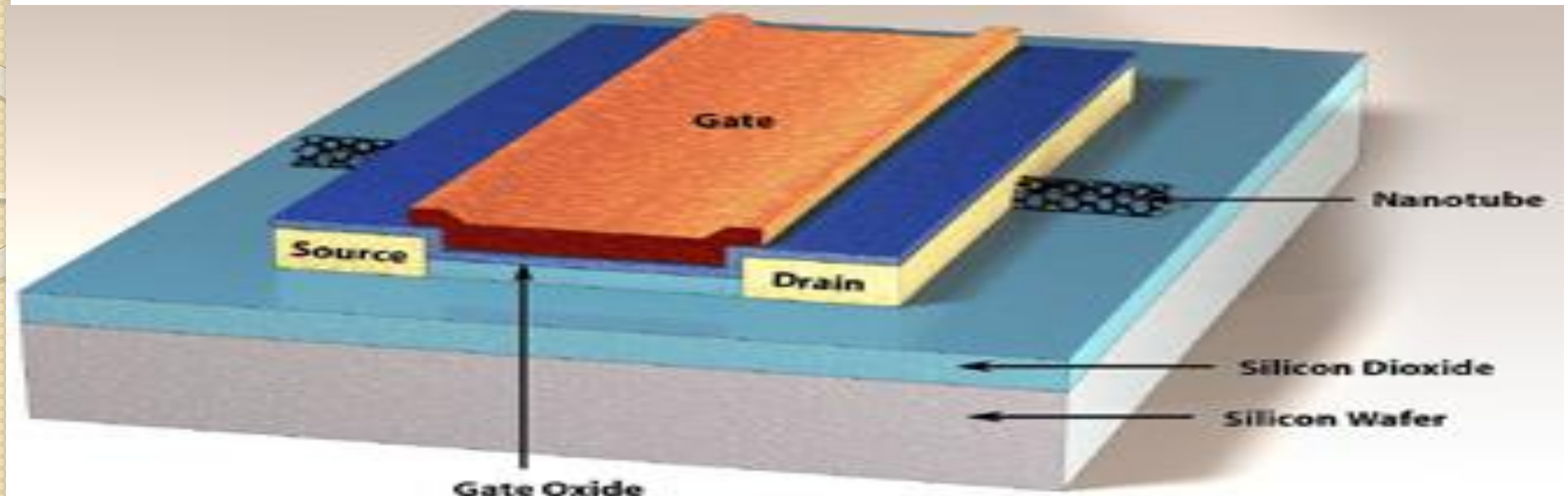
The concept (1998)





Reversible electromechanical junction

Carbon Nanotube FET



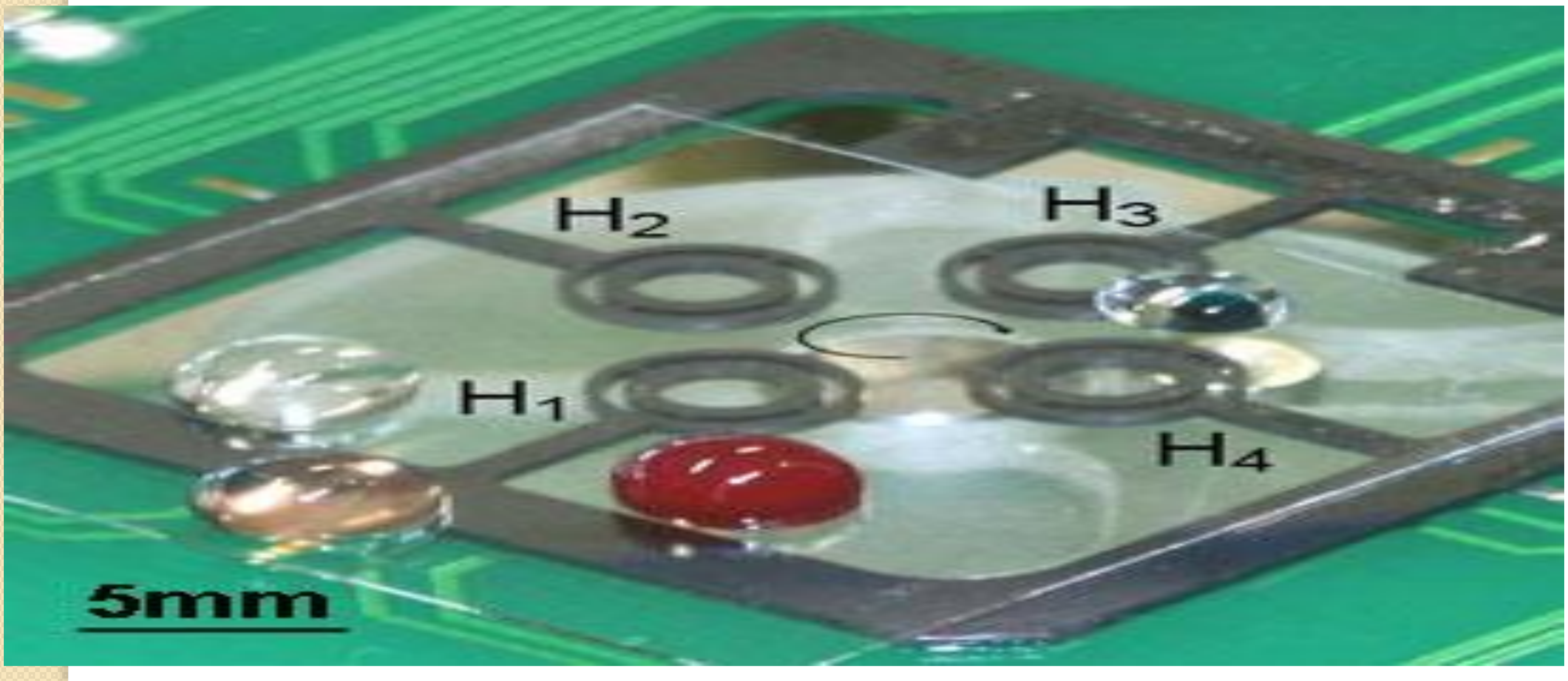
Courtesy: IBM

- CNT can be used as the conducting channel of a MOSFET.
- These new devices are very similar to the CMOS FETs .
- All CNFETs are pFETs by nature.
- Very low current and power consumption
- Although tubes are 3nm thick CNFETs are still the size of the contacts, about 20nm.

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**



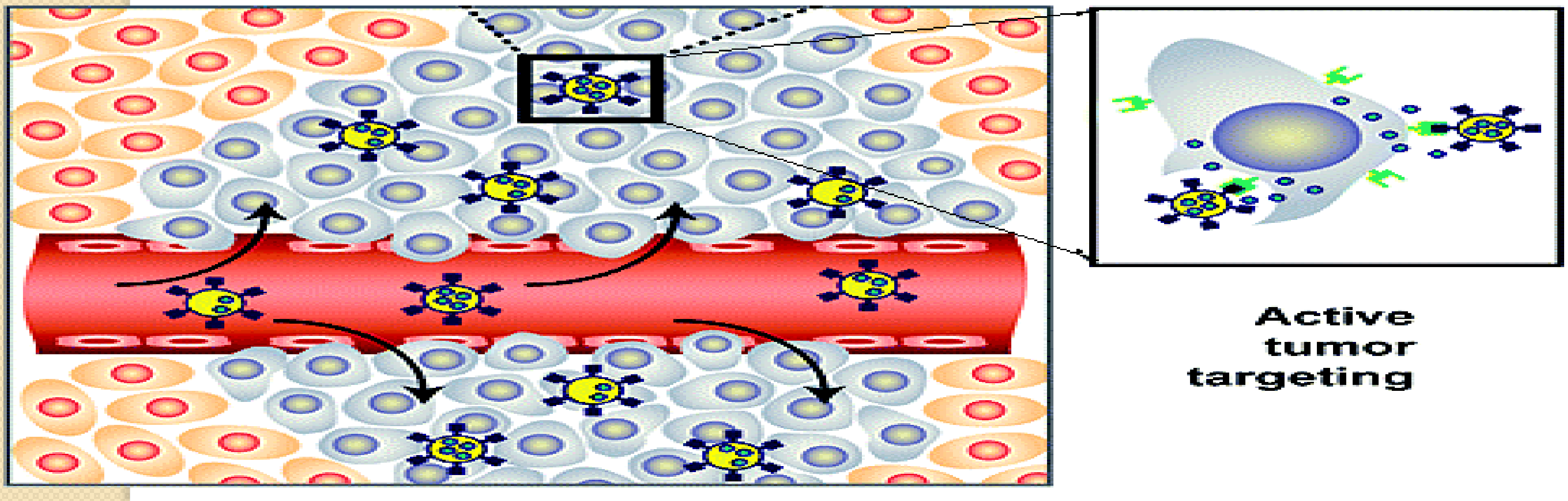
Drug Delivery Systems

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

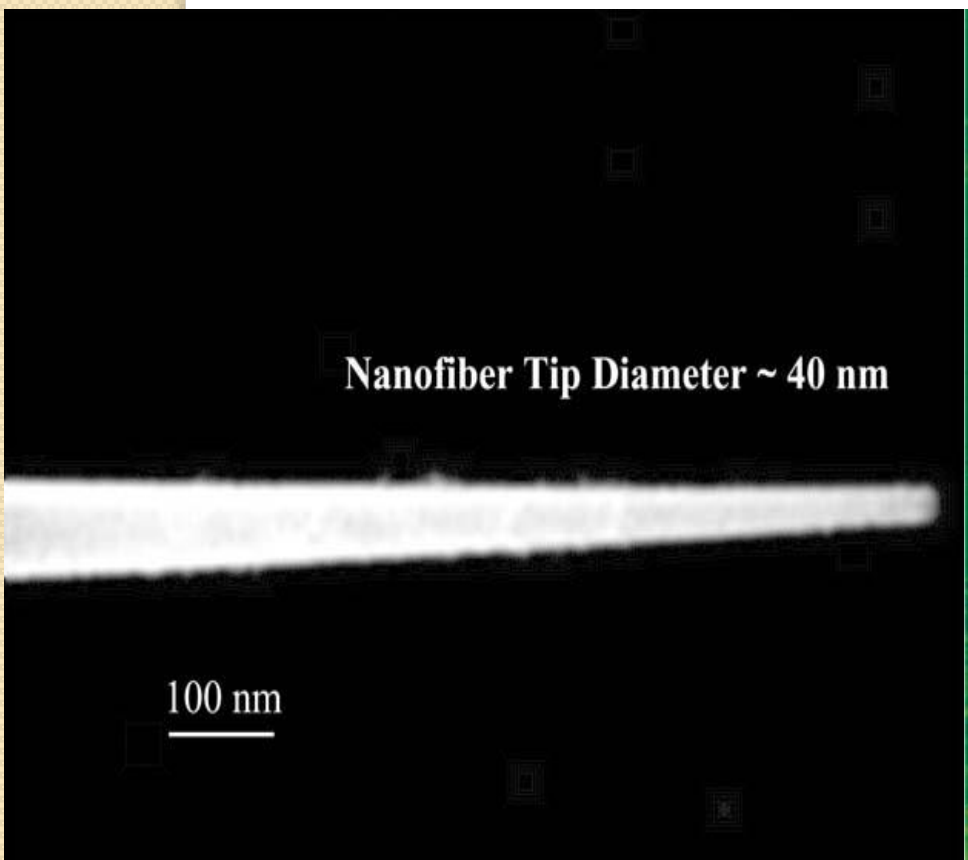
Targeted drug delivery

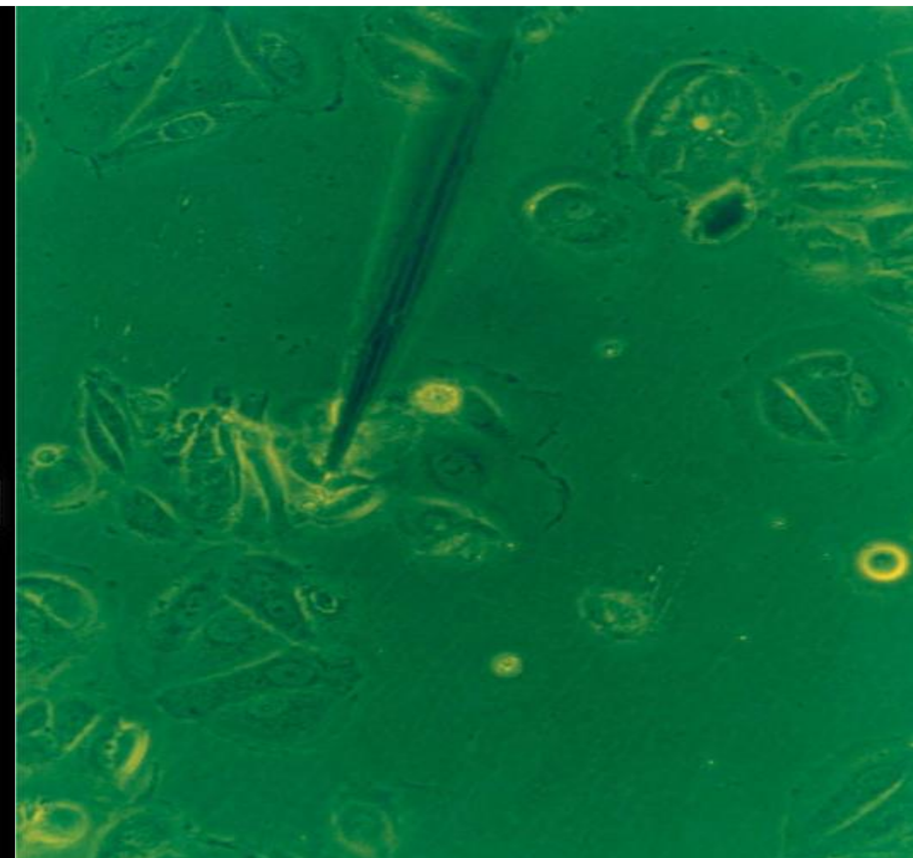
- *ACS Nano 2009, DOI: 10.1021/nn900002m*



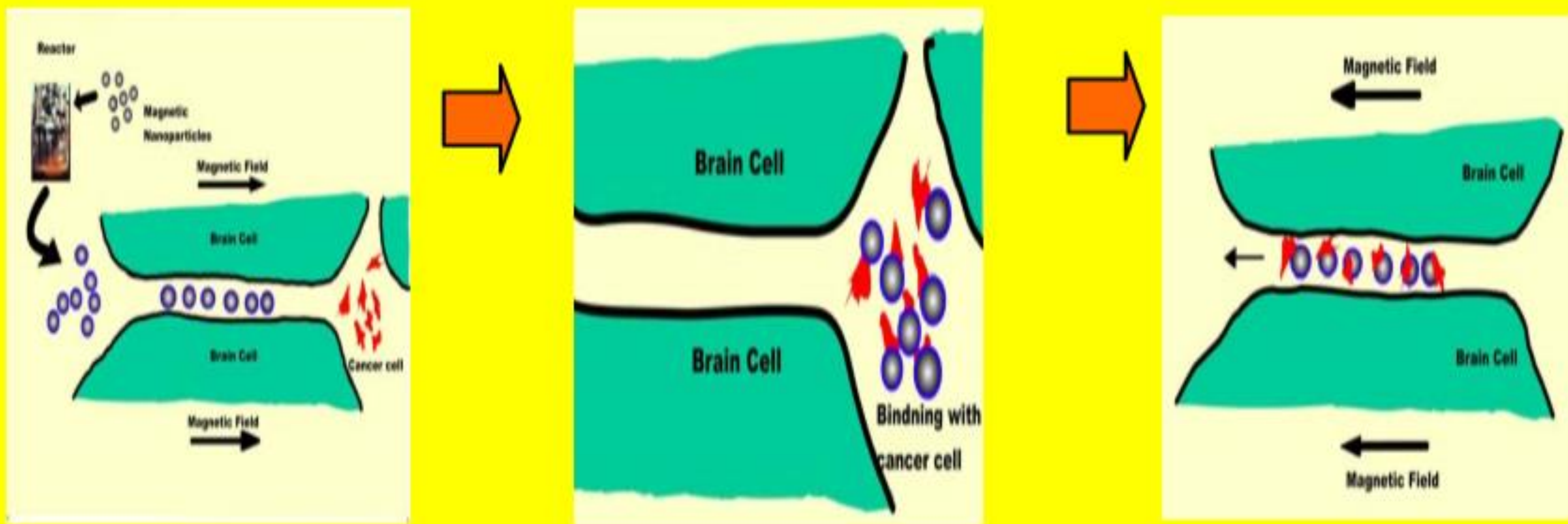
Nanotechnology in Medicine

Tiny detectives: this optical nanofiber can be used to study a particular cell without destroying it.





Magnetic Targeting



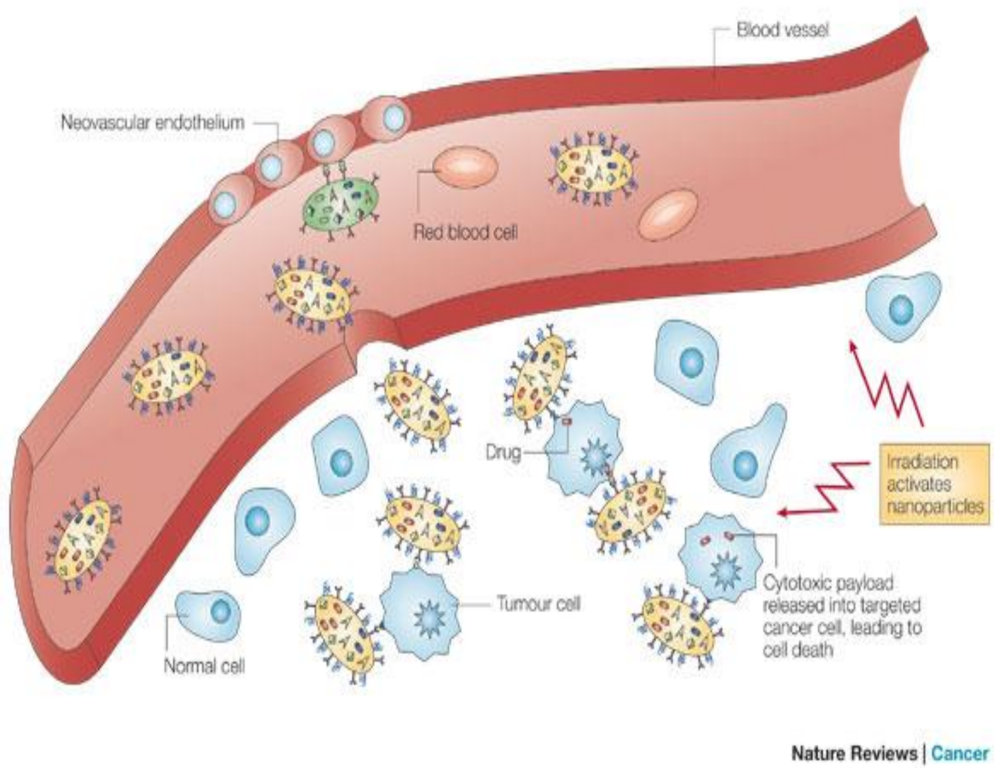
Insertion of functionalized magnetic particles in brain

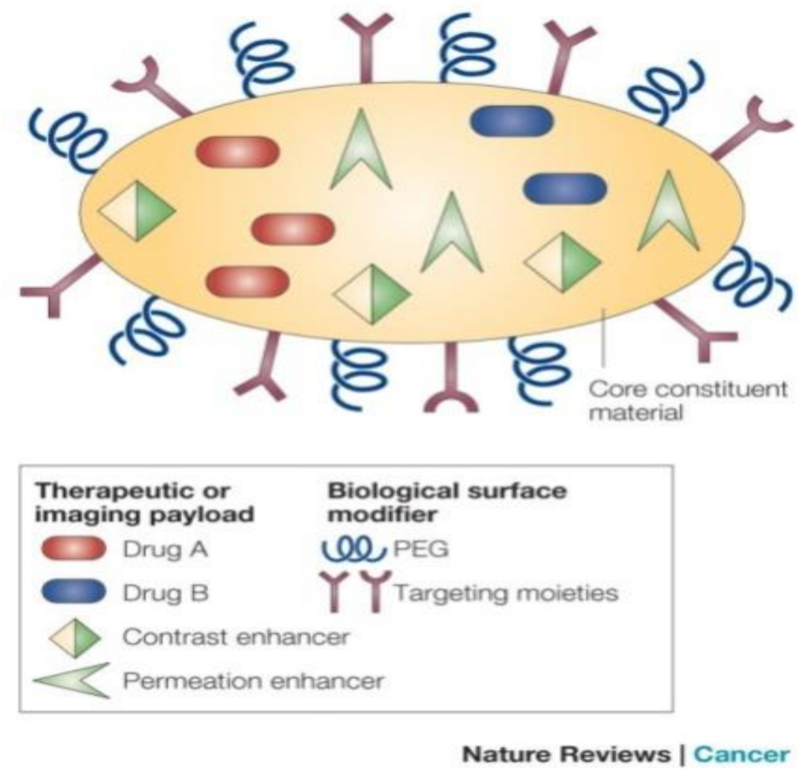
Reaction of functionalized nanoparticles with target

Removal of target-loaded magnetic particles

Treatment-Targeted drug delivery

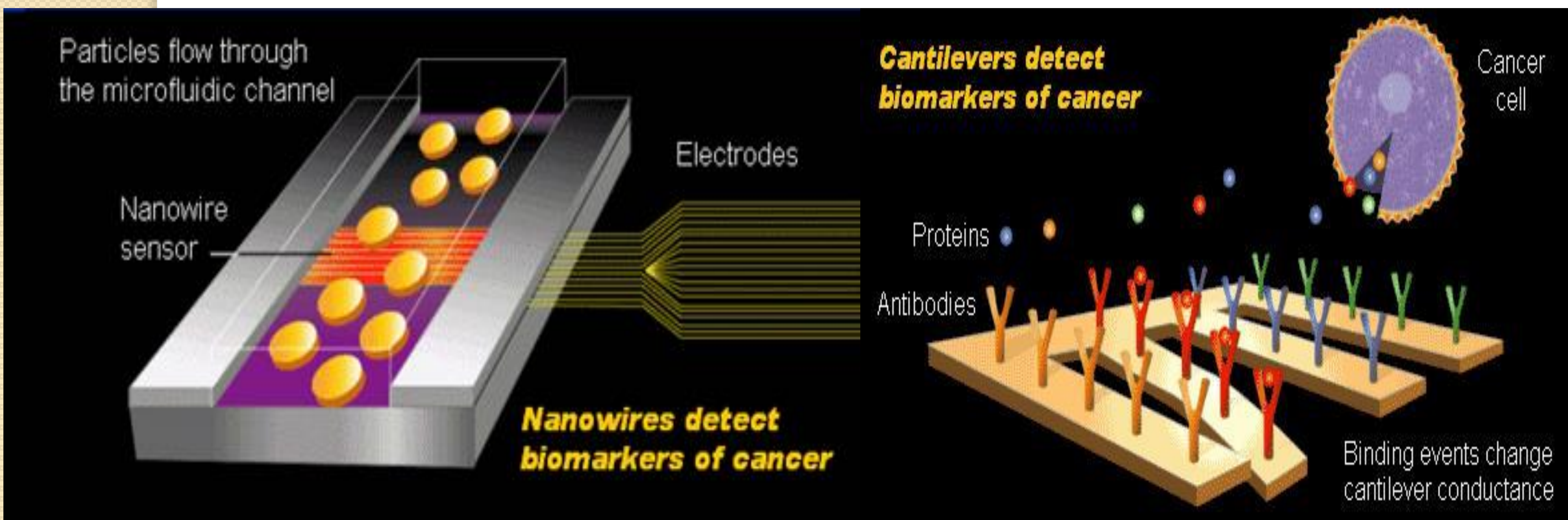
- Nanoparticles containing drugs are coated with targeting agents (e.g. conjugated antibodies)
- The nanoparticles circulate through the blood vessels and reach the target cells
- Drugs are released directly into the targeted cells





Detection, diagnosis and treatment

- Lab on chips help detection and diagnosis of diseases more efficiently
- Nanowire and cantilever lab on chips help in early detection of cancer biomarkers



The microfluidic channel with nanowire sensor can detect the presence of altered genes associated with cancer ***– J. Heath, Cali. Insti. of Technology***

The nanoscale cantilever detects the presence and concentration of various molecular expressions of a cancer cell ***– A. Majumdar, Univ. of Cal. at***

CNT-enhanced sporting goods (Zyvex)

CNT COMPOSITE

EASTON

36

Stain Resistant Clothes

Nanofibers create cushion of air around fabric,10 nm carbon whiskers bond with cotton, acts like peach fuzz; many liquids roll off

http://mrsec.wisc.edu/Edetc/IPSE/educators/activities/nanoTex.html

Paint That Doesn't Chip

Protective nanopaint for cars, Water and dirt repellent, Resistant to chipping and scratches, Brighter colors, enhanced gloss, In the future, could change color and self-repair?

Mercedes covered with tougher, shinier nanopaint

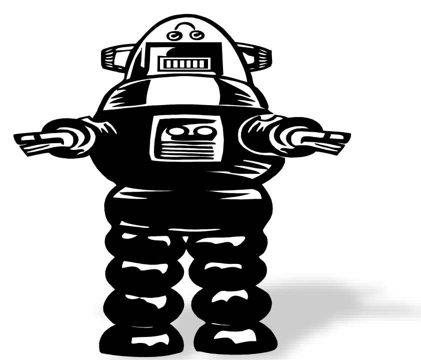
Nano-paint that Cleans air on buildings could reduce pollution

Summary

Nanotechnology is ubiquitous and pervasive. It is an emerging field in all areas of science, engineering and technology.

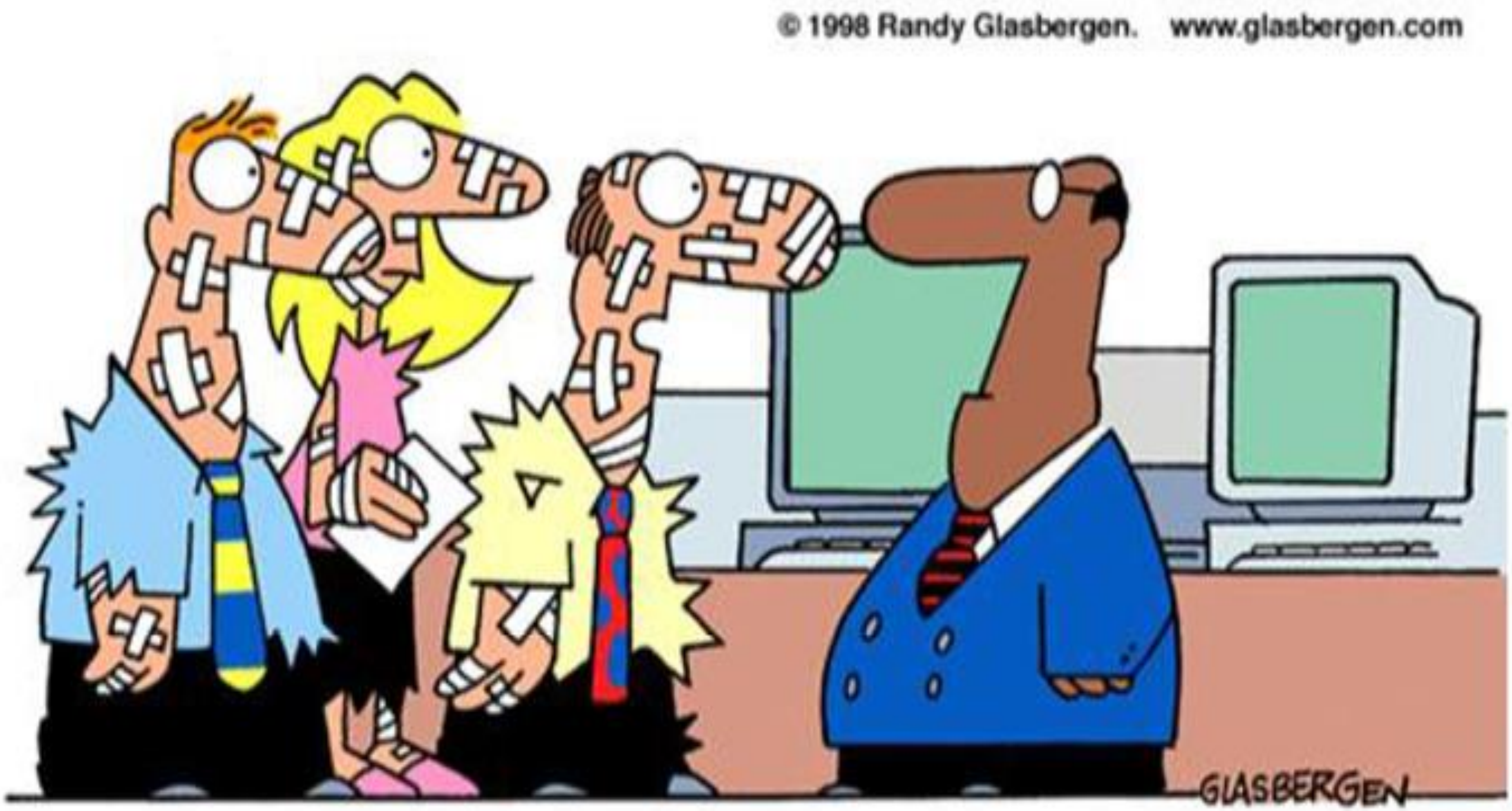
Welcome to
Nano World!

Robot image



manjunatha_s@yahoo.com

The Challenges?



"Frankly, sir, we're tired of being on the cutting edge of technology."

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  Boonserm Kaewkamnerdpong and Peter J. Bentley

  Department of Computer Science, University College London, UK

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Thank you for your attention!

Thank You!