NanoScience and Technology - An Introduction

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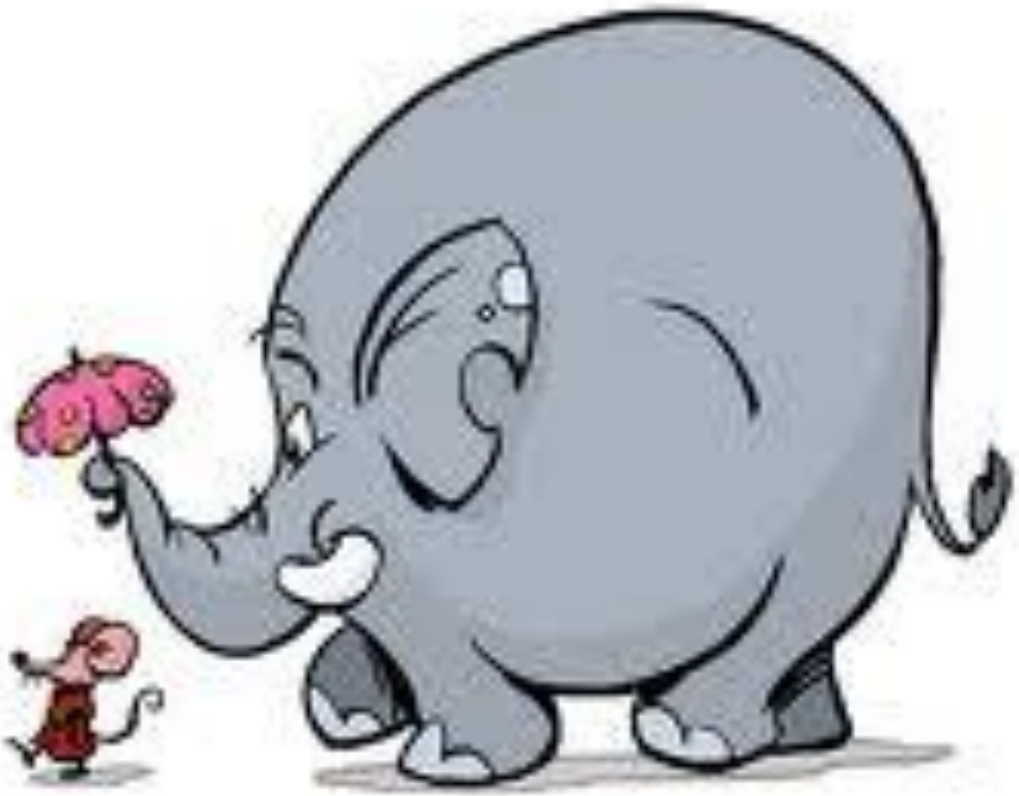
22PH324A
PHYSICS OF NANOMATERIALS AND APPLICATIONS
Unit 1: II M.Sc – III SEMESTER

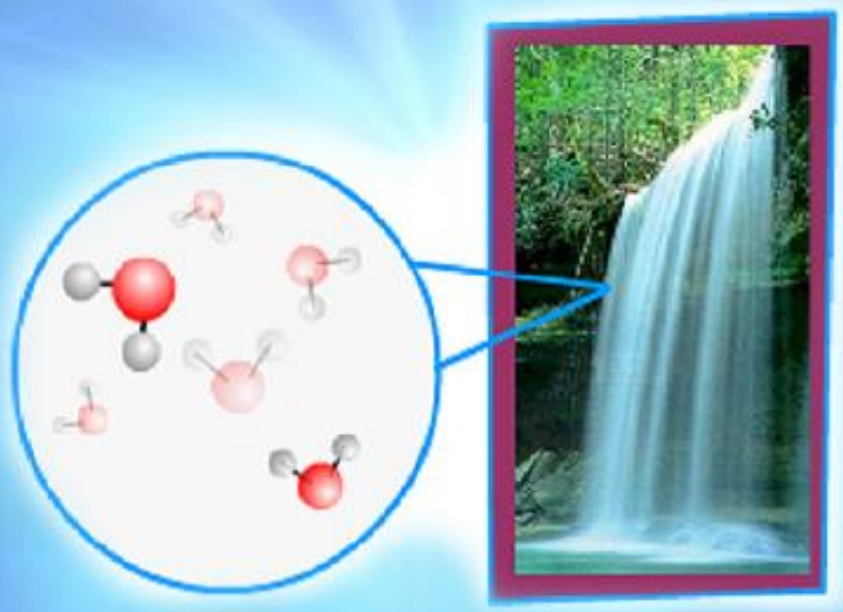

TATA nano

Small is beautiful ? !



What are Atoms and Molecules?

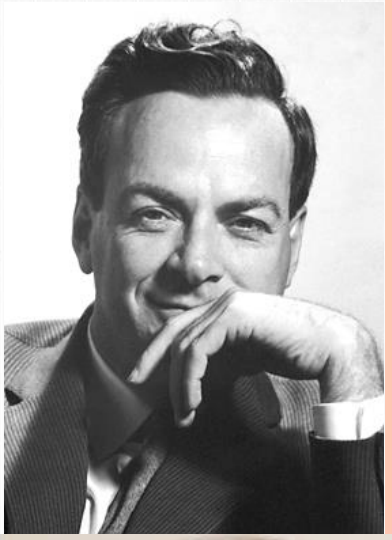
Atoms and molecules are the smallest building blocks of the universe. Our world depends on how atoms join together to form molecules.



The next "Big Thing" is happening in very, very, very small small!

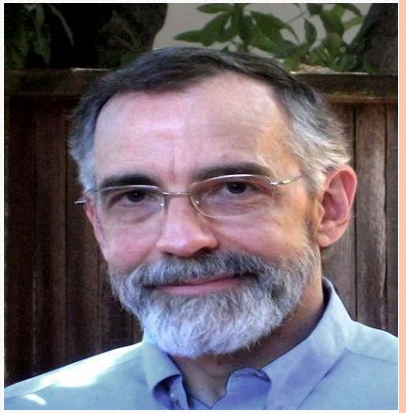
"Nanotechnology is an enabling technology that will change the nature of almost every human-made object in the next century"

Richard Feynman in his talk (1959 APS)
There's Plenty of Room at the Bottom,
in which he described the possibility of synthesis via direct manipulation of atoms imitating nature



The term "nano-technology" was first used by **Norio Taniguchi** in 1974

K. Eric Drexler used the term **"nanotechnology"** in his 1986 book **Engines of Creation: The Coming Era of Nanotechnology**, proposed the idea of a nanoscale **"assembler"** which would be able to build a copy of itself and of other items of arbitrary complexity with atomic control.



What is Nano?

Nano comes from the Greek word nanos, meaning dwarf.

What is the Nanometer Scale?

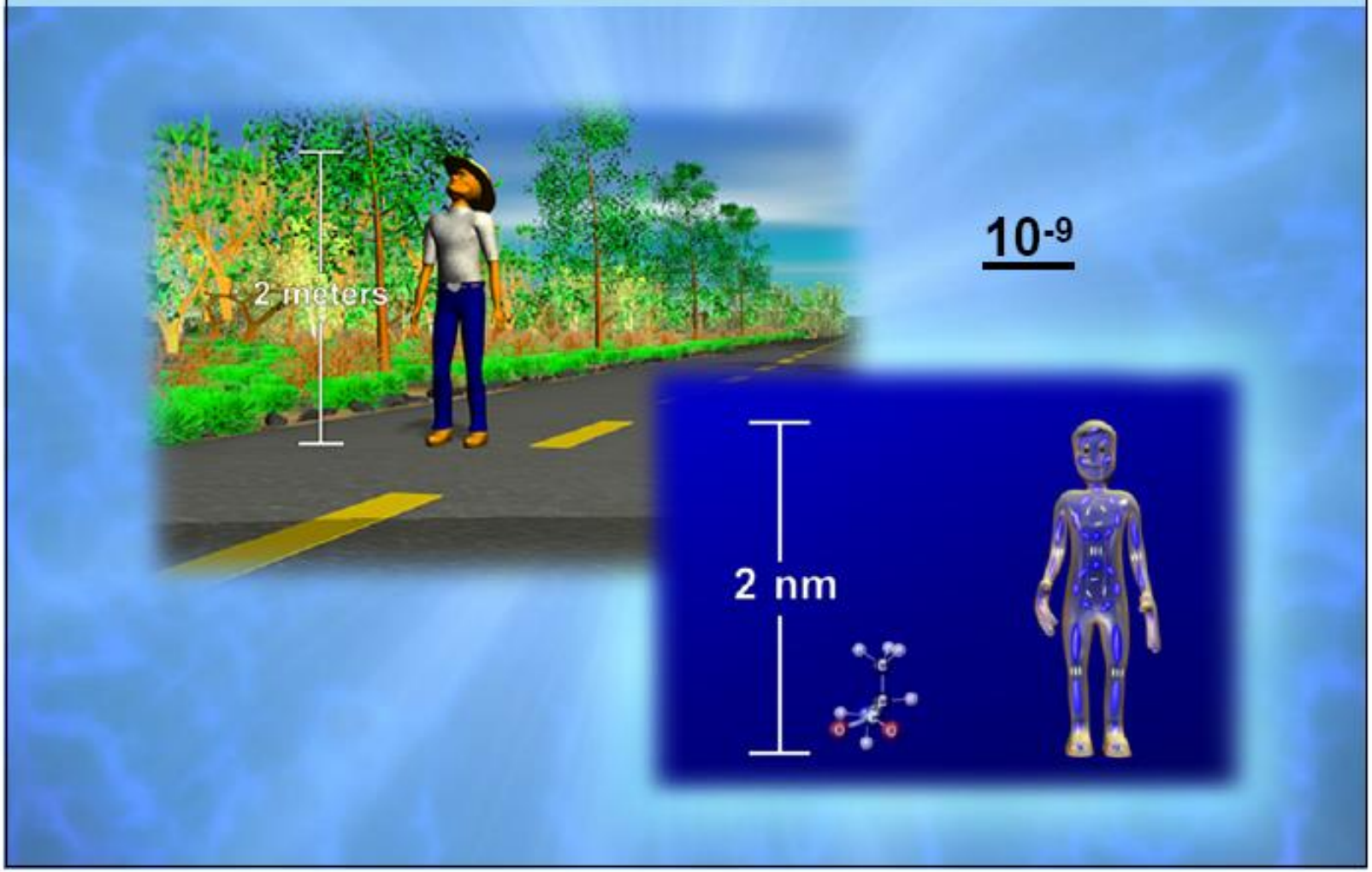
It is a standard of measurement of the very small.
One nanometer (nm) is one-billionth of a meter and is 10^{-9}.

Meter - m
Millimeter - mm - 1,000 times smaller than a meter
Micrometer - μ - 1,000 times smaller than a millimeter
Nanometer - nm - 1,000 times smaller than a micrometer

1,000 X 1,000 X 1,000 = 1,000,000,000 times smaller

Please Remember!

A nanometer is one-billion times smaller than a meter!



The Nanoscale Is Difficult to See!

At the nanoscale, our world is seen as atoms and molecules.

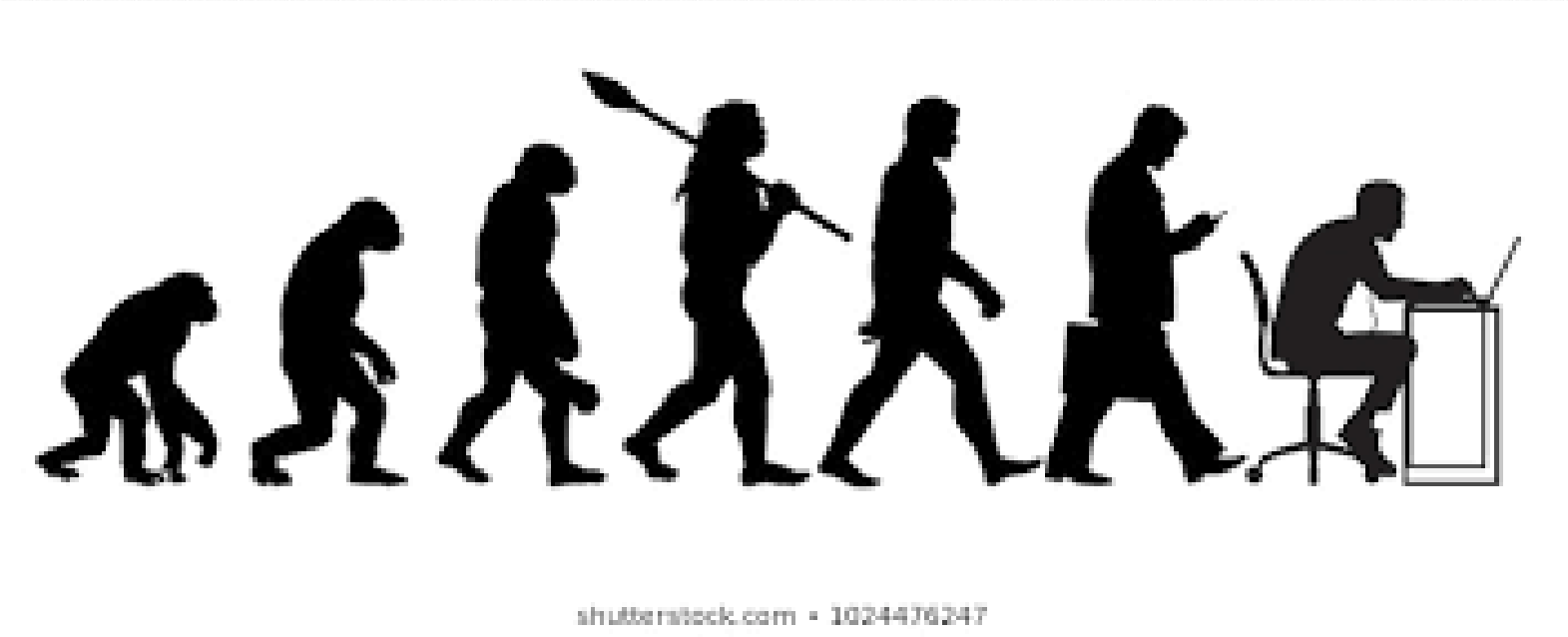
What is Science?

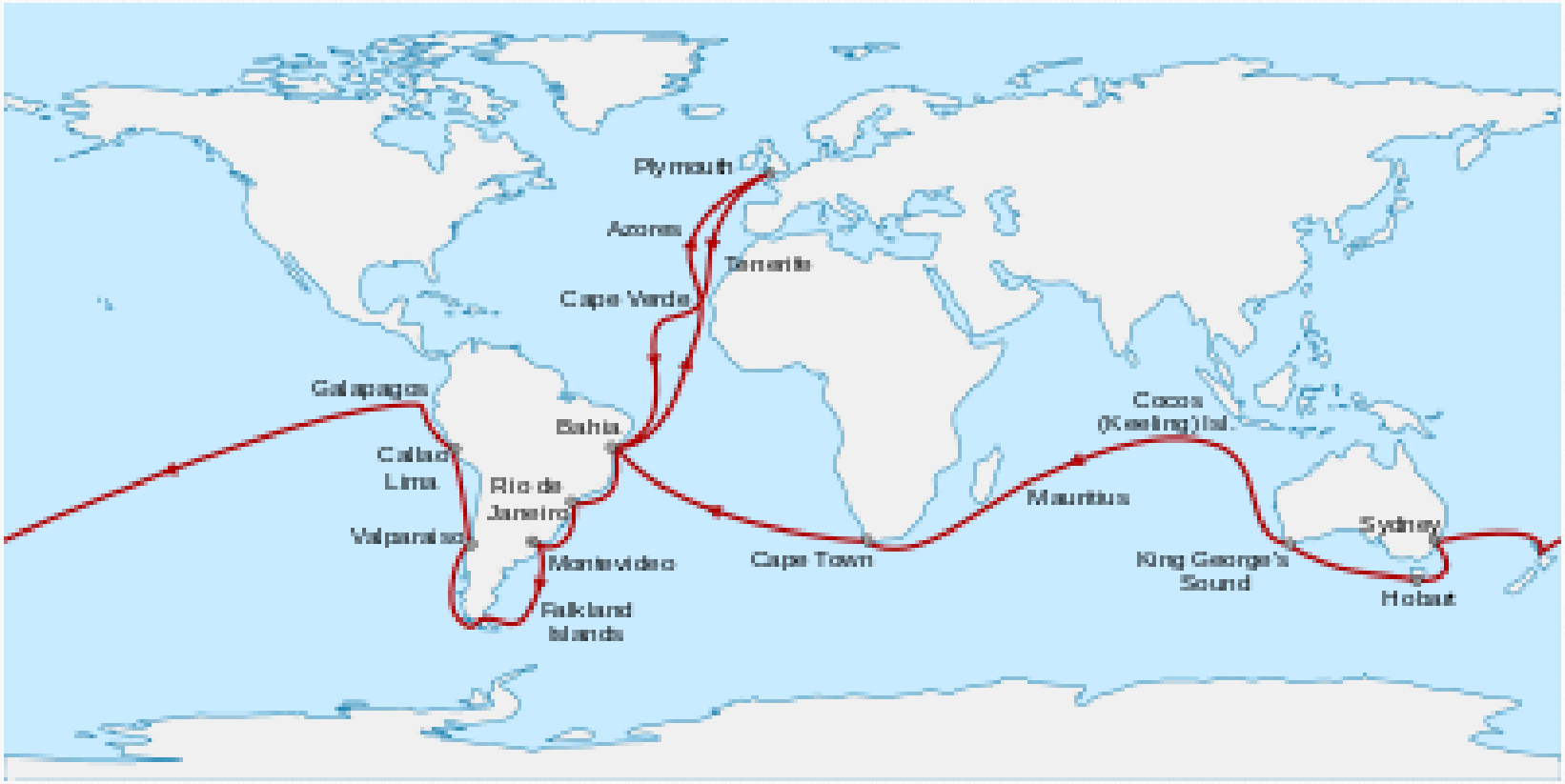
What is Science?

The systematic study of the structure and behaviour of the physical and natural world through observation and experiment.

Charles Robert Darwin

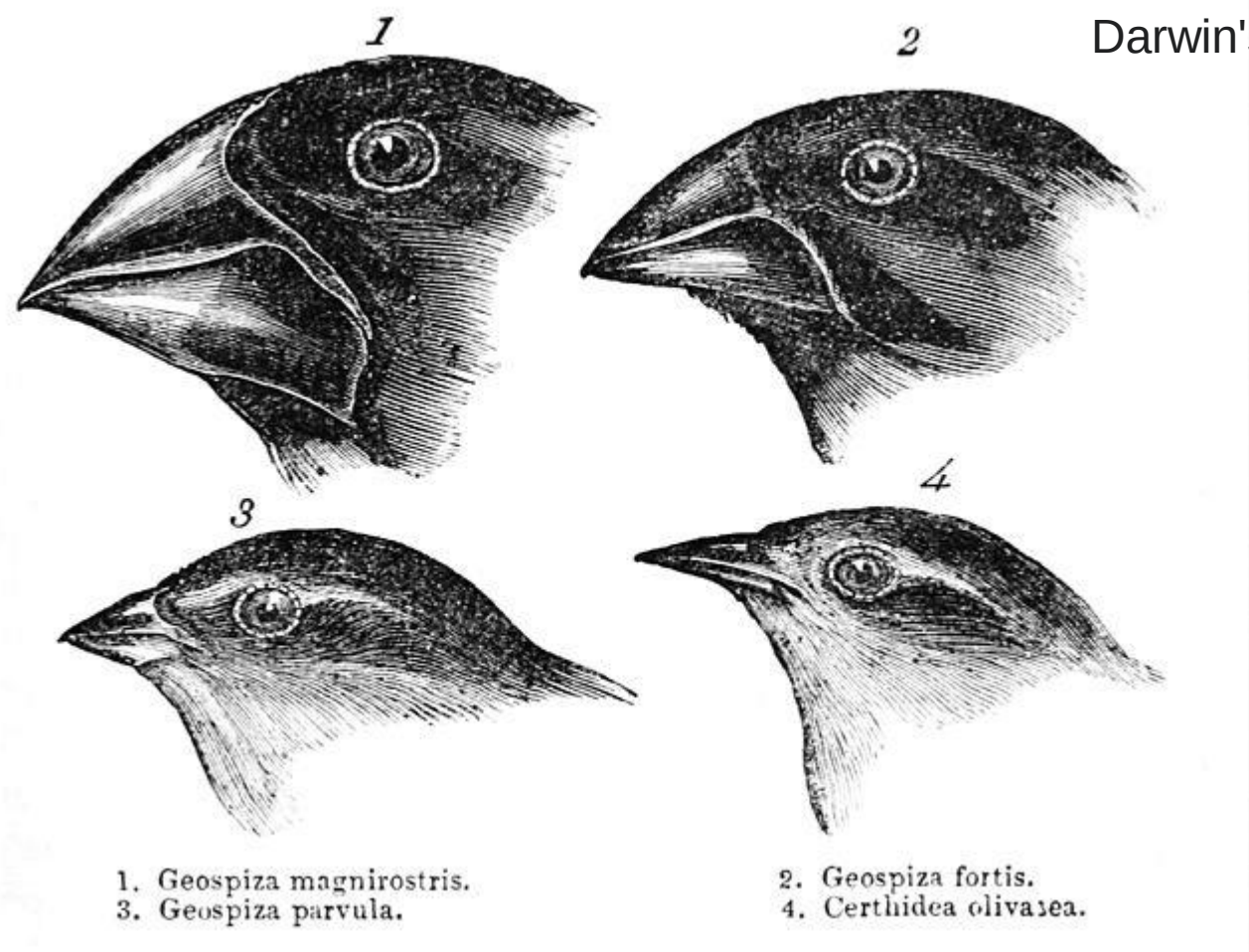
British naturalist and biologist known for his theory of evolution and his understanding of the process of natural selection.




Plymouth
Azores
Tenerife
Cape Verde
Galapagos
Callao
Lima
Bahia
Rio de
Janeiro
Valparaiso
Montevideo
Falkland
Islands
Cape Town
Mauritius
Cocos
(Keeling) Isl.
Sydney
King George's
Sound
Hobart

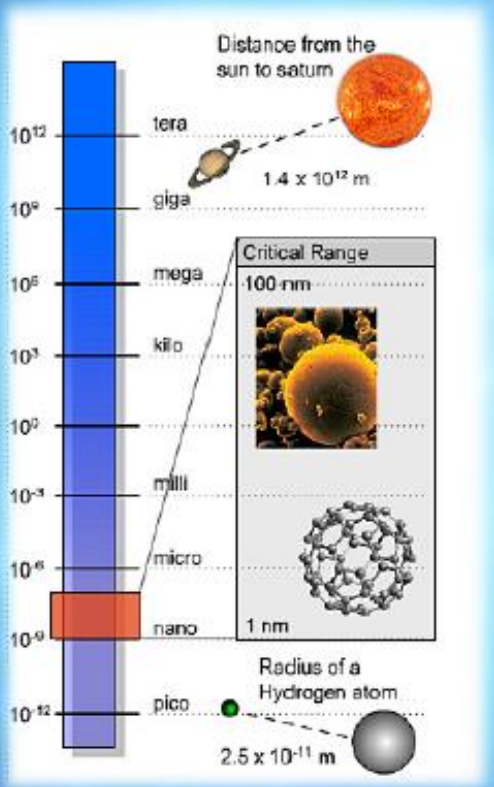
Evolutionism is a term used (often derogatorily) to denote the theory of evolution

Darwin's in *Origin of Species*



1. Geospiza magnirostris.
2. Geospiza fortis.
3. Geospiza parvula.
4. Certhidea olivasea.

What are Nanoscale Science and Technology?



Nanoscale science: investigates the properties of matter in the critcal range of 1nm – 100 nm.

Nanotechnology: Is building and using devices from 1 nm – 100 nm.

Research is working with **unknown**

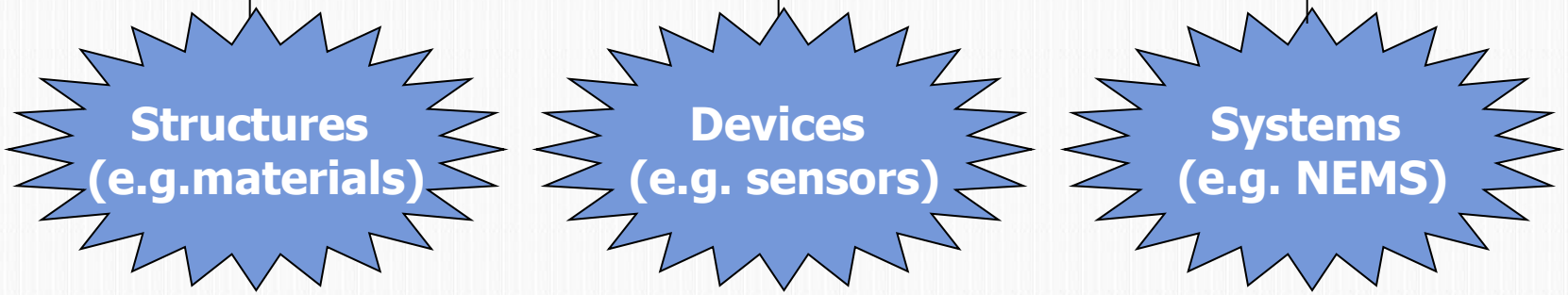
Development is working with **known**

Why Nanotechnology?

And why now?

WHAT IS NANOTECHNOLOGY?

Nanotechnology is the manipulation of matter at the nanometer* scale to create novel structures, devices and systems.



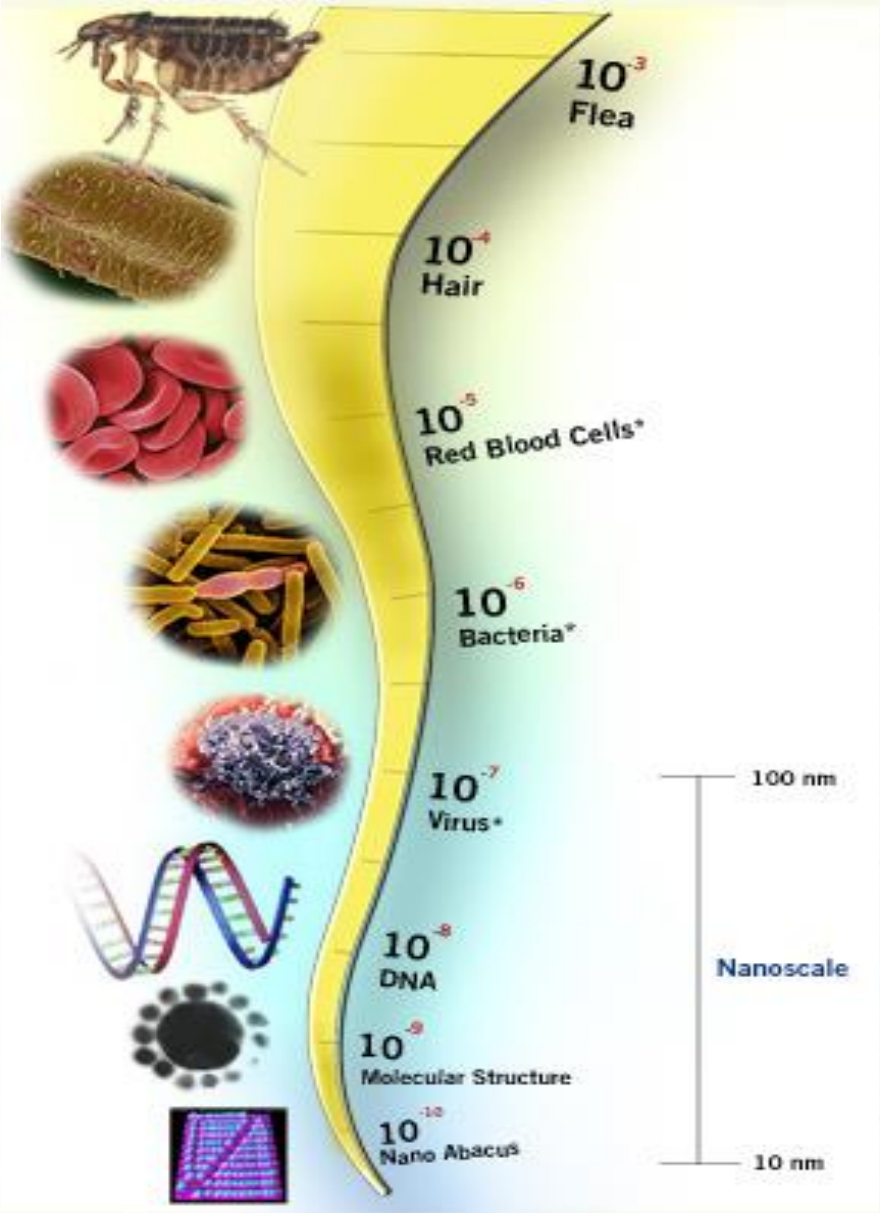
* 1 millimeter = 1,000 micrometers;
1 micrometer = 1,000 nanometers

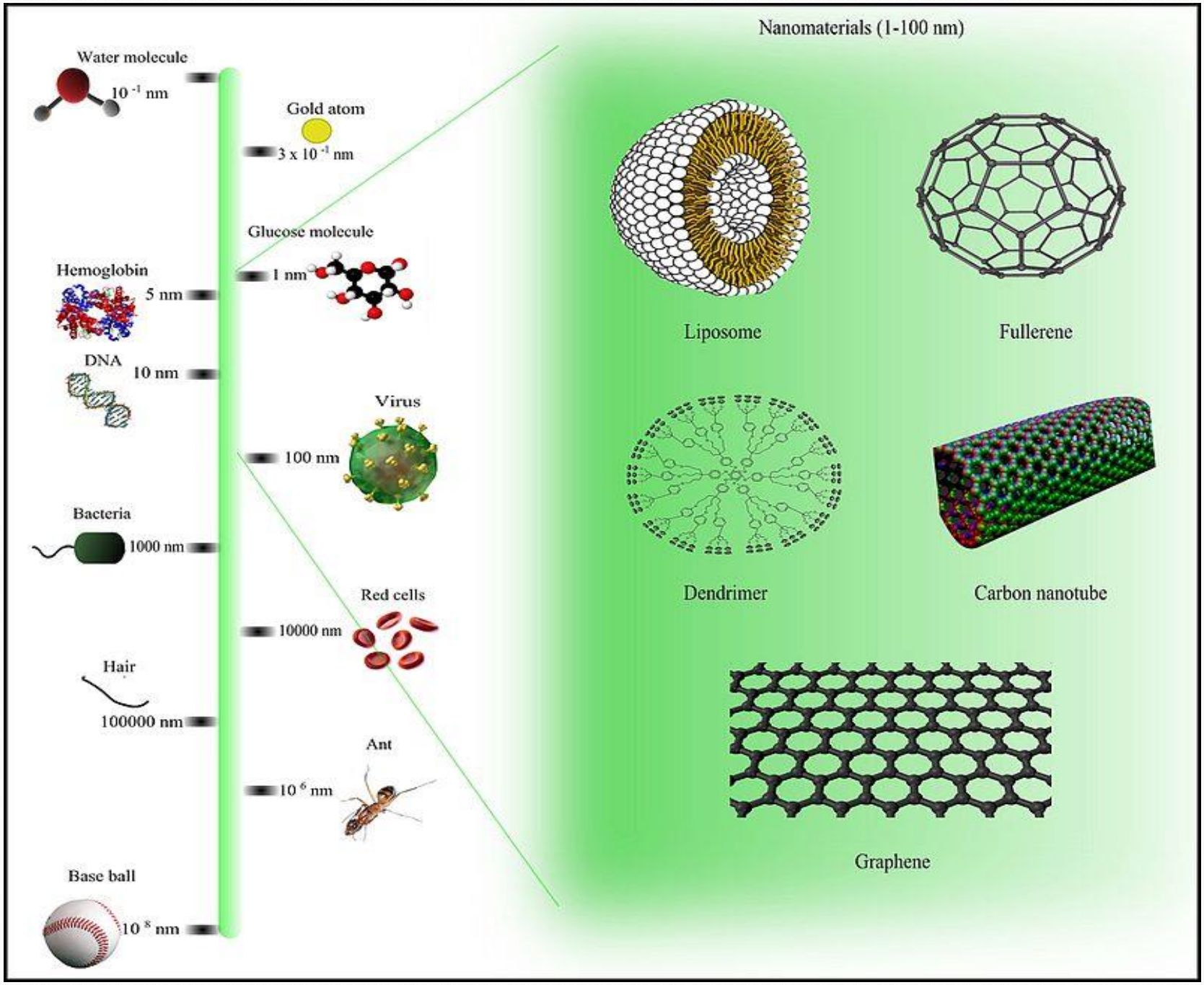
What is Nanotechnology?

Nanotechnology is about:

- Making small objects
- Manipulating small objects
- Creating new materials by varying the size of the objects
- Building structures from small objects

Small is small

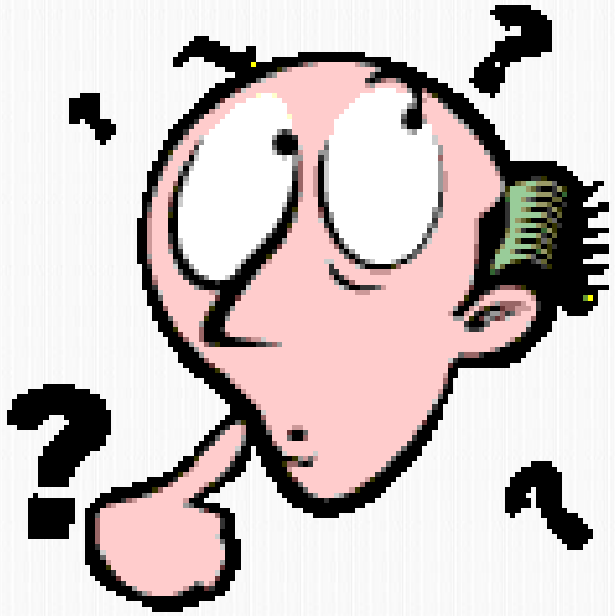



Nanomaterials (1-100 nm)
Water molecule
10 -1 nm
Gold atom
3 x 10 -1 nm
Glucose molecule
1 nm
Hemoglobin
5 nm
DNA
10 nm
Virus
100 nm
Bacteria
1000 nm
Red cells
10000 nm
Hair
100000 nm
Ant
10 6 nm
Base ball
10 8 nm
Liposome
Fullerene
Dendrimer
Carbon nanotube
Graphene

Orders of Scale

Tera	– trillion, 10^{12}
Giga	– billion, 10^{9}
Mega	– million, 10^{6}
Kilo	– thousand, 10^{3}
Macro	– referring to big or visible
Milli	– 10^{-3}
Micro	– referring to small, also 10^{-6}
Nano	**– 10^{-9}**
Angstron	– 10^{-10}
Pico	– 10^{-12}
Femto	– 10^{-15}

Understanding Size



How big (small) are we talking about?

Understanding Size

- 1 centimeter

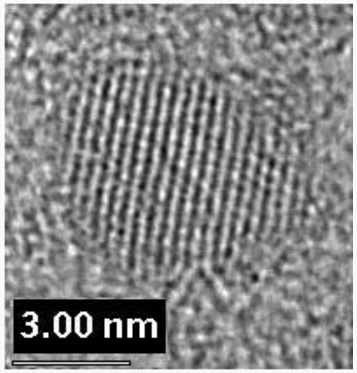
source: CERN http://microcosm.web.cern.ch/microcosm

How do we know about nanoscale?

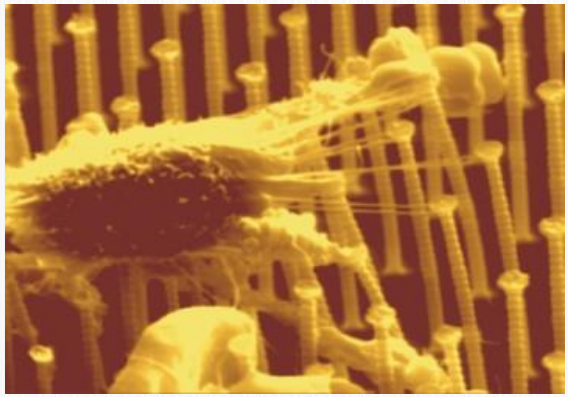
- Powerful Microscopes (relatively old invention)

Cat Flea

Scanning Electron Microscope (SEM)

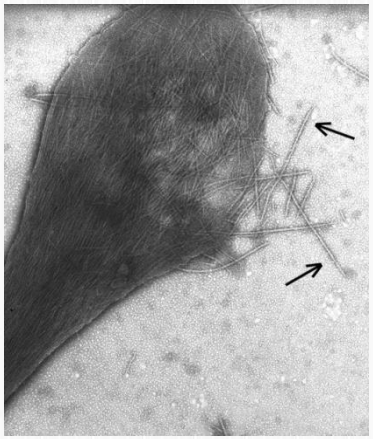


CdSe/ZnS Nanocrystal



Fibroblast Cell on Pillars

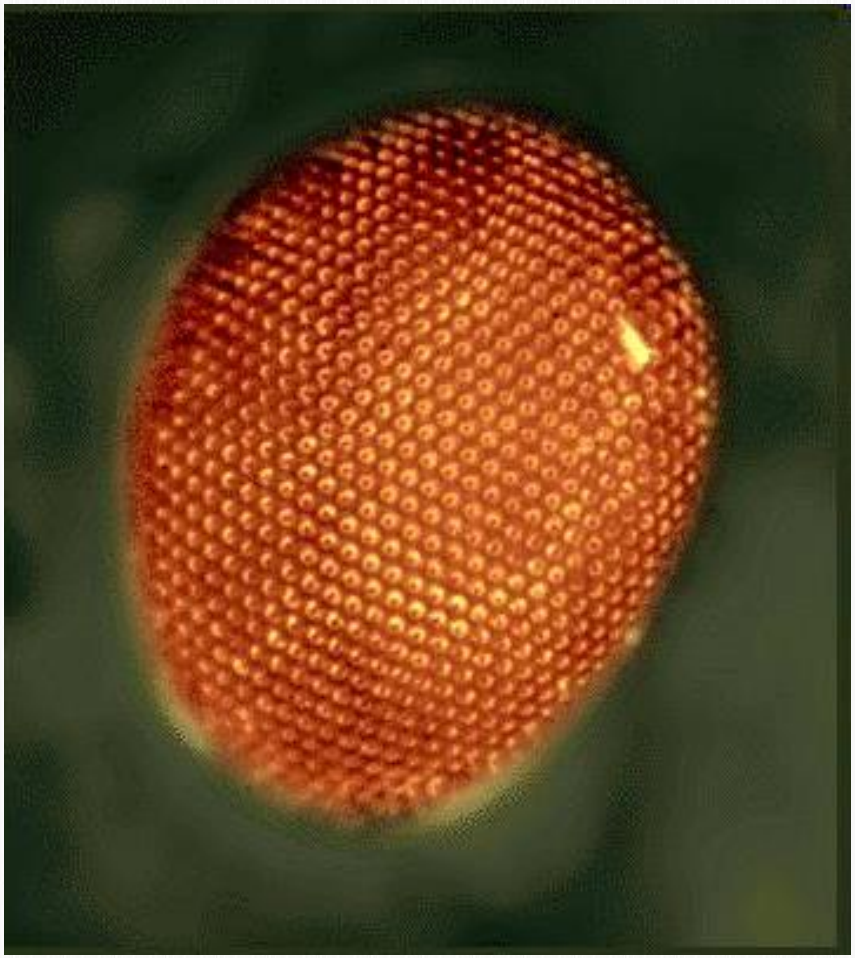
Transmission Electron Microscope (TEM)



Sickled hemoglobin in red blood cell

This slide is adapted from the presentation on "An Introduction to Nanotechnology," by Terry Bigioni, posted at http://www.homepages.utoledo.edu/tbigion/BigioniGroup/Outreach_Home.html

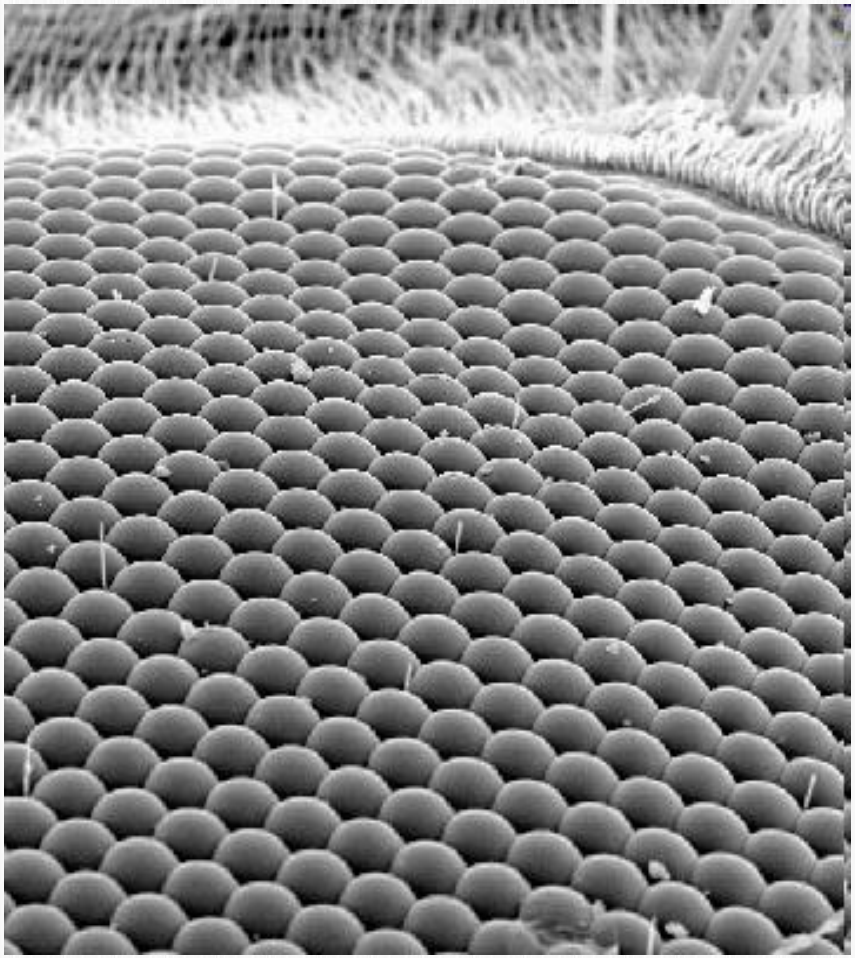
Understanding Size



- 100 micrometers

source: CERN http://microcosm.web.cern.ch/microcosm

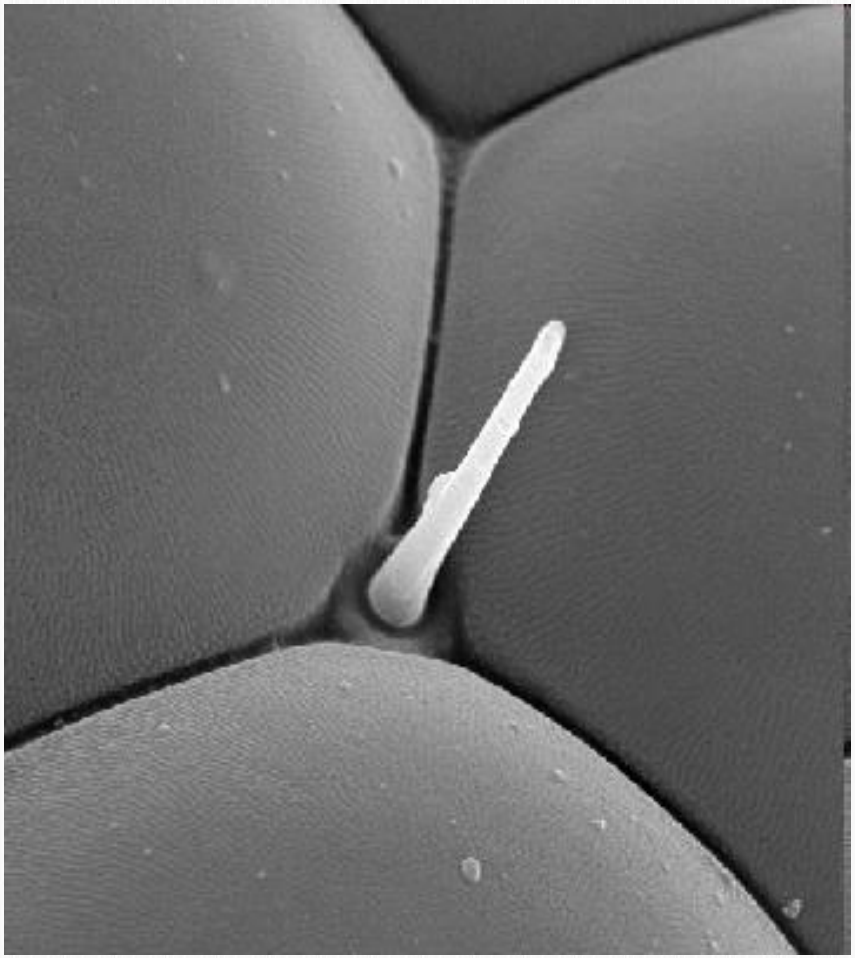
Understanding Size



- 10 micrometers

source: CERN http://microcosm.web.cern.ch/microcosm

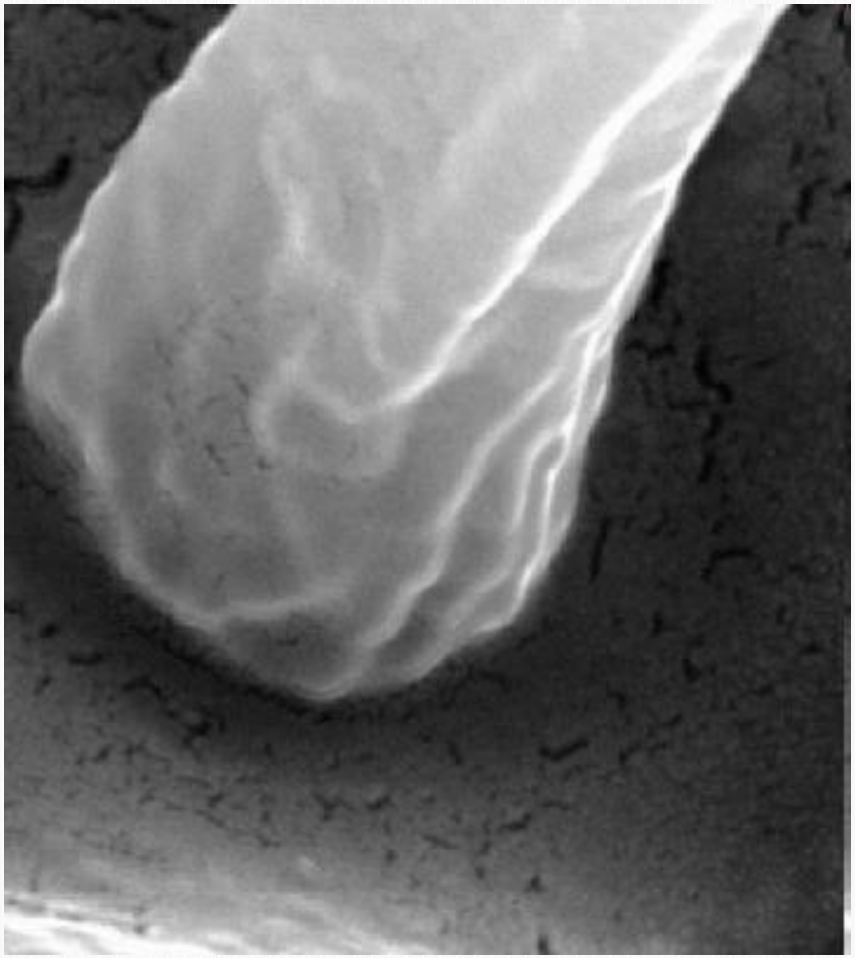
Understanding Size



- 1 micrometer

source: CERN http://microcosm.web.cern.ch/microcosm

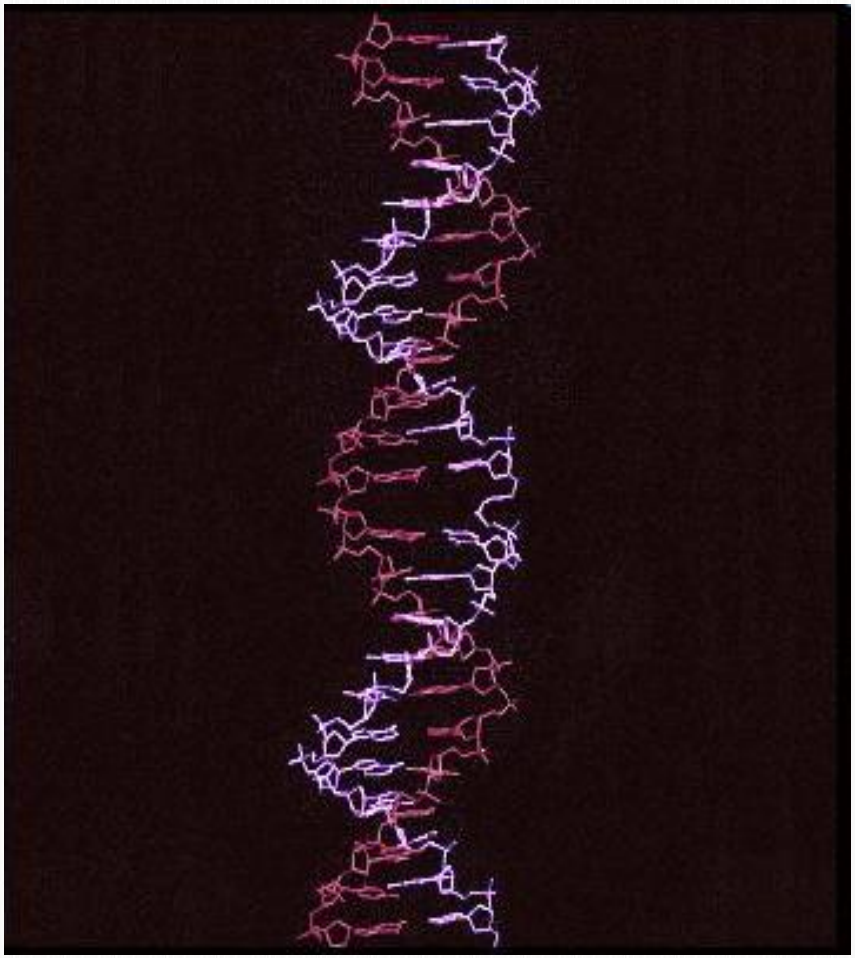
Understanding Size



- 100 nanometers

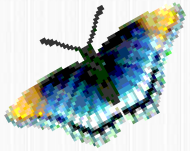
source: CERN http://microcosm.web.cern.ch/microcosm

Understanding Size



- 10 nanometers

source: CERN http://microcosm.web.cern.ch/microcosm



Color in Butterfly Wings

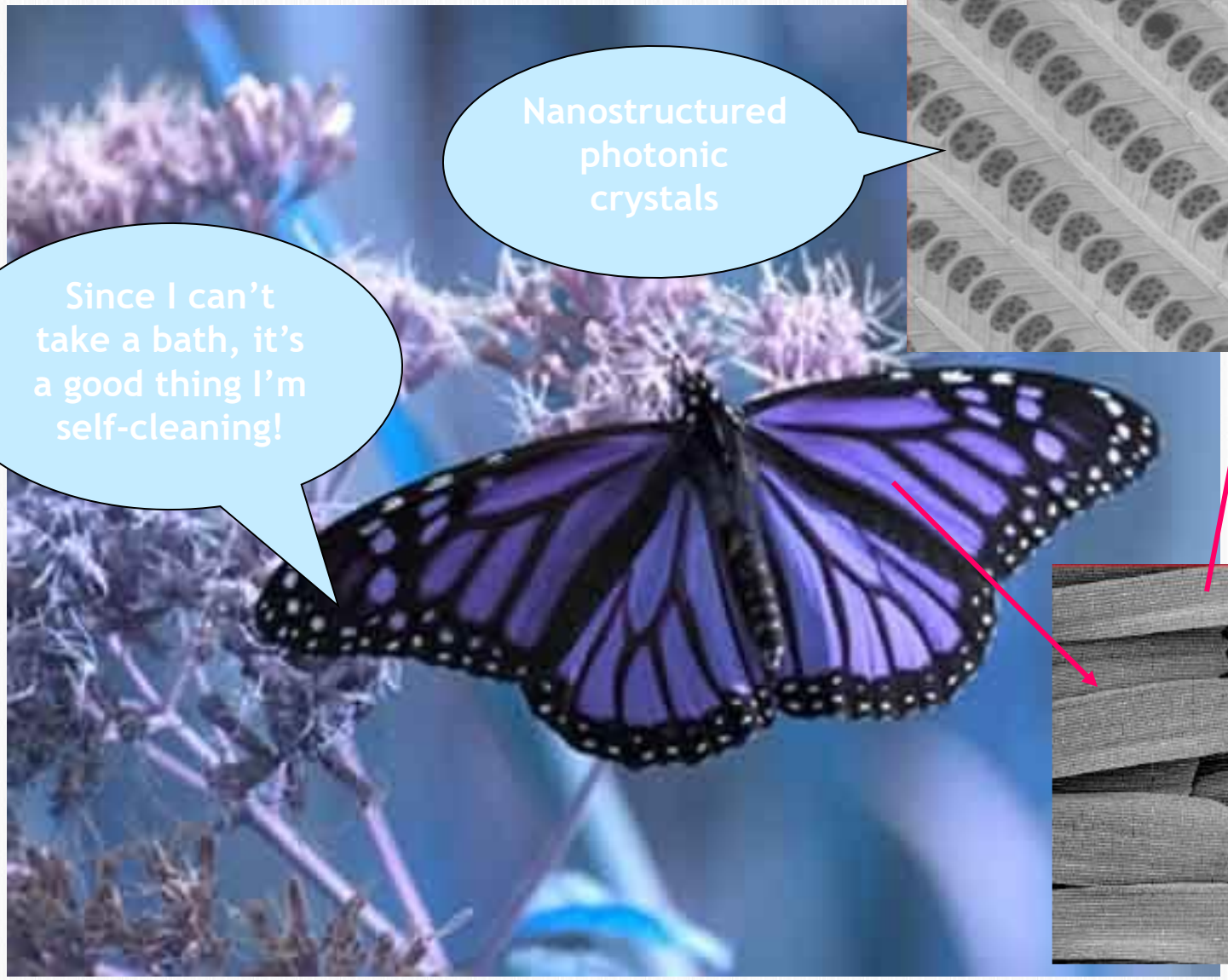
It is well known that the coloration of butterfly wings has two main sources. Color arises either from pigmentation or from structure of the wing scales. The first one is also called chemical color, the second one physical or structural color.

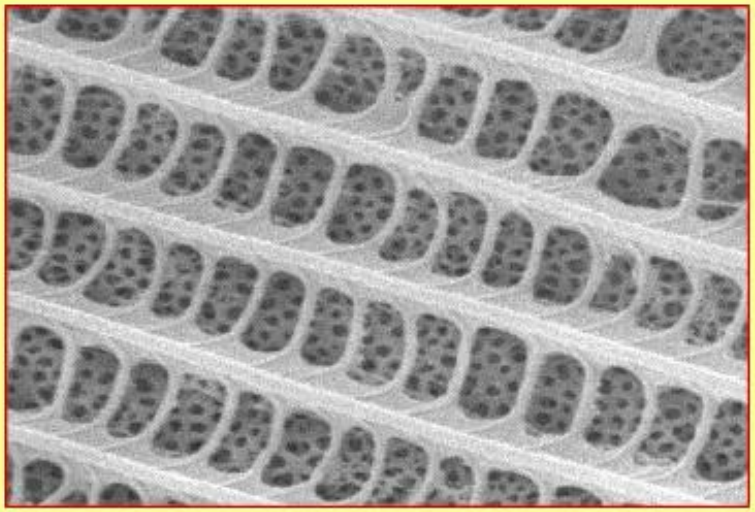
Pigments found in butterflies (melanins, pterins) can produce yellow, orange-yellow, red, black, and brown colors.

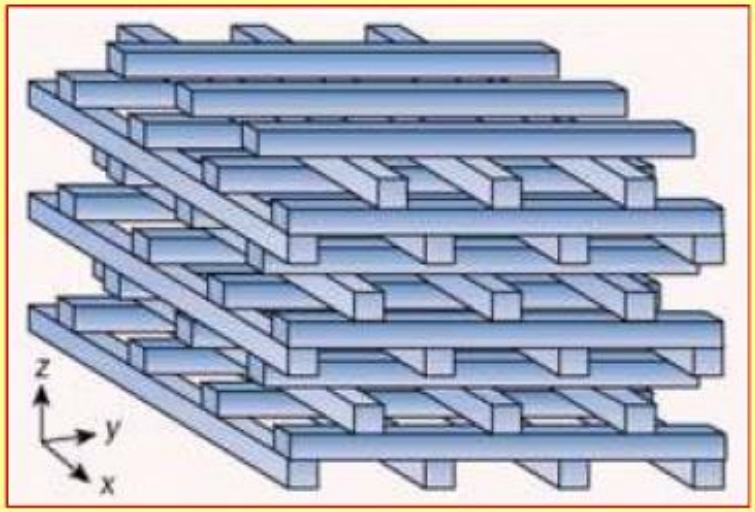
As to our best knowledge, in butterflies pigments can produce no blue, violet and green colors.

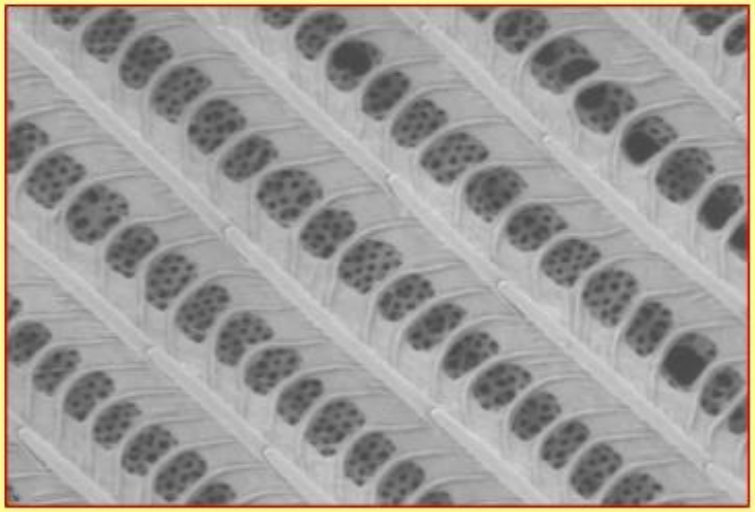
Blue, violet and green colors are result of the scales micro- and nanostructure. From here we concentrate on structural color.

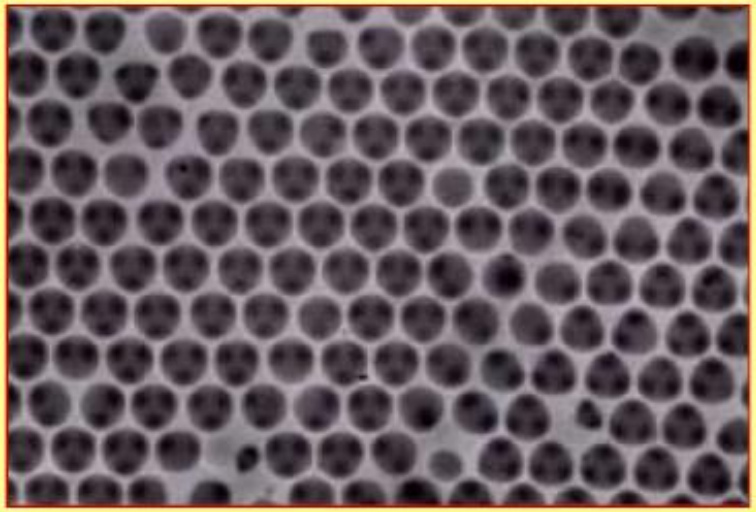
Color in Butterfly Wings






z
y
x



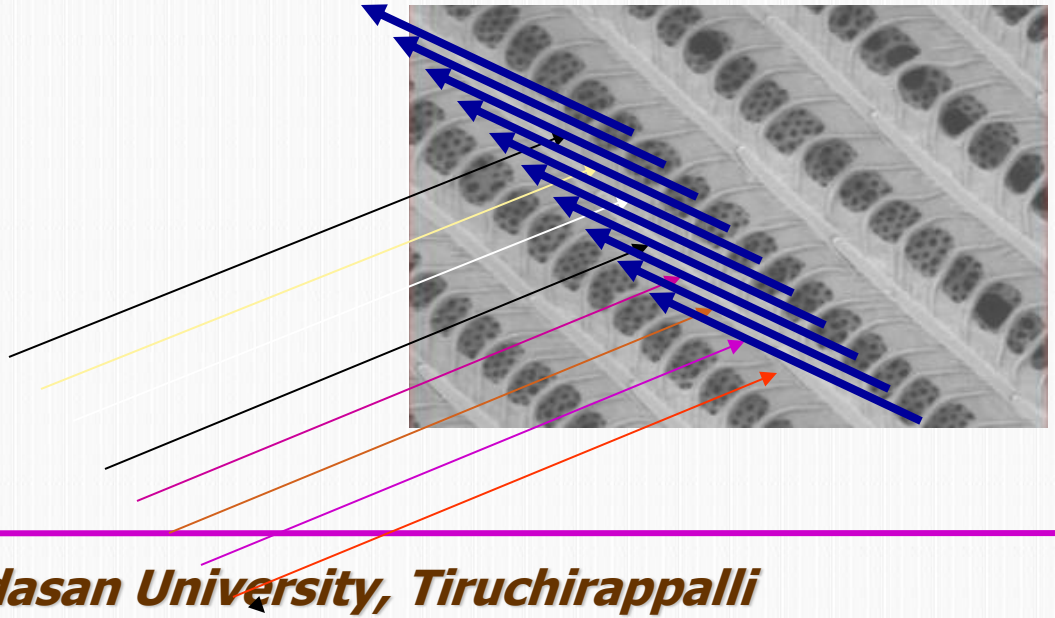


Physics Phenomena! : *Photonic crystals*

@ PCs contain regularly repeating internal regions of high and low dielectric constant \ affect the propagation of EM

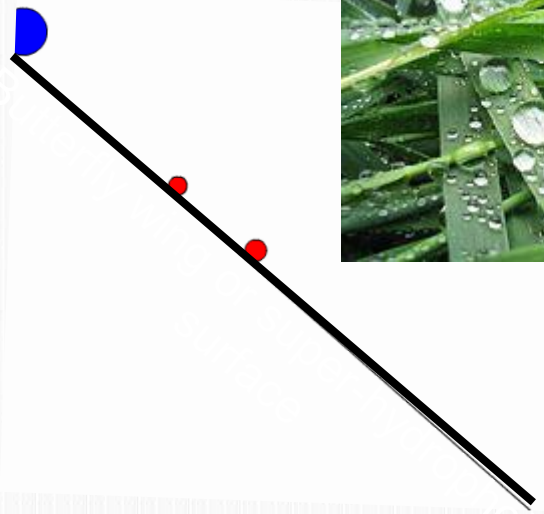
@ Photons propagate through this structure (with out scattering) or not depend on their wavelength.

@ Disallowed bands of specific wavelength is the photonic band gap!!



Reflected wavelength is the optical insulator!

Because of the nanostructures on a butterfly wing or other hydrophobic surface, a waterdrop forms into a ball, rolling from the surface and taking the dirt with it.

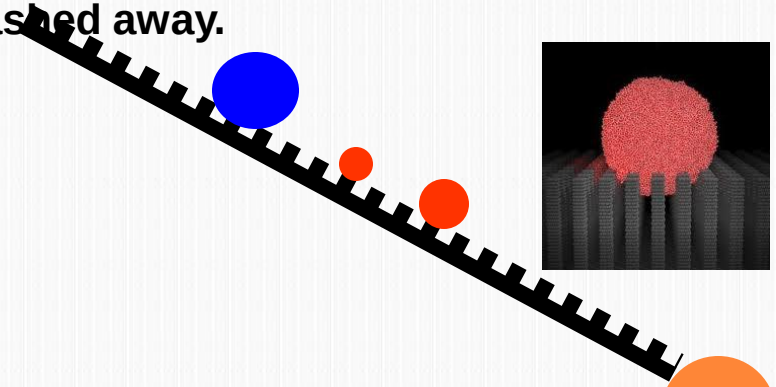


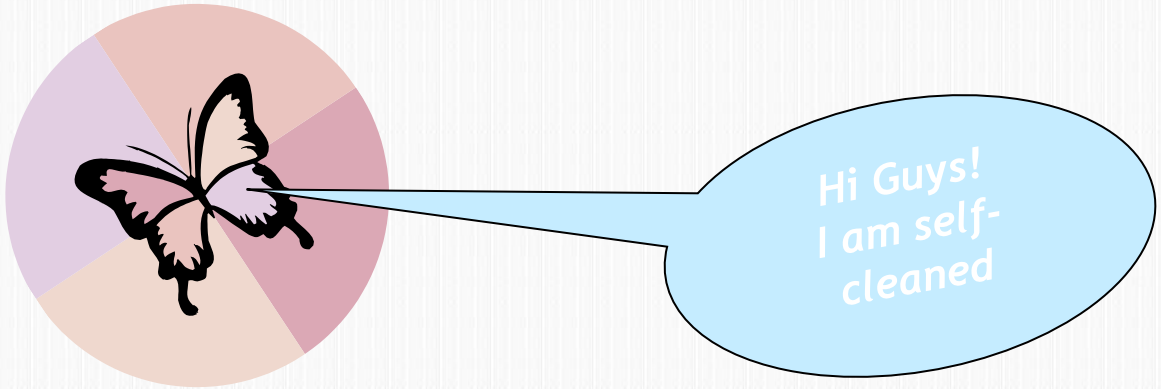
= water

= dirt

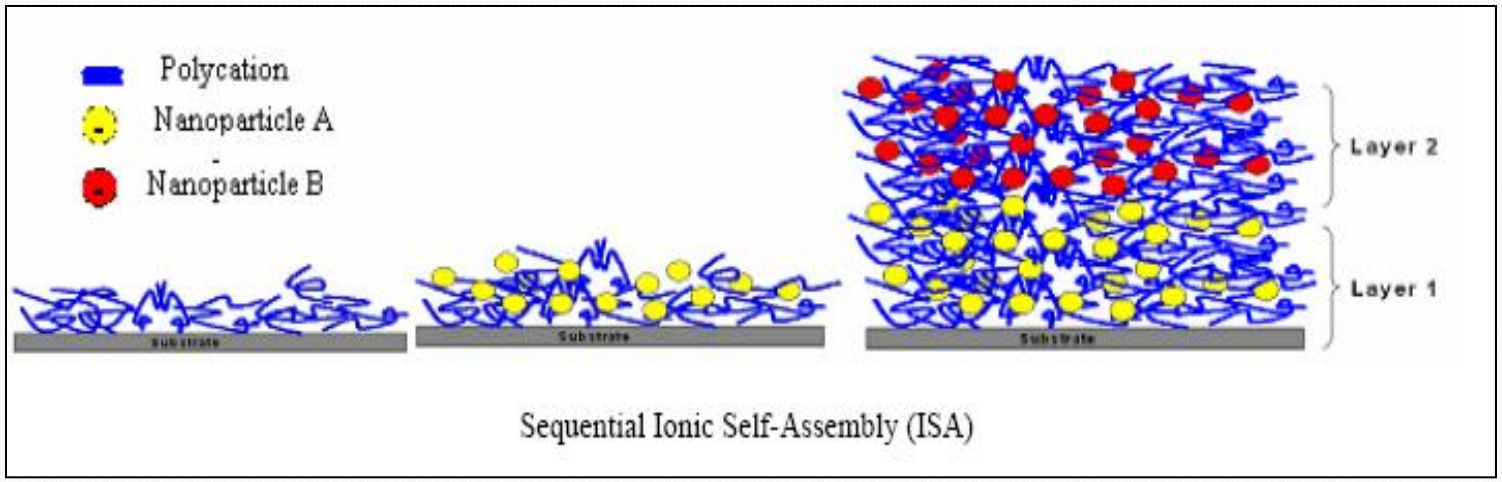
This magnified image shows the nanostructures on a wing surface. Because of the waxiness of the surface, the waterdrop rolls – rather than slides – down the surface with little friction. The drop collects dirt and bacteria on its way, and in effect cleans itself.

Nanostructures, (tiny waxy "spikes“), on the surface prevent a water droplet from reaching the underlying material. It rolls off the waxy tips which are very small compared to the water droplet. The force of the rolling water is greater than the force of attraction between the surface and dirt or bacteria which allows it to be washed away.



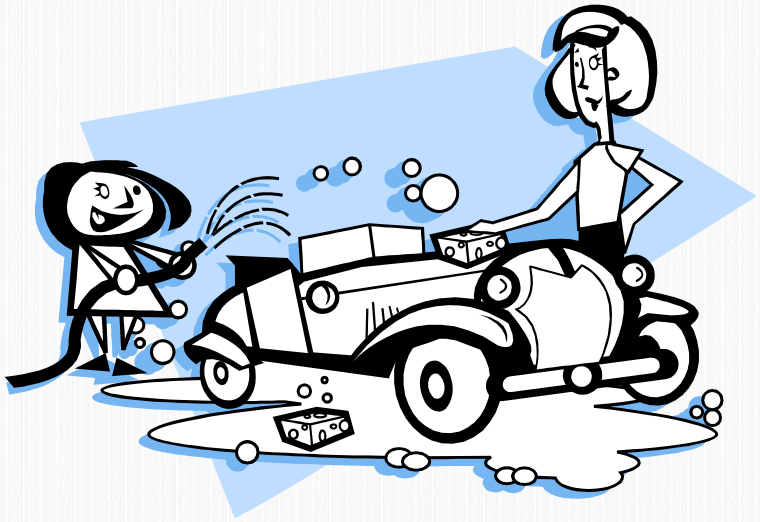


butterfly wing inspires scientists to develop textiles by assembling nanoparticles into layers from the 'bottom up'.



Sequential Ionic Self-Assembly (ISA)

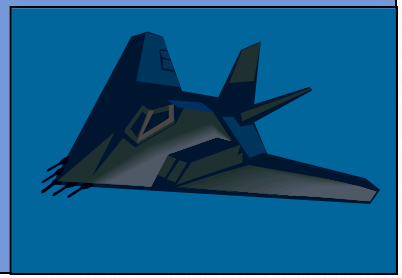
Beautiful colored self-cleaning , odor free , wrinkle free and water repellent cloths!



Does that sound like a good idea to you?-

Toucan Beaks

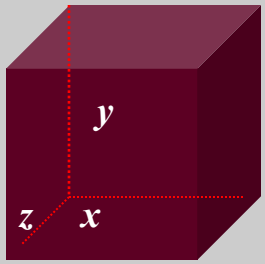
- ***The nanostructure of toucan beaks inspires automotive panels that could protect passengers in crashes.***
- ***And inspires construction of ultralight aircraft components.***

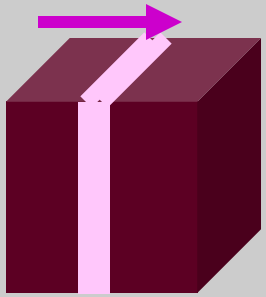


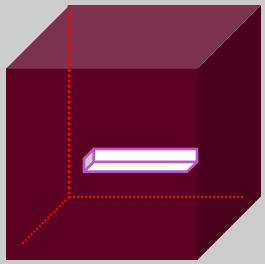
@ Take a nanoscience idea from nature.

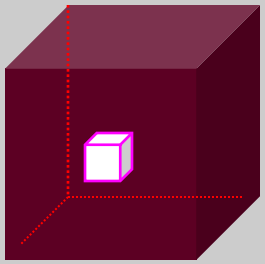
@ Create a superbeing or supertool that has a special power based on this nanoscience idea.

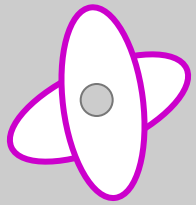
Comparison of typical dimension





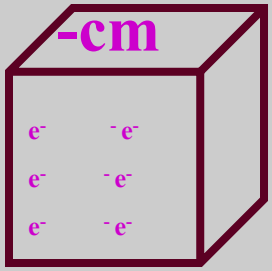






3D
Atom

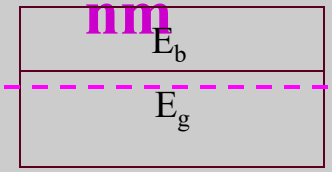
-Bulk crystals (cm)



e- free to move (K.E =0)

2D

2DEGs -Q Well(nm)



1D

Quantum wire

0D (3D)

Quantum Dot

nm **Å**

de Broglie $\lambda = h/p = h/\sqrt{3m_{eff}kT}$

Fabrication process

Top-down and bottom – up appraoch

Top-down approach is like carving a structure from block with small tools

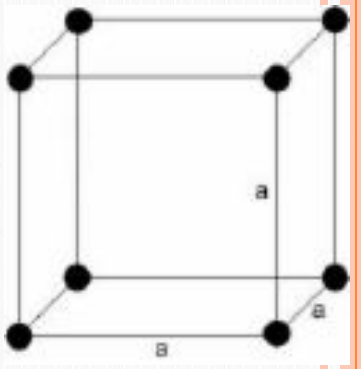
Fabrication process

Bottom-up approach is like building a structure with brick and mortar

Surface-to-volume ratio is high

Defect free structure, strain can easily be accommodated

Effect of Surface to Volume ratio:



- Assume cubic solid of side 'a'
- Surface area = 6 x a^2 , Volume = a^3
- Surface area to volume ratio = $6a^2/a^3$ =6/a

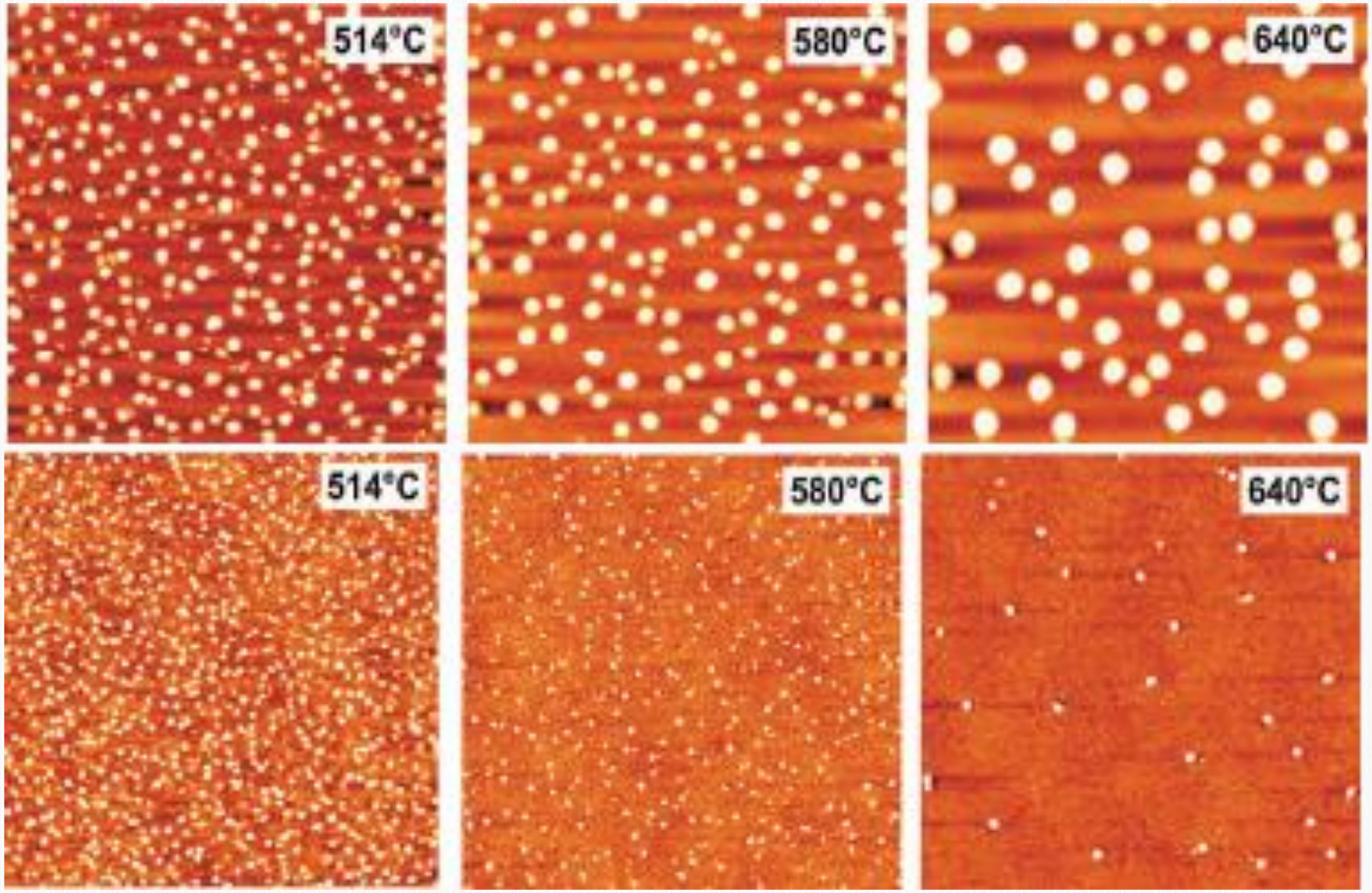
'Cut the solid into four pieces each piece having a side a/2'

- Surface area of each piece =6 x $(a/2)^2$ = $6a^2/4$
- Volume of each piece = $a^3/8$
- Surface area to volume ratio = $(6a^2/4)/(a^3x8)=12/a$

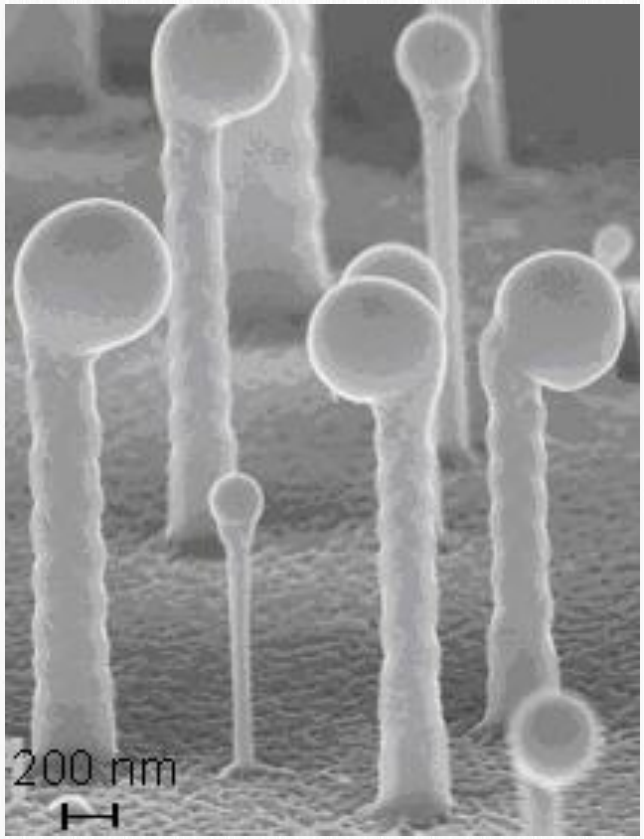
Result :

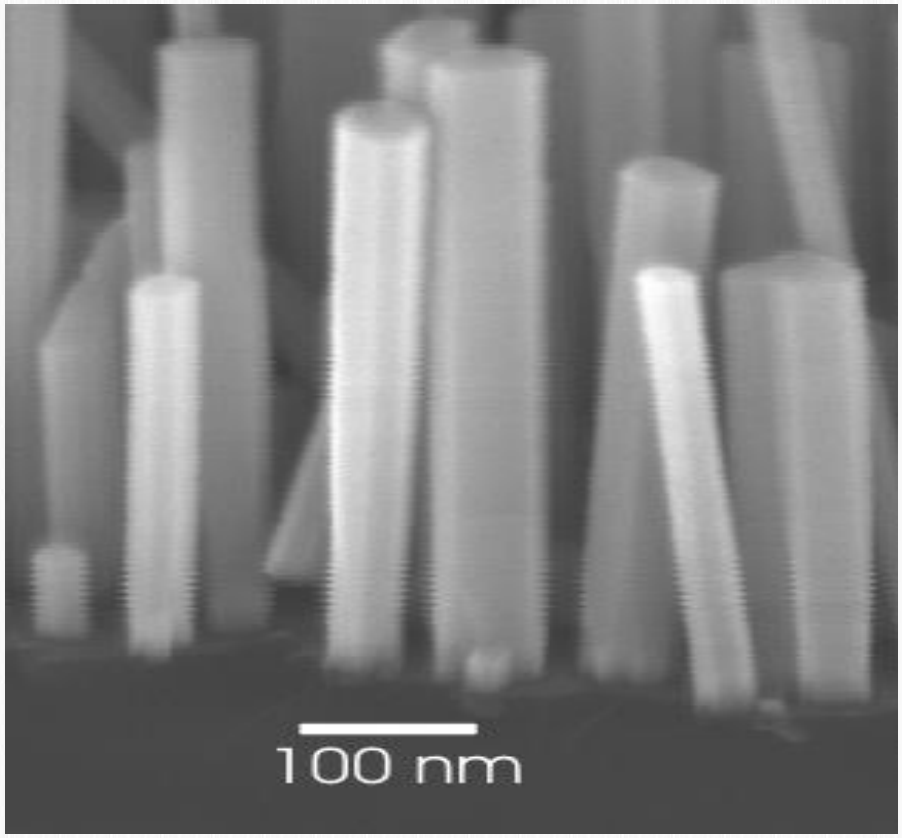
- by reducing the size we increase the surface area to volume ratio.
- If the density of the solid remains same, then more number of atoms will be on the surface.

GaN Nano crystals

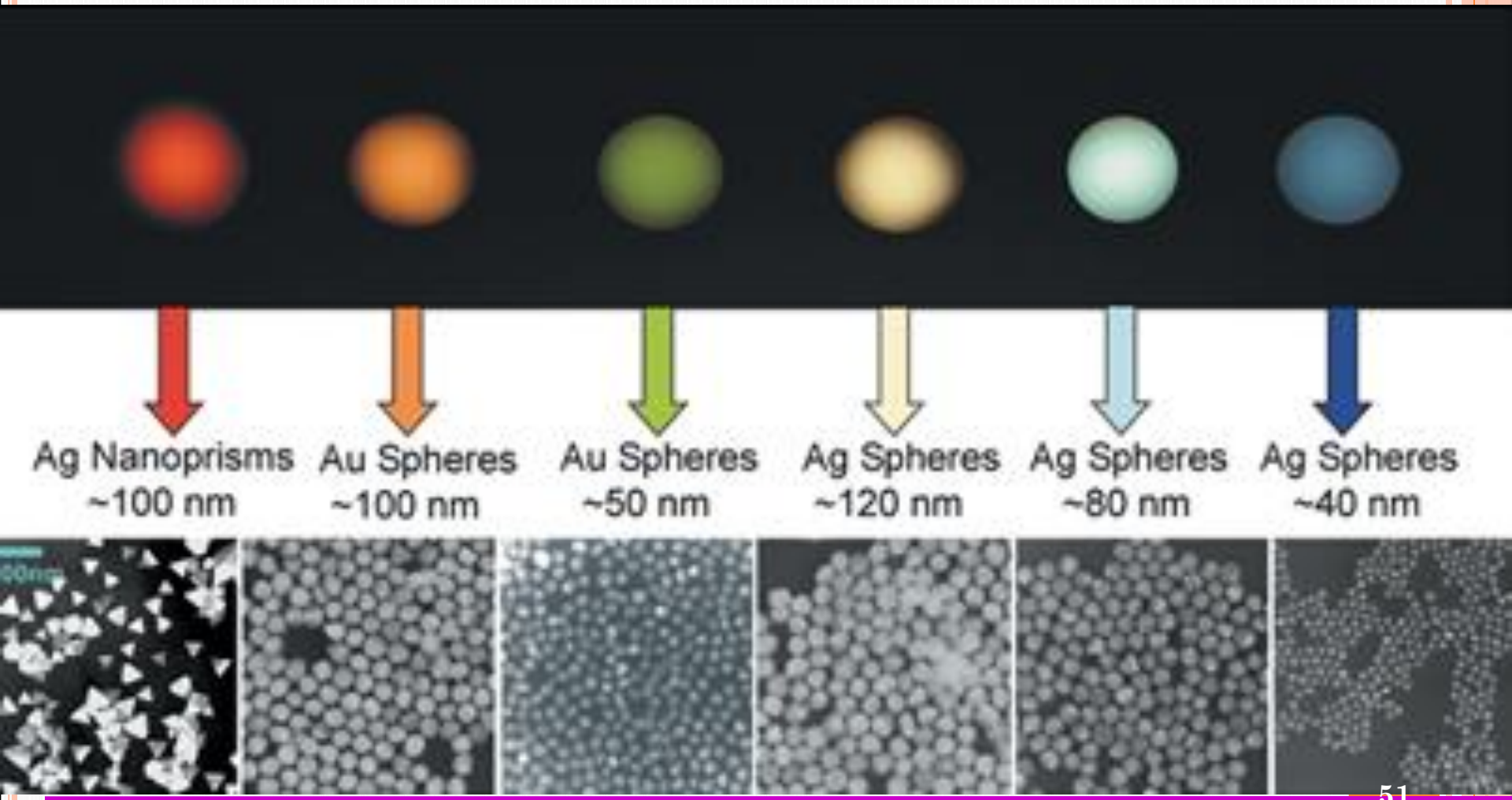


Nano wire

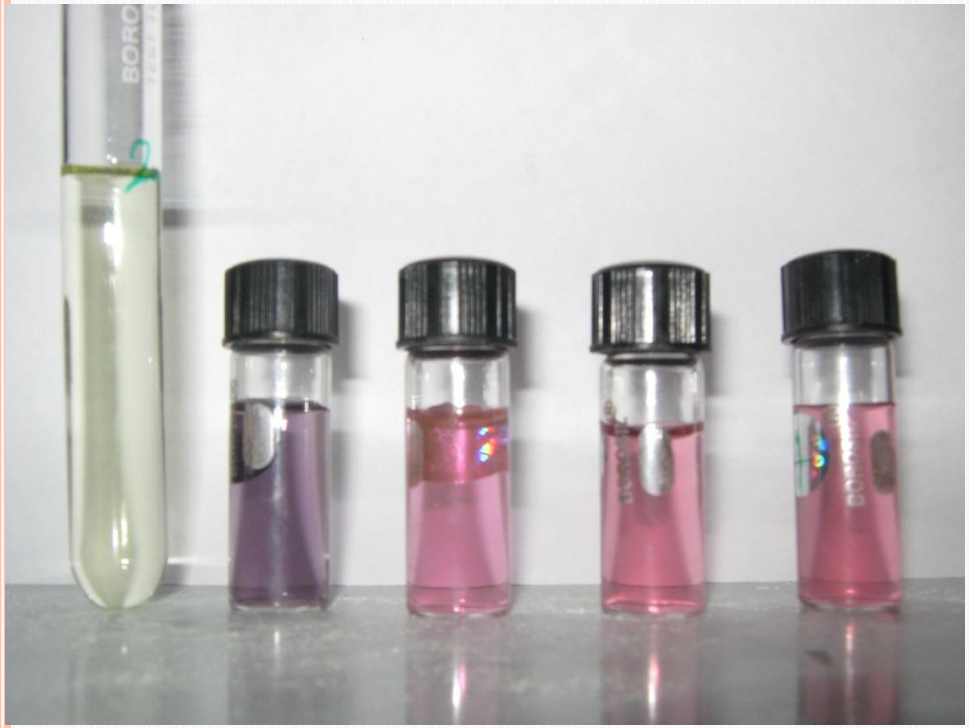


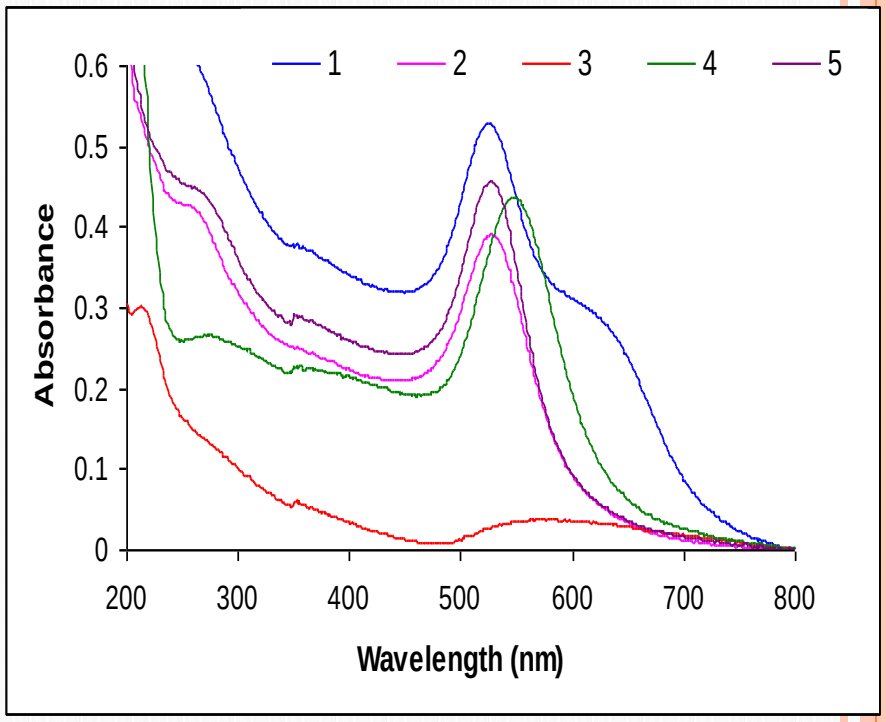


Size effects



Size effects





Quantization effects

The Lycurgus Cup (glass; British Museum; 4th century A. D.)

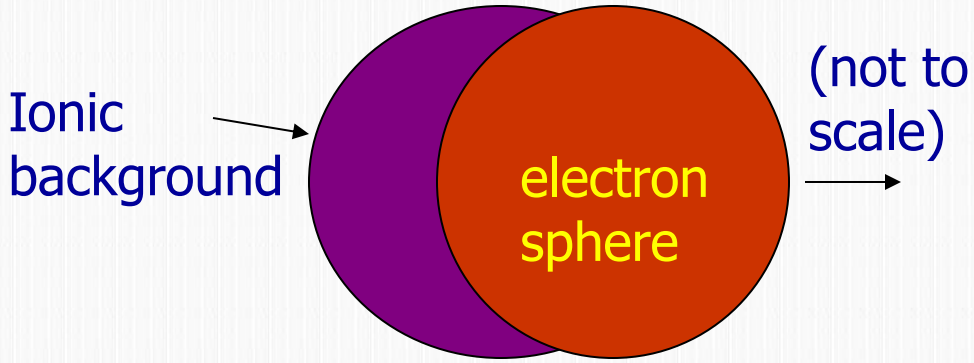
When illuminated from outside, it appears green. However, when Illuminated from within the cup, it glows red..

Lycurgus Cup illuminated from within

When illuminated from within, the Lycurgus cup glows red. The red color is due to tiny gold particles embedded in the glass, which have an absorption peak at around 520 nm

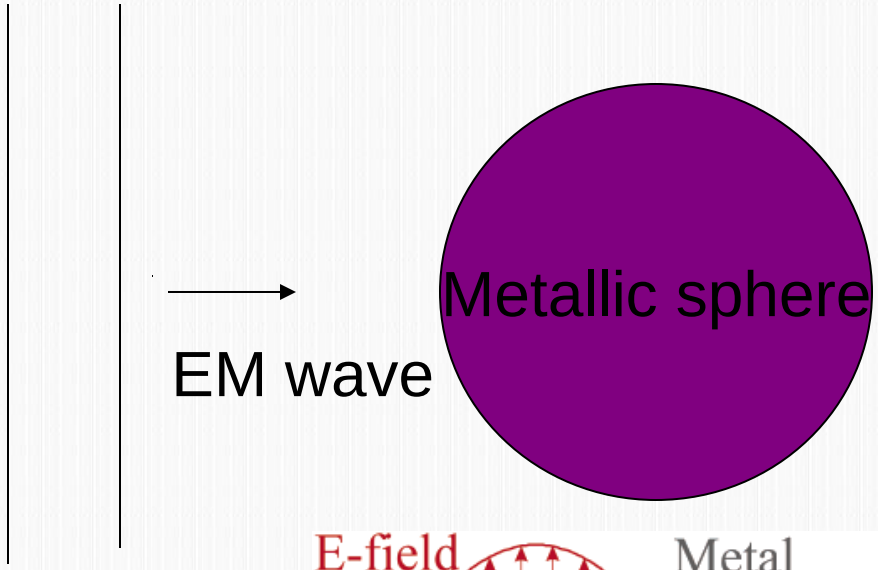
What is the origin of the color? Answer: "surface plasmons" - SP

- An SP is a natural oscillation of the electron gas inside a gold nanosphere.
- SP frequency depends on the dielectric function of the gold, and the shape of the nanoparticle.

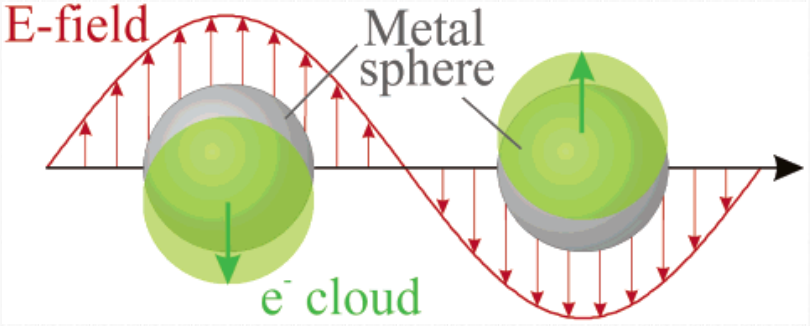


Electron cloud oscillates with frequency of SP; ions provide restoring force.

Sphere in an applied electric field



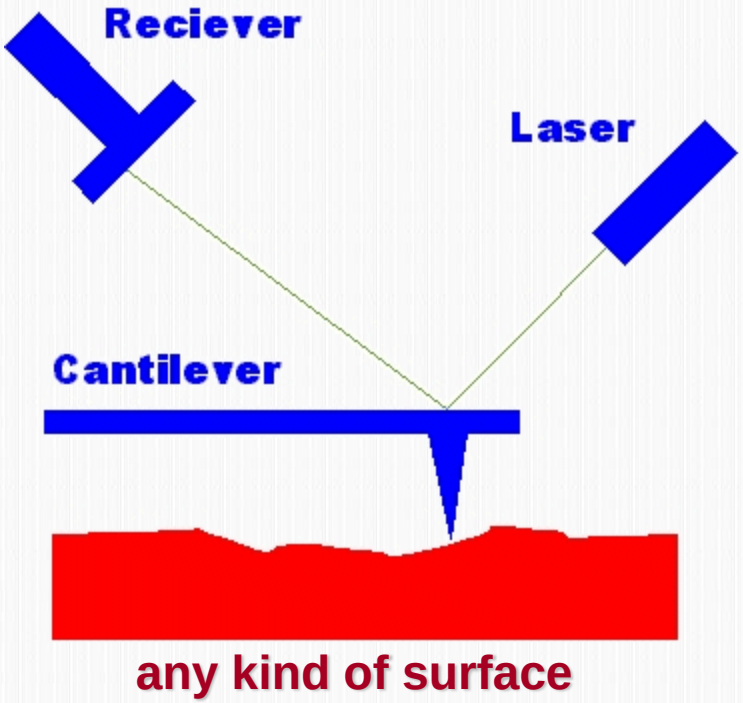
Incident electric field is $E_o \exp^{(-i\ w\ t)}$



Surface plasmon is excited when a long-wavelength electromagnetic wave is incident on a metallic sphere.

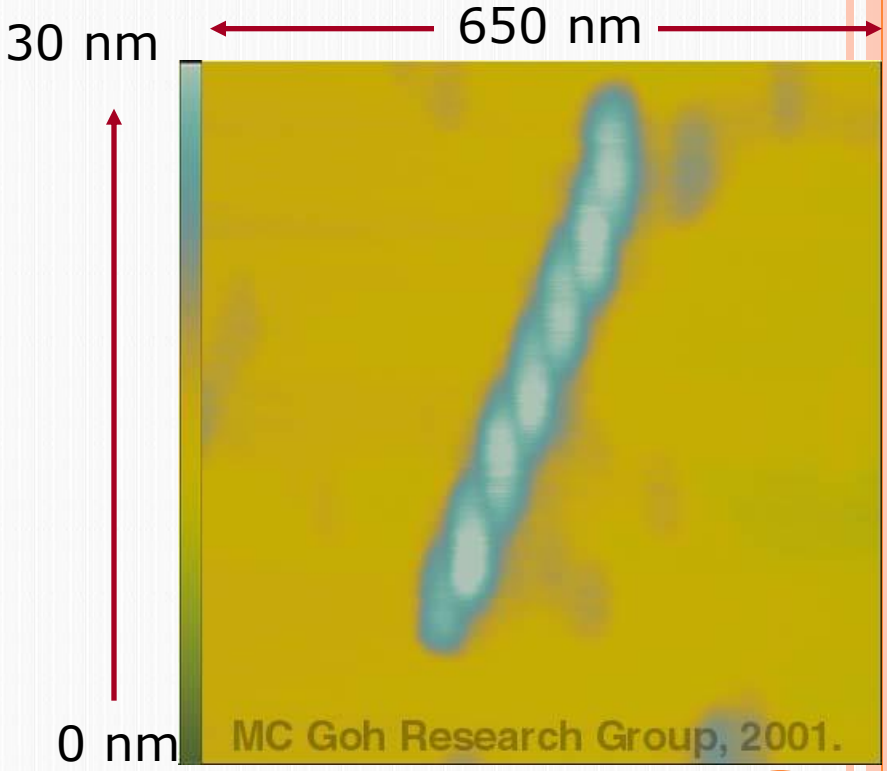
How do we know about nanoscale?

- New tools: Scanning Tunneling Microscope (STM) and Atomic Force Microscope



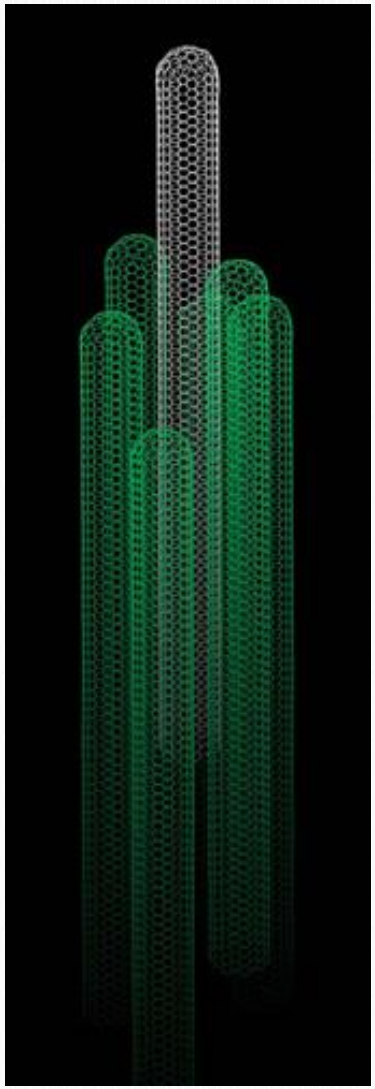
AFM

Invented in 1986 by
Binnig, Quate and Gerber



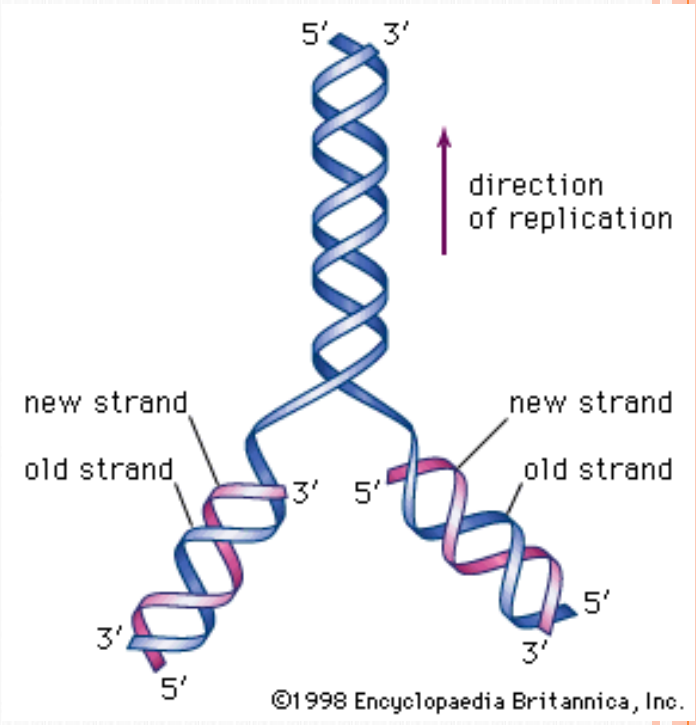
Paired Helical Filament

This slide is adapted from the presentation on "An Introduction to Nanotechnology," by Terry Bigioni, posted at http://www.homepages.utoledo.edu/tbigion/BigioniGroup/Outreach_Home.html

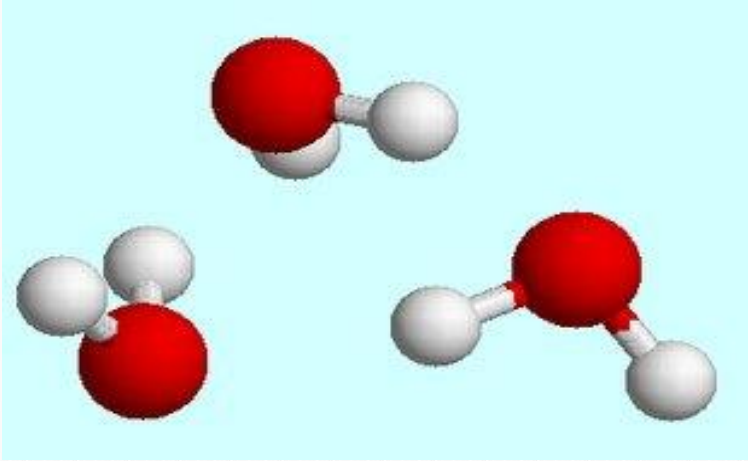


Carbon Nanotubes

The study of nanometer scale things?



DNA



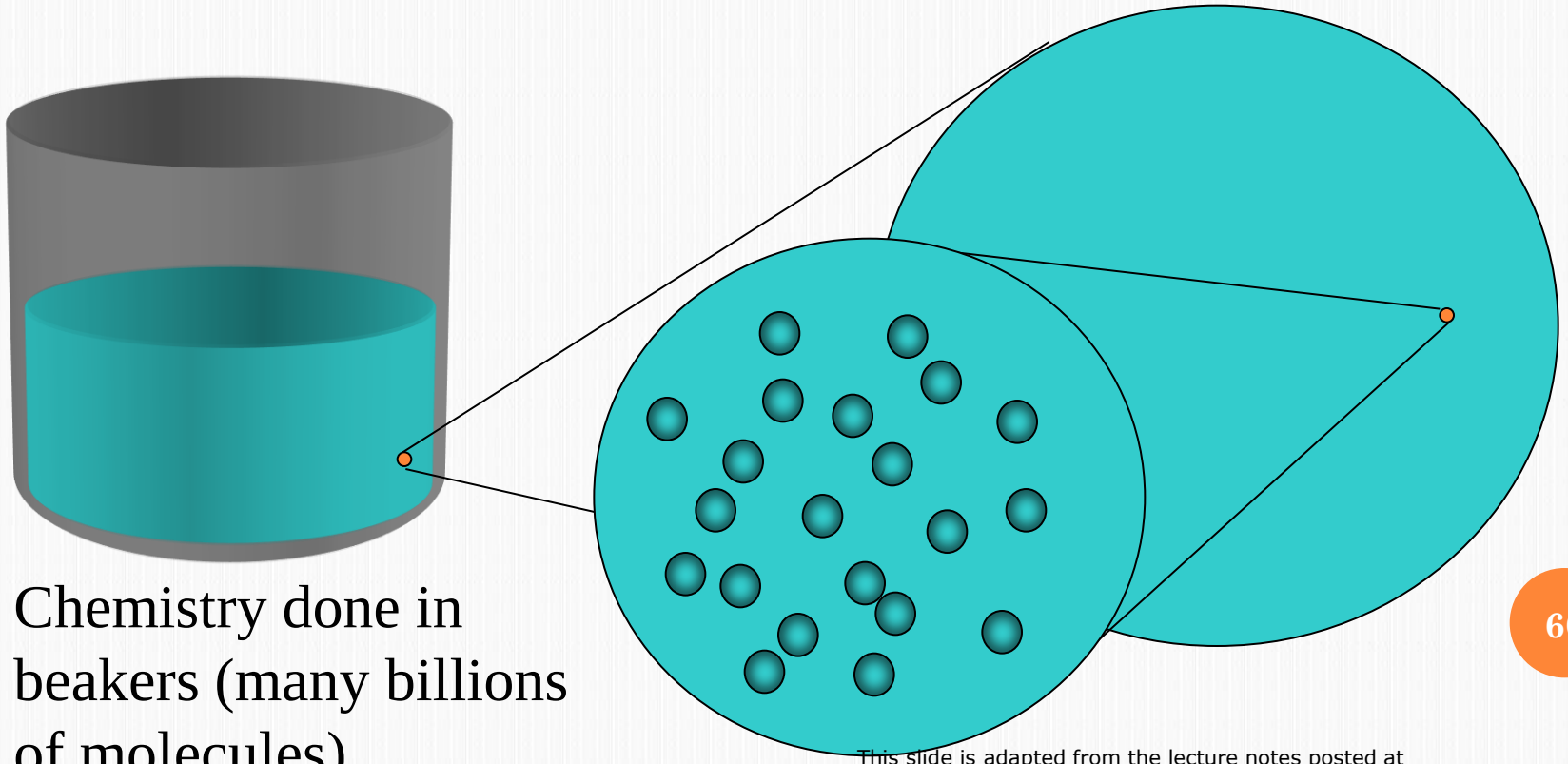
Water

This slide is adapted from the lecture notes posted at http://www.physics.unc.edu/~falvo/Phys006D_Fall07/ by Professor Michael Falvo

Isn't this just Physics, Biology and Chemistry??

Interdisciplinary

YES … and NO.

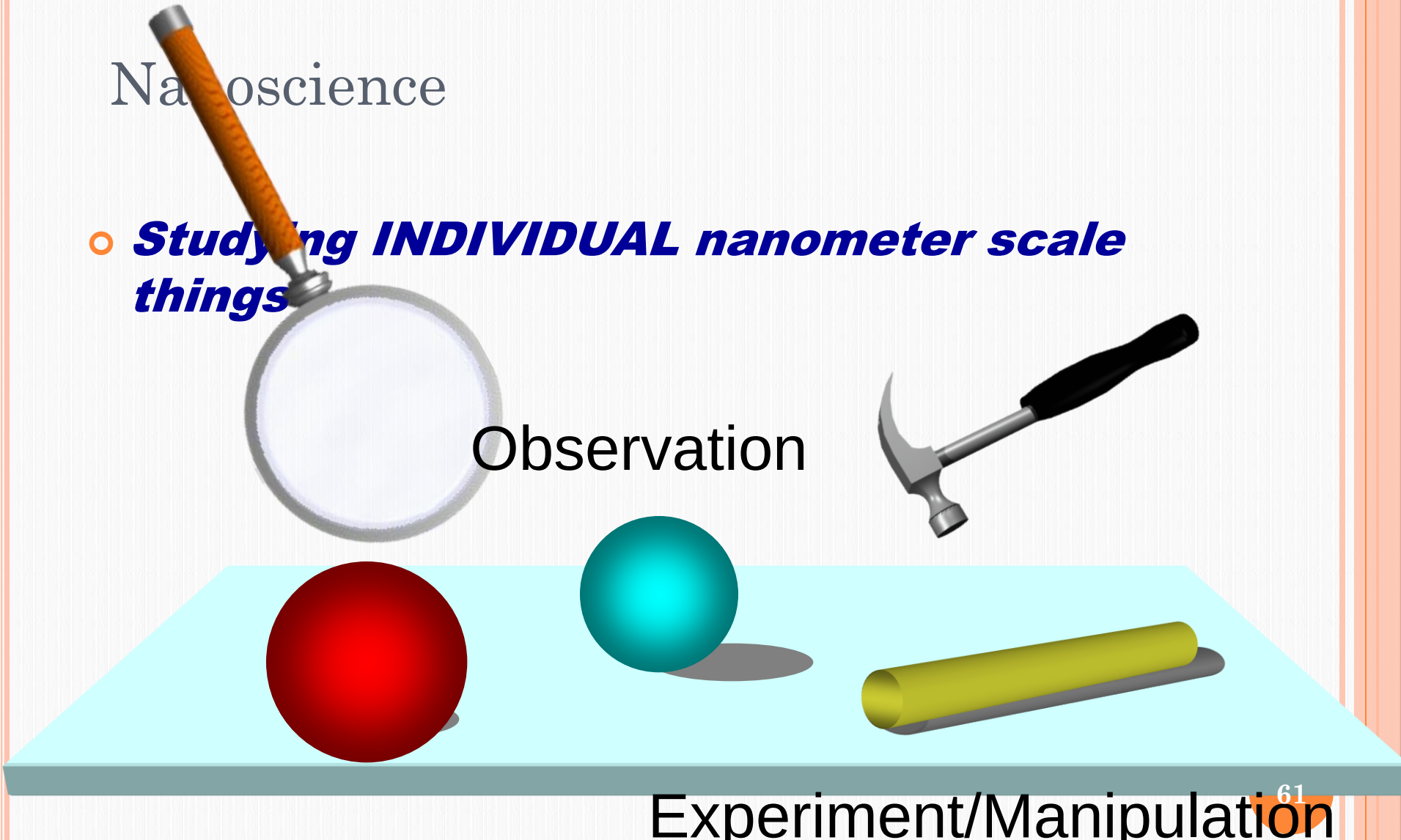


Chemistry done in beakers (many billions of molecules)

This slide is adapted from the lecture notes posted at http://www.physics.unc.edu/~falvo/Phys006D_Fall07/ by Professor Michael Falvo

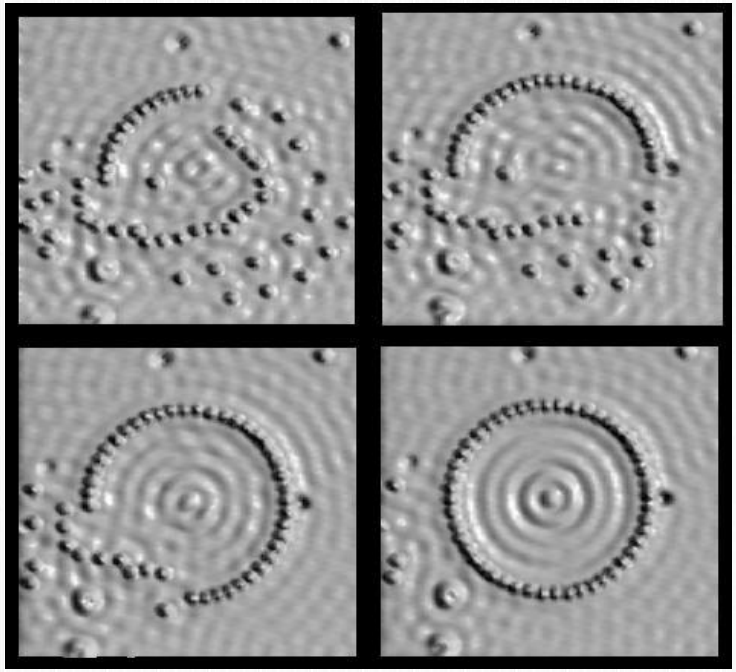
Nanoscience

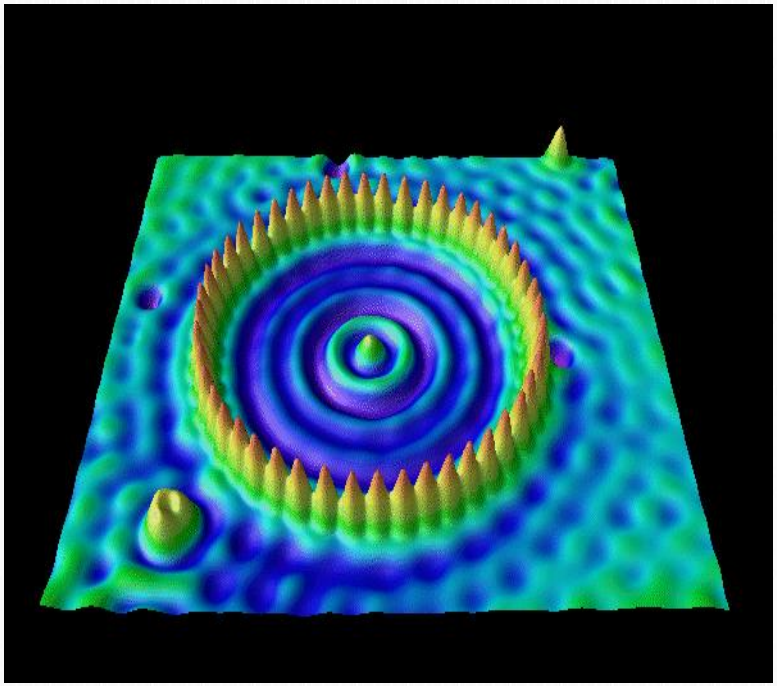
- ***Studying INDIVIDUAL nanometer scale things***



This slide is adapted from the lecture notes posted at http://www.physics.unc.edu/~falvo/Phys006D_Fall07/ by Professor Michael Falvo

Can Scientists really do this now?

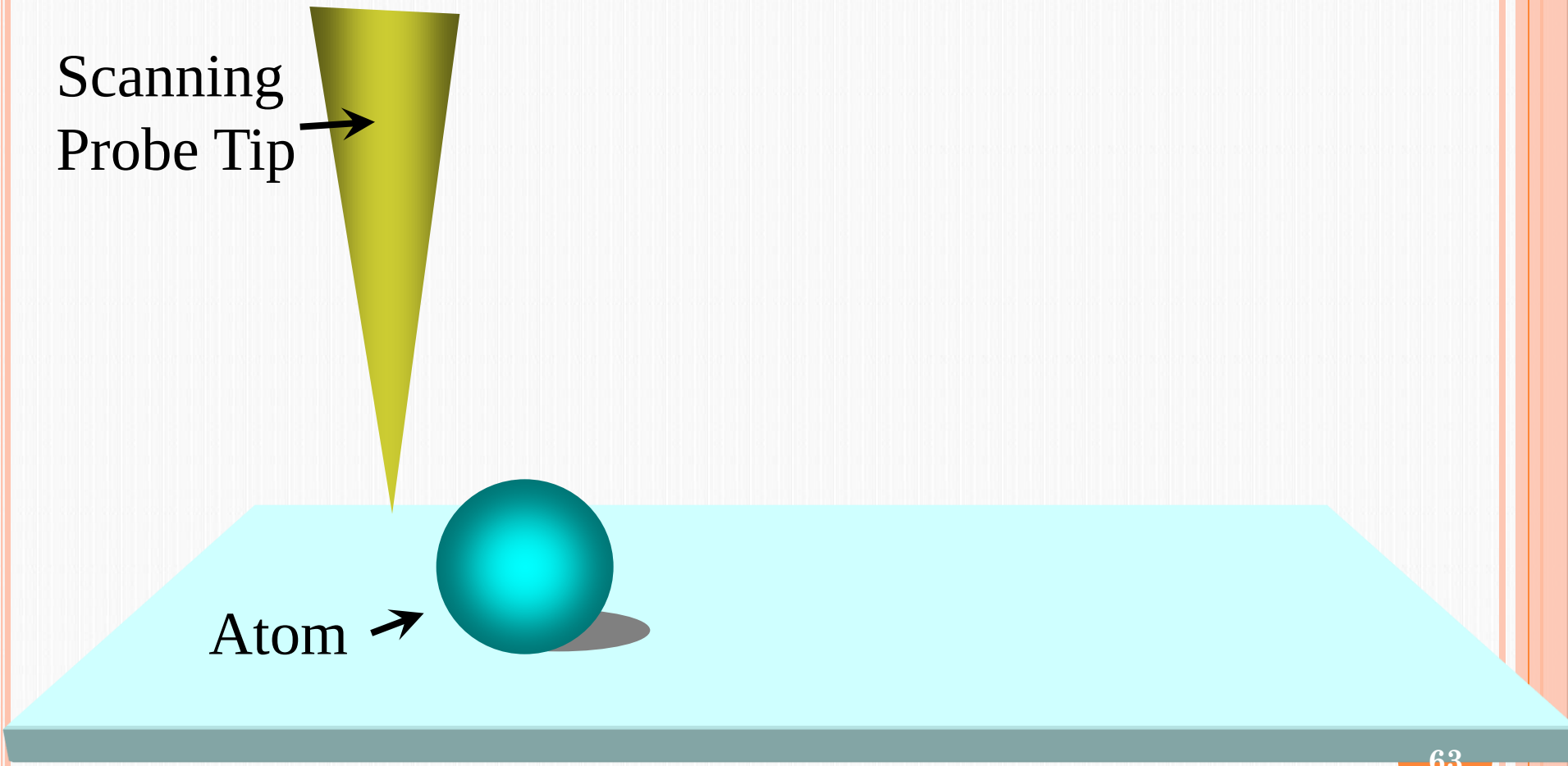




Don Eigler, IBM

Iron atoms on a copper surface

Atomic Manipulation



This slide is adapted from the lecture notes posted at
http://www.physics.unc.edu/~falvo/Phys006D_Fall07/ by Professor Michael Falvo

NOBEL PRIZE in Physics in 2010

+

=

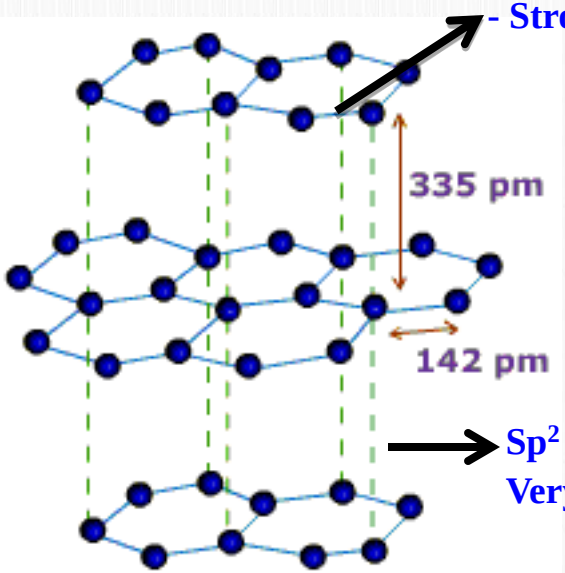
Scotch Tape

Piece of Graphite

Nobel Prize 2010

Andre Geim

Kostya Novoselov



Sp^3 hybridized bond

- Strong σ Bond in plane

Sp^2 hybridized π bond

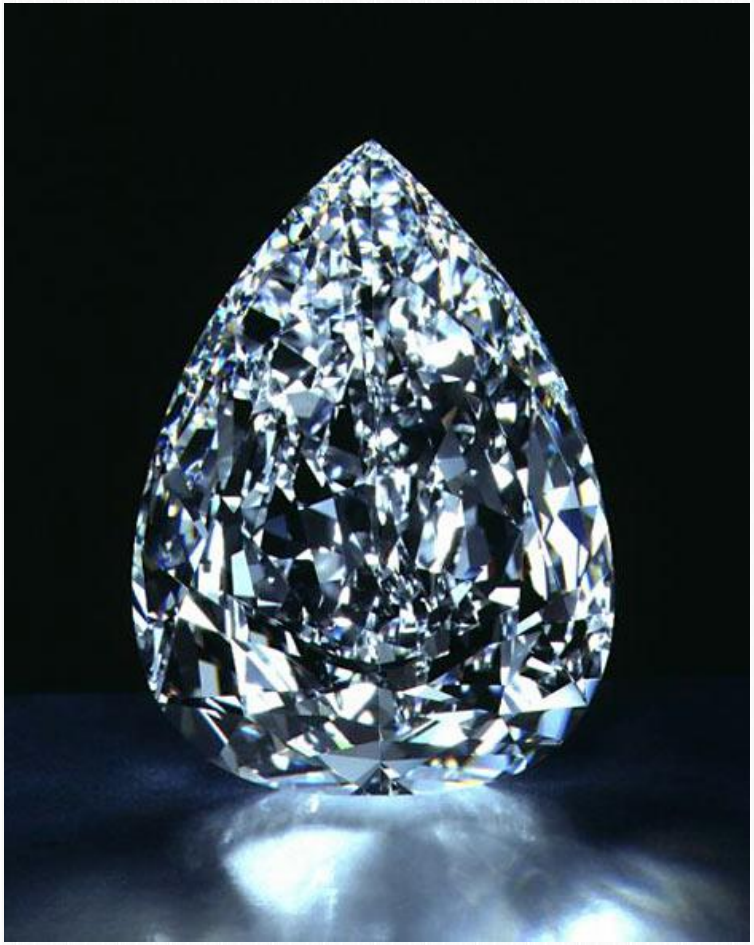
Very weak Interaction

Carbon is very important in Nature

1- it is the 4th most abundant element (after H, He and O),

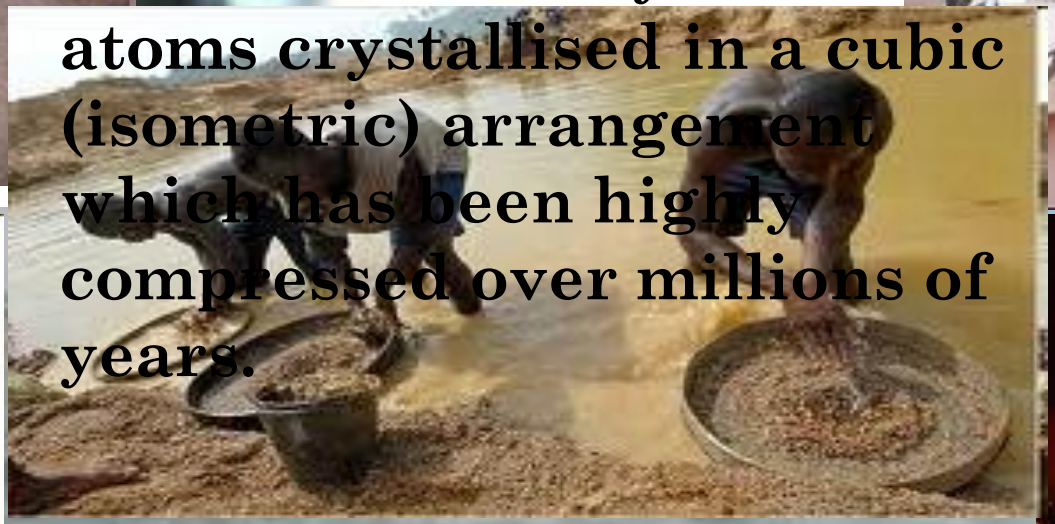
2- it is part of the very important natural processes (DNA, Cells, photosynthesis, CNO cycle for the formation of stars…)

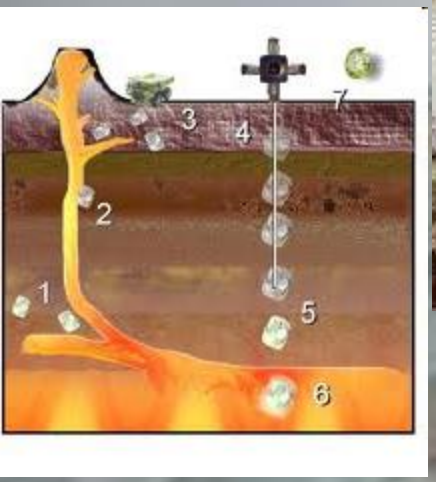
3D Allotrope ..



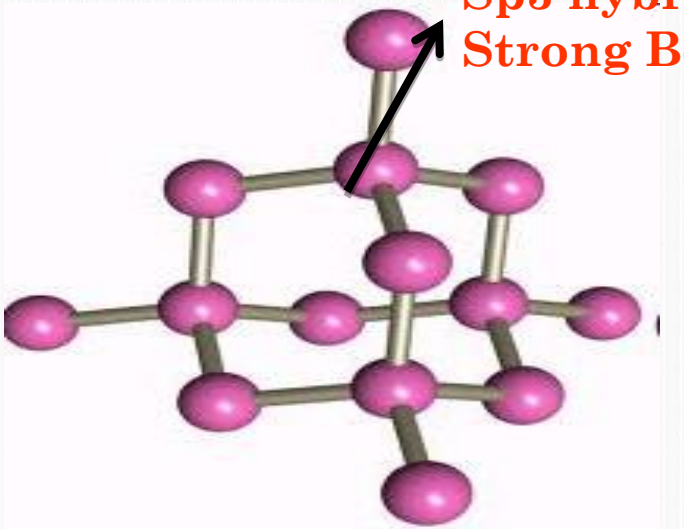
Diamonds are formed when extreme heat (temperatures of 2200 degrees Fahrenheit) and extreme pressure cause carbon atoms to crystallize forming diamonds approximately ninety miles under the earth's surface. Diamonds reach the surface of the earth via volcanic channels. Diamonds are deposited on the surface of the earth when a volcano erupts. Diamonds are the hardest of all known bodies scoring a level of 10 (harder than steel) on the Mohs Hardness Scale.

A Diamond is a clear transparent precious gem stone made totally of Carbon atoms crystallised in a cubic (isometric) arrangement which has been highly compressed over millions of years.

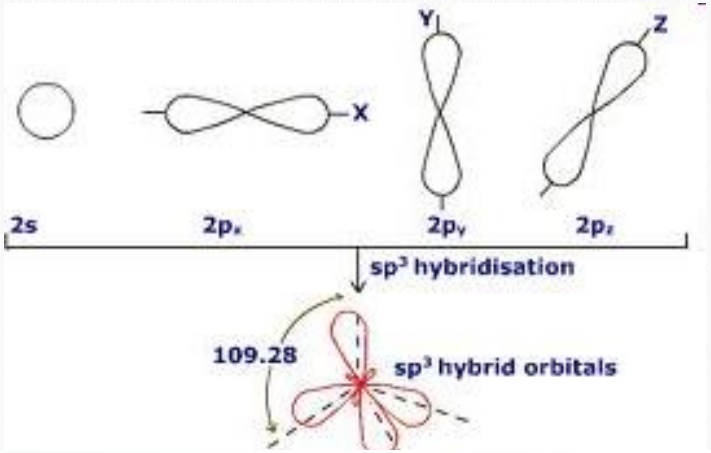




3D Allotrope ……



Tetrahedron structure

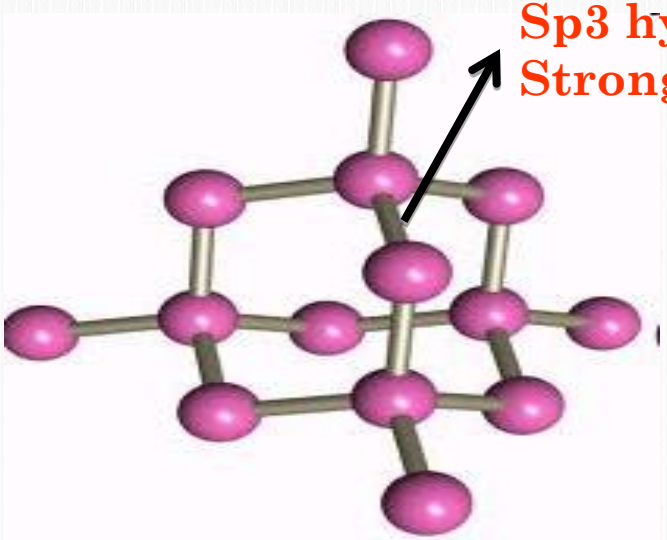


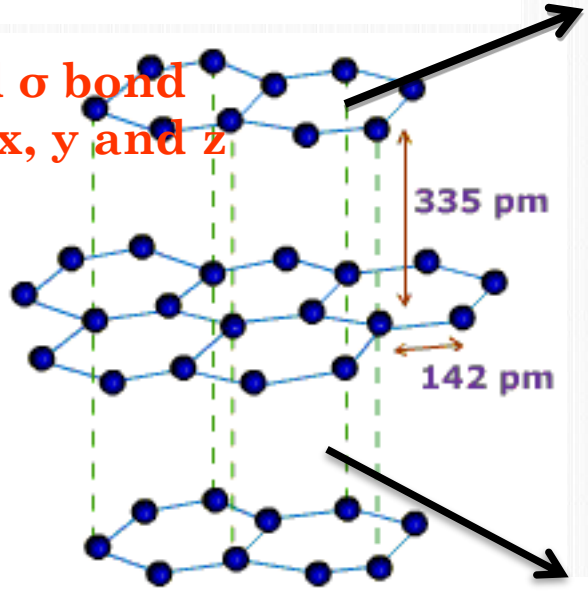
…is a transparent crystal of tetrahedral shaped bonded carbon atoms. A tetrahedron is composed of four triangular faces, three of which meet at each vertex. The tetrahedral arrangement of atoms is the source of many of

3D Allotrope ……

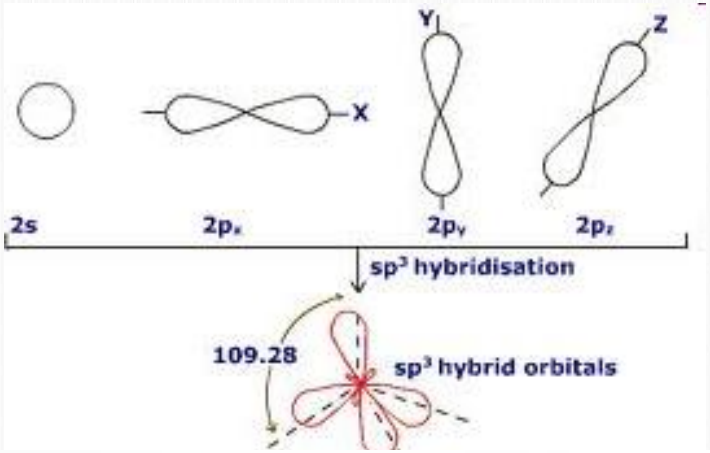
Sp2 hybridized σ bond
- Strong Bond in plane

Sp3 hybridized σ bond
Strong Bond – x, y and z

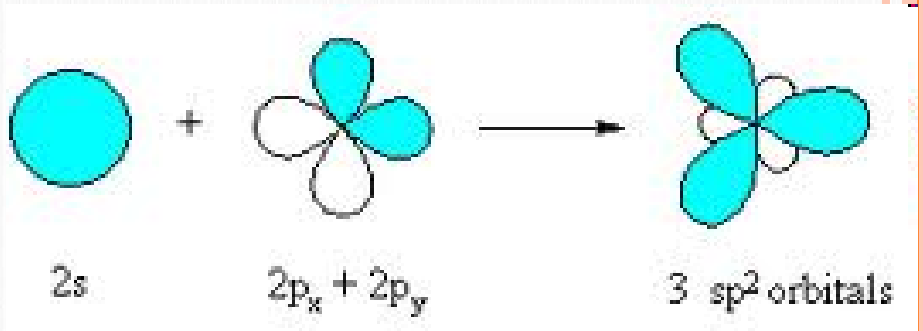




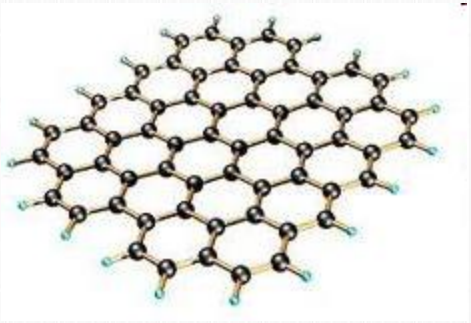
Tetrahedron structure



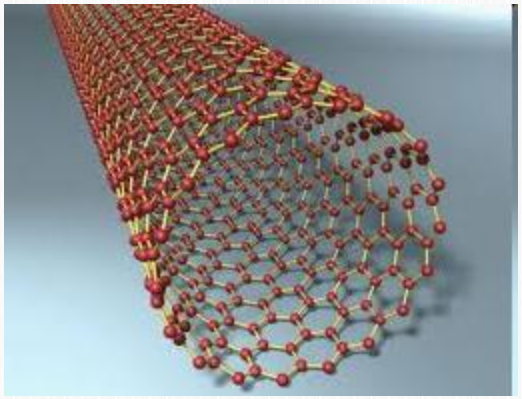
Sp2 hybridized π bond
Very weak Interaction



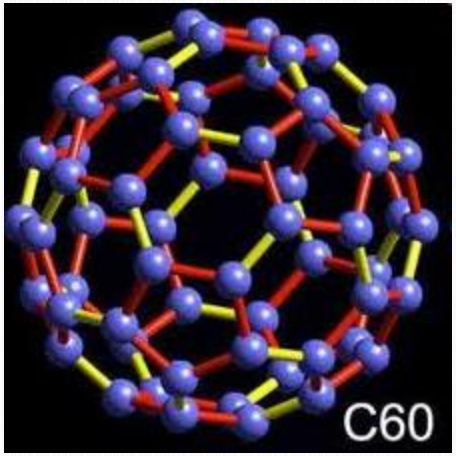
Dimensionality of carbon



2D

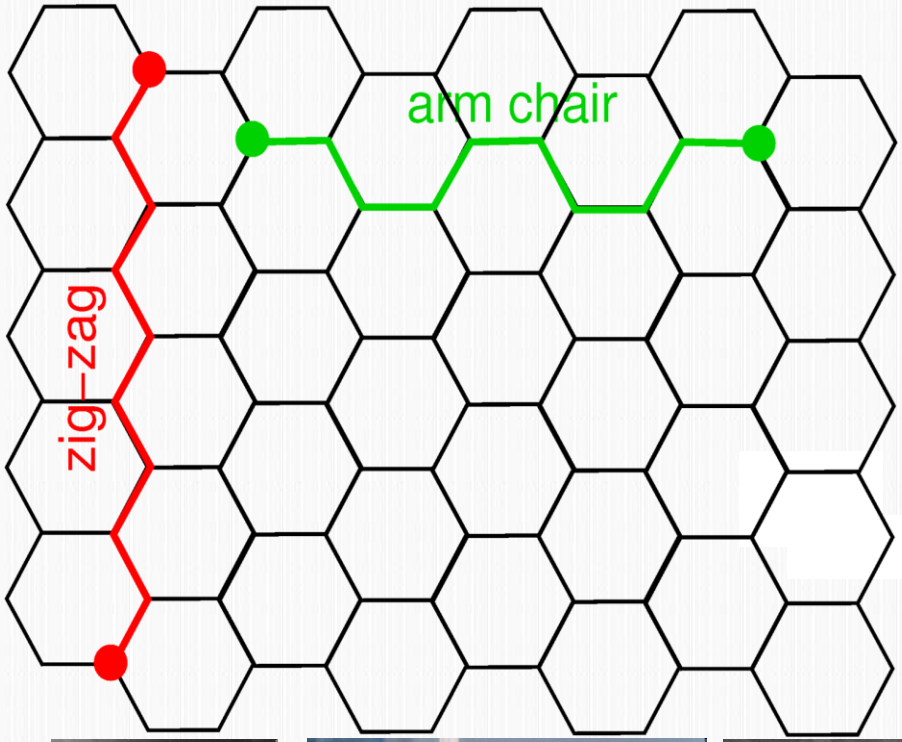


1D

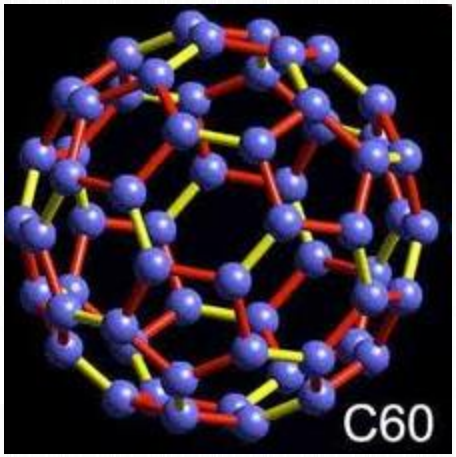


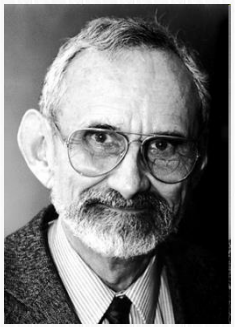
0D

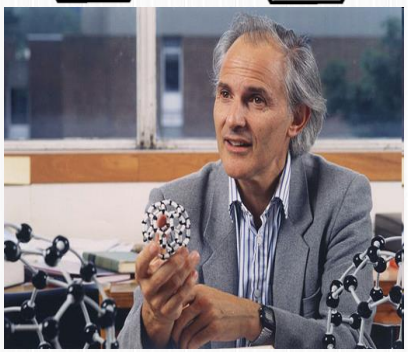
The Nobel Prize in Chemistry 1996

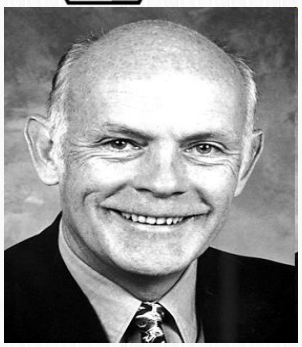


Curling





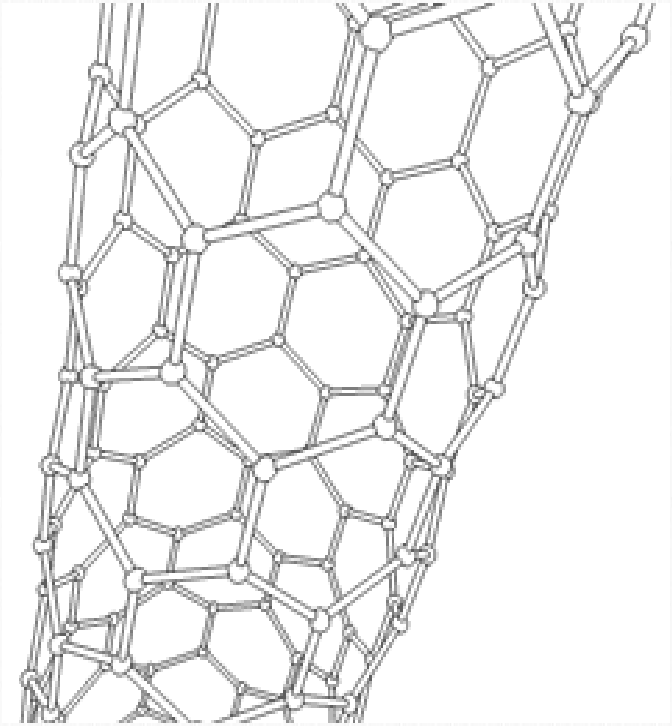




Robert F. Curl Jr.

Sir Harold Kroto

Richard E. Smalley



Discovered by Iijima in 1991?

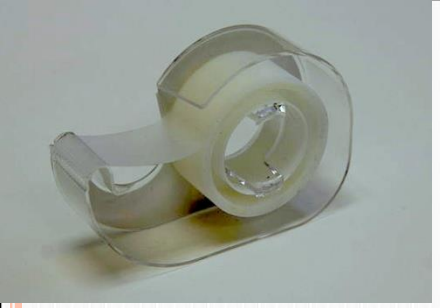
Single Atomic Layer of Carbon atoms aligned in a Honey Comb Lattice.

Can be considered as the Mother of all Carbon Based Allotropes.

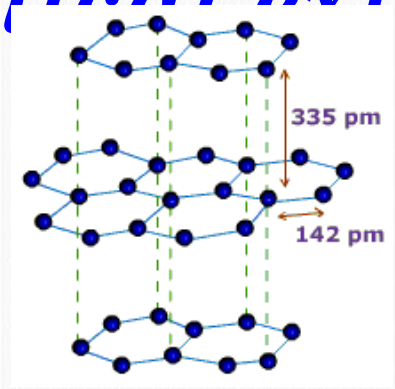
Competition is Heavy.

Thermodynamically single atomic layer of any material is highly unstable.

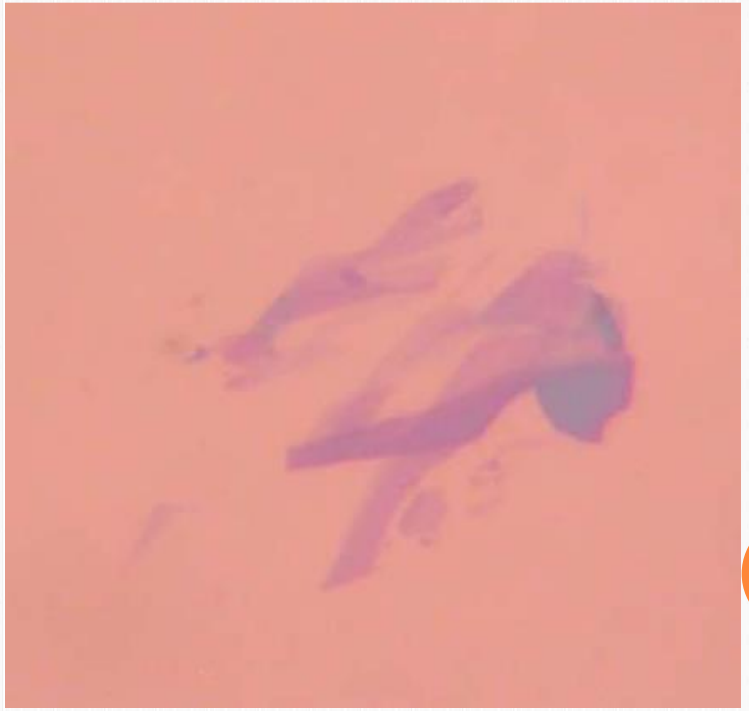
Has excellent electronic, optical and thermal properties.

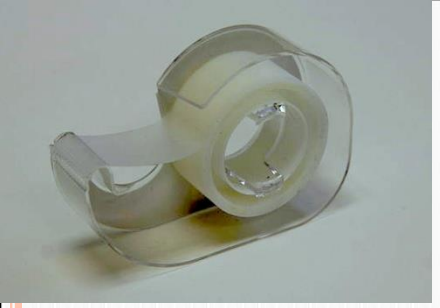


Scotch tape – Mechanical exfoliation



The mechanical energy is used to break π bonds





Scotch tape – Mechanical exfoliation

"A fresh surface of a layered crystal was rubbed against another surface (virtually any solid surface is suitable), which left a variety of flakes attached to it (the rubbing process can be described as similar to "drawing by chalk on a blackboard"). Unexpectedly, among the resulting flakes we always found single layers. Their preliminary identification amid thicker flakes and other residue was done n an optical microscope. 2D crystallites become visible on top of an oxidized Si wafer because even a monolayer adds up sufficiently to the optical path of reflected ight so that the interference color changes with respect to the one of an empty substrate (phase contrast). The whole

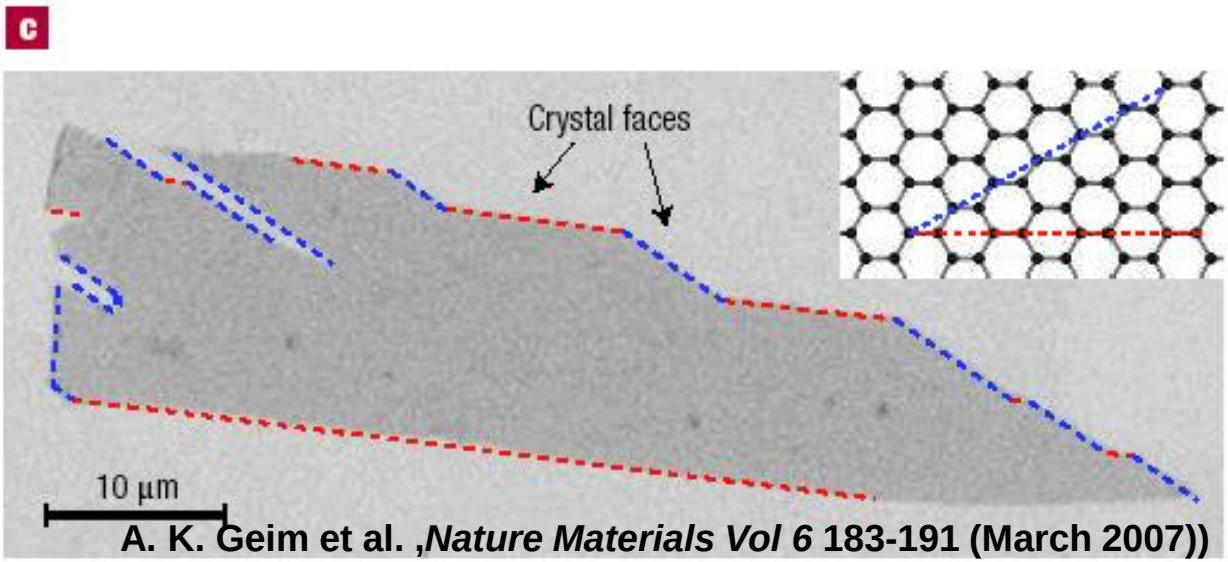
Discovery

22 OCTOBER 2004 VOL 306 SCIENCE www.sciencemag.org

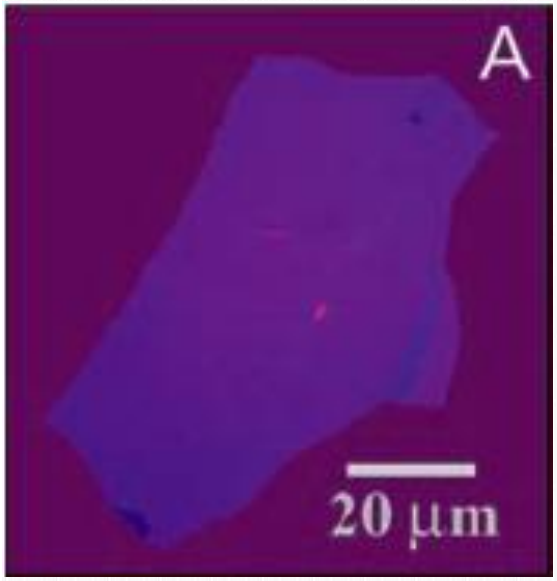
Electric Field Effect in Atomically Thin Carbon Films

K. S. Novoselov,[1] A. K. Geim,[1]* S. V. Morozov,[2] D. Jiang,[1] Y. Zhang,[1] S. V. Dubonos,[2] I. V. Grigorieva,[1] A. A. Firsov[2]

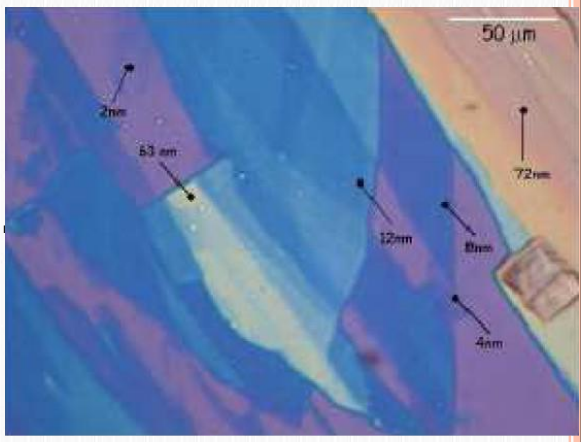
2D Allotrope: N.S. Novoselov 2004 [K.S. Novoselov et al.,



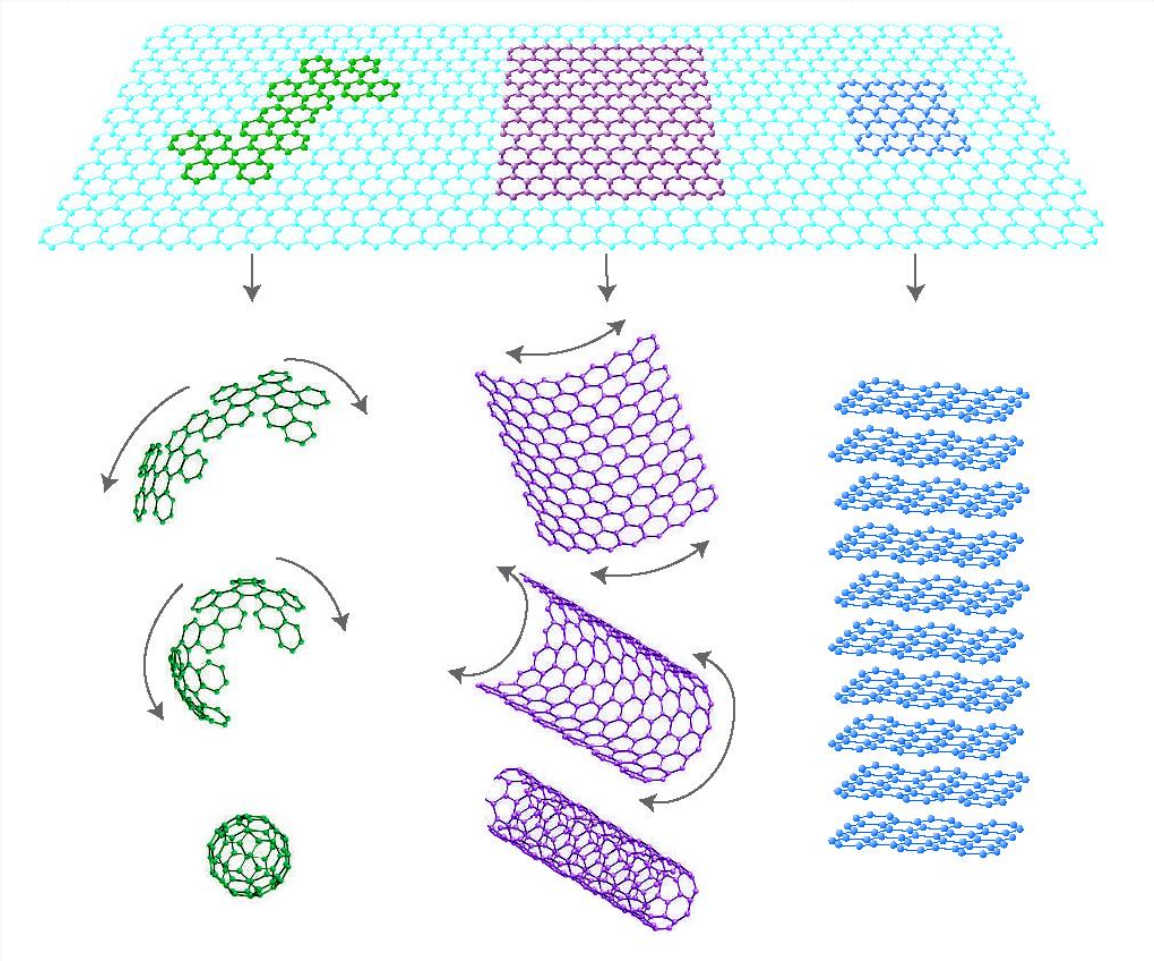
A. K. Geim et al. ,*Nature Materials Vol 6* 183-191 (March 2007))



- K. Novoselovet al.,Science 306, 666, 2004.
- K. Novoselovet al., Nature 438, 197, 2005.
- K. Novoselovet al., Nature Physics 2, 177, 2006.



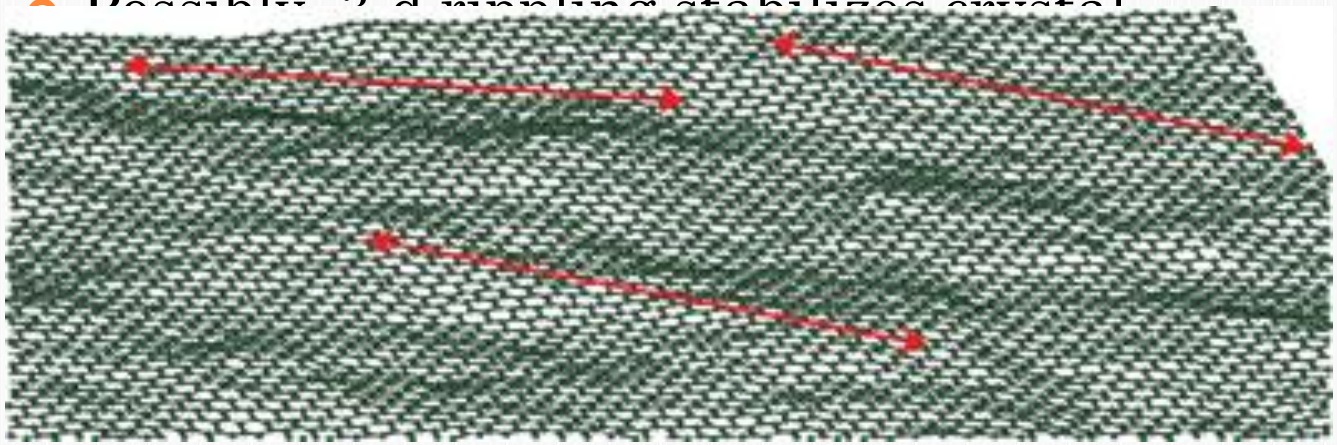
Mother of Carbon *structures*



Curling **Rolling** **Stacking**

A Two dimensional crystal

- In the 1930s, Landau and Peierls (and Mermin, later)showed thermodynamics prevented 2-d crystals in free state.
- Melting temperature of thin films decreases rapidly with temperature -> monolayers generally unstable.
- In 2004, experimental discovery of graphene- high quality 2-d crystals
- Possibly, 2-d rippling stabilizes crystal



Representation of rippling in graphene. Red arrows are ~800nm long.

http://www.nature.com/nmat/journal/v6/n11/fig_tab/nmat2011_F1.html#figure-title

A TWO DIMENSIONAL CRYSTAL

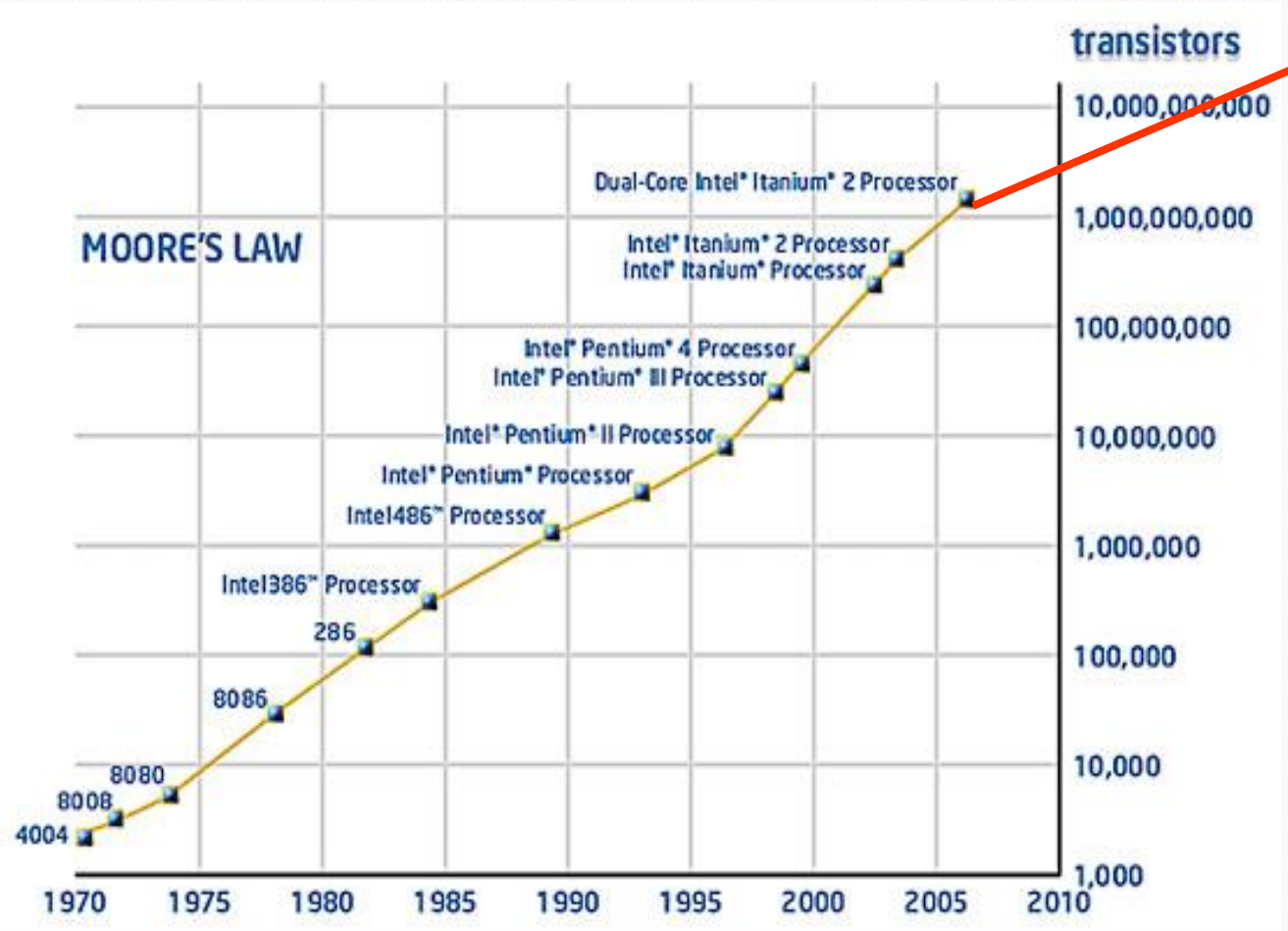

SCIENCE PHOTO LIBRARY

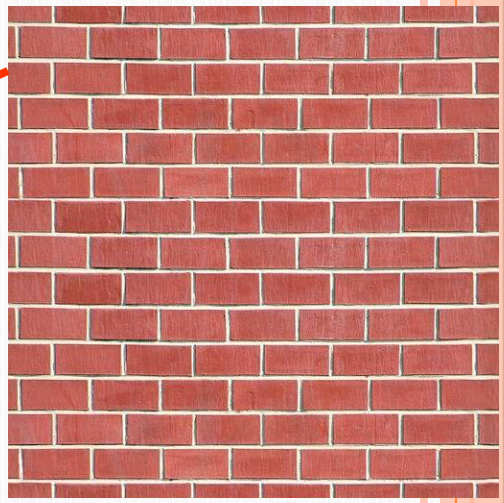
PHYSICAL PROPERTIES OF GRAPHENE

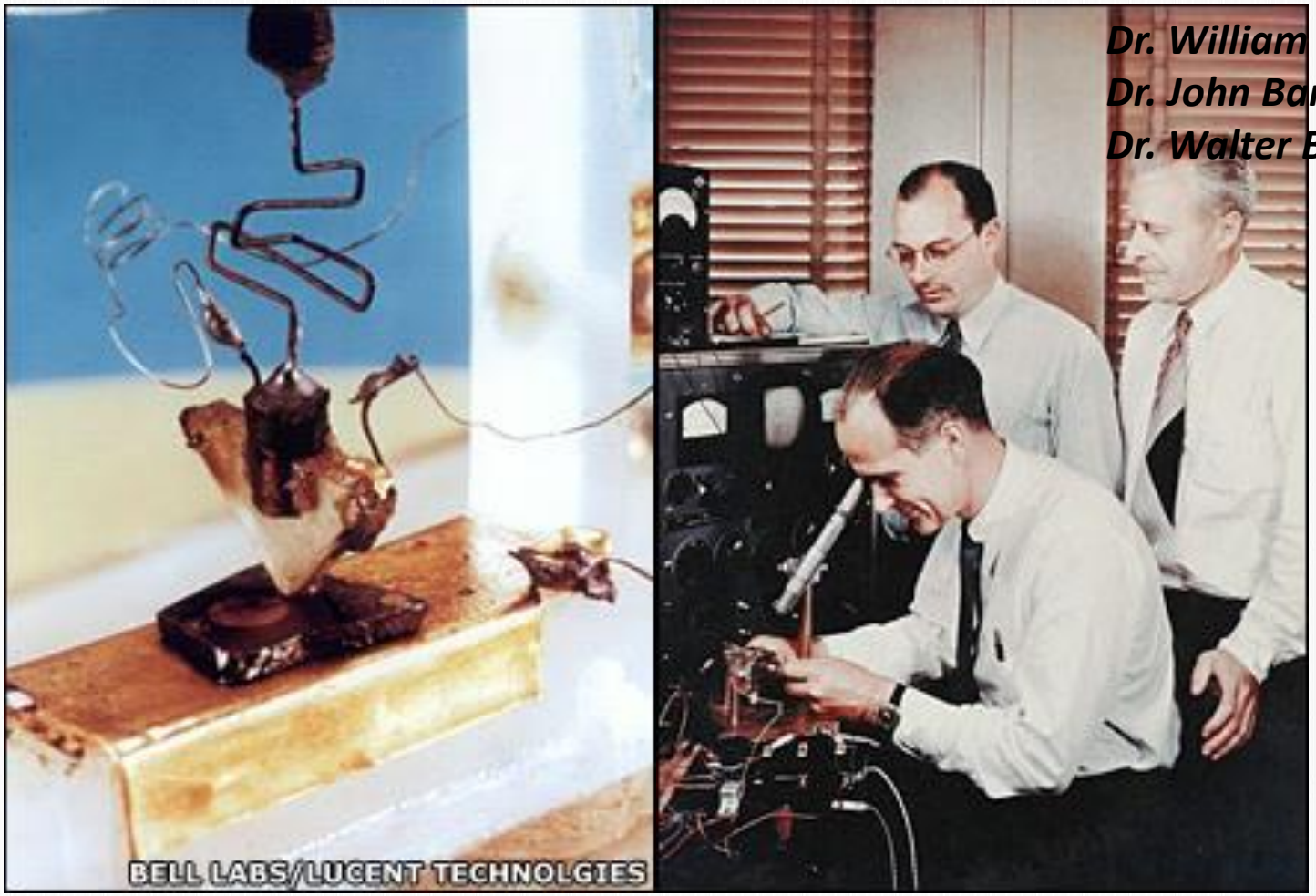
Young modulus	-	***~1 TPa***
spring constant	-	*1-5 N/m*
Carrier mobility	-	*2 X 10^6 $cm^2V^{-1}s^{-1}$ @300K*
Resistivity	-	*10^{-6} ohm-cm*
Thermal conductivity	-	*4.84-5.30 X 10^3 $Wm^{-1}K^{-1}$*
Carrier Velocity	-	***1 X 10^6 m/s***
Low Johnson Noise		
Zero mass Carriers	-	*Dirac Fermions*

- *Hard to Believe Graphene is*
  - *100 times stronger than Steel!*

Why Graphene?







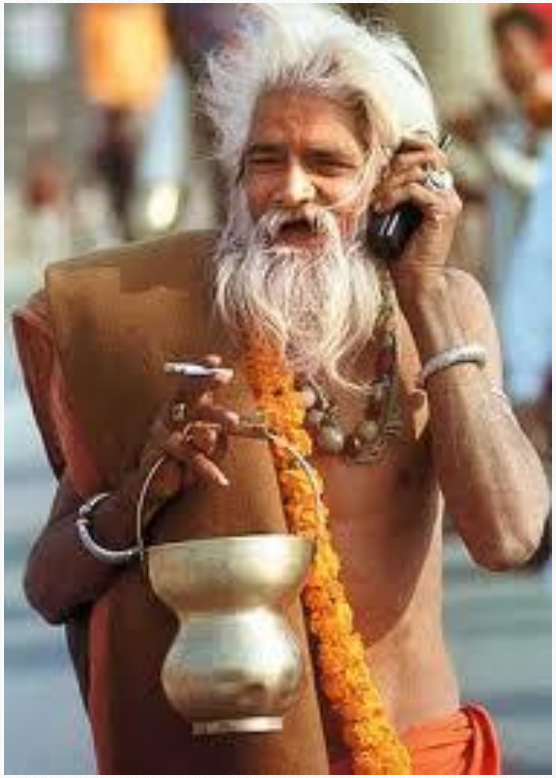
Dr. William Shockley,
Dr. John Bardeen,
Dr. Walter Brattain

The subsequent invention of transistor using this unusual property, not only lead to the Nobel Prize in Physics in 1956

but, more importantly it accelerated us through the *INFORMATION AGE*.

The invention of transistor was first device for the development of INFORMATION AGE. It has changed the many aspects of human modern life that drive the current Socio – Economic lifestyles.

TRANSISTOR WAS THE FIRST TOOL !

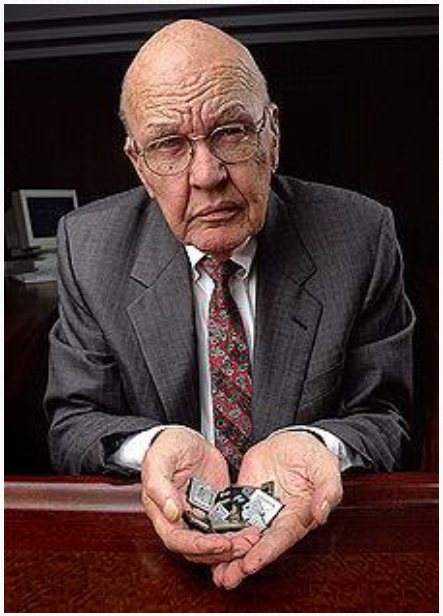



NEC

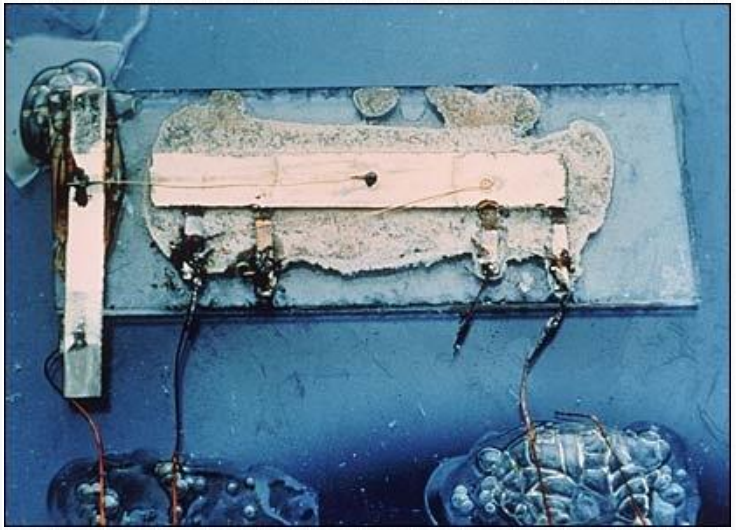
Integrated Circuit

The invention of the transistor ushered in the development of the integrated circuit,- the forerunner of today's silicon chips.

The first demonstration was made by Jack Kilby in 1958



1923-2005



Robert Noyce - **Fairchild semiconductor**

Jack Kilby - **Texas Instrument**

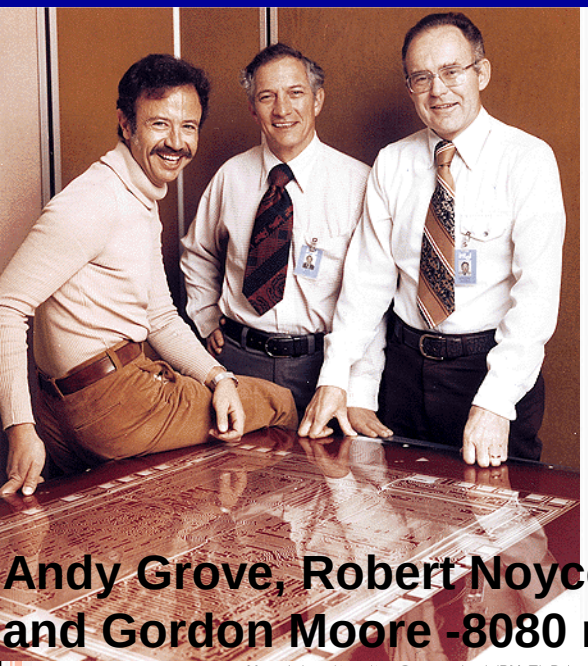
Nobel Price in Physics 2000

Herbert Kroemer - **Growing of heterostructures**

Zhores Alferov - **Semiconductor laser based on heterostructures**

Jack S. Kilby - **Invention of the IC**

Semiconductor Road Map / Moore's law



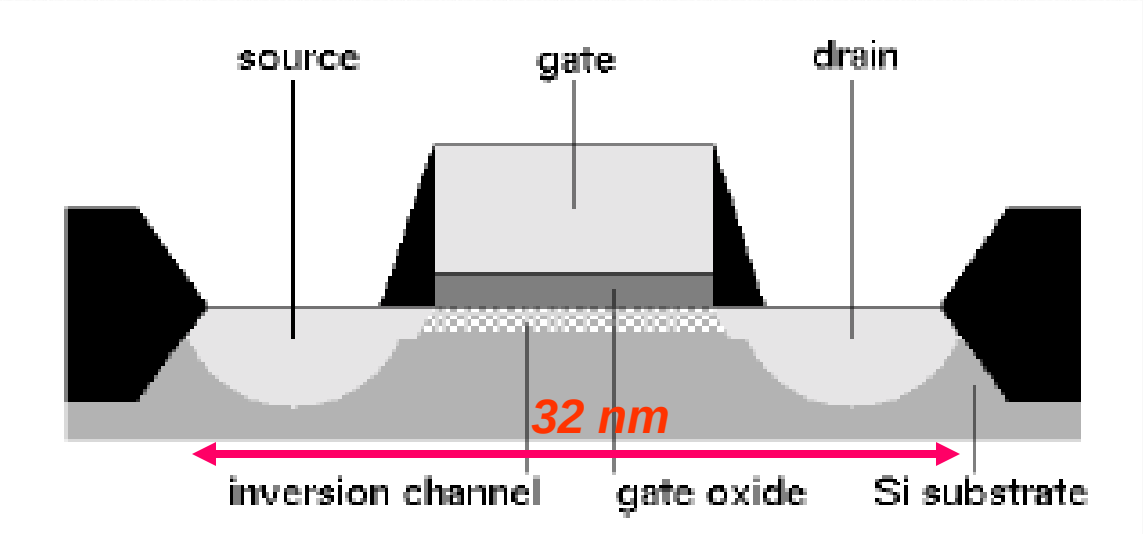
Andy Grove, Robert Noyce and Gordon Moore -8080 mp

In 1965, his prediction, popularly known as Moore's Law,
states that the number of transistors on a chip will double about every two years.

Has kept that pace for nearly 50 years, continues to be guiding principle of the semiconductor industries.

As the process shrink, the wasted energy becomes a major problem and results in a less efficient system

Hafnium-based high-k metal gate used in production today



32nm silicon technology

Intel® Itanium® processors codenamed Tukwila

1.9 billion transistor in a single die

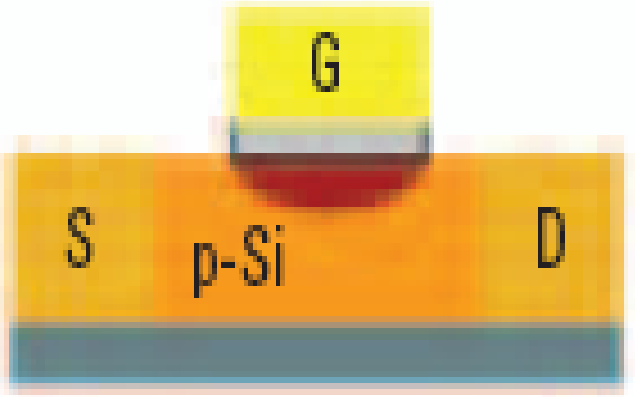
Source : Intel corpn

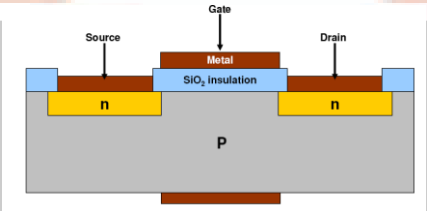
$V_G > 0$

Depletion of carriers, conductance decreases

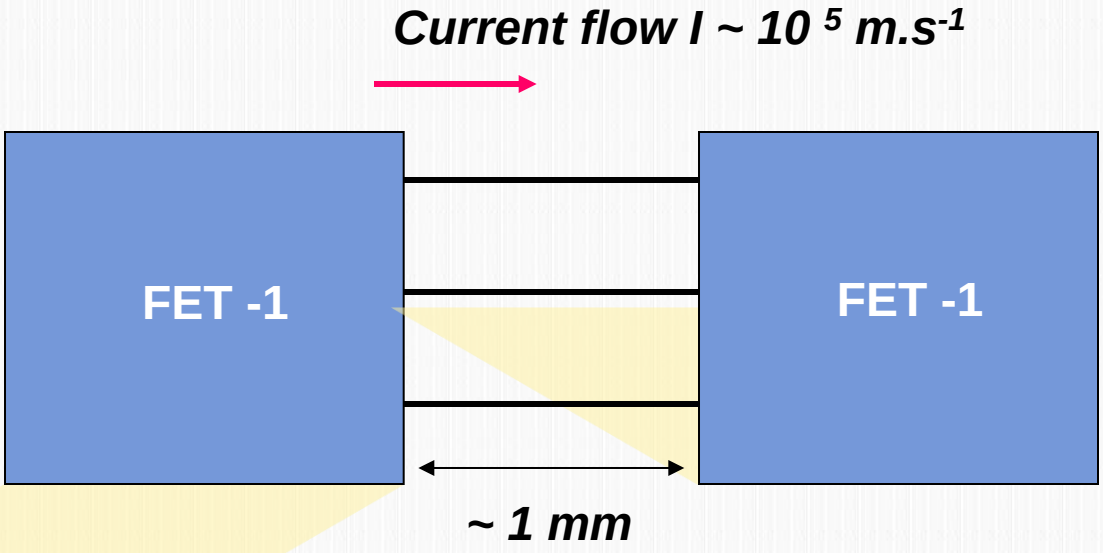
$V_G < 0$

Accumulation of carriers, conductance increases





MINIATURIZATION



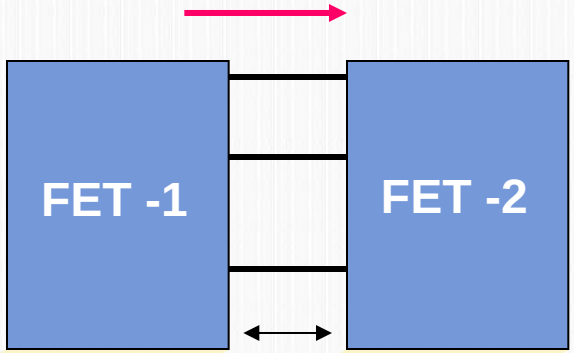
FETs connected by ~ *1 mm can communicate with each other at a rate of ~ 10 GHz.*

Higher speeds can be achieved by

1. *increasing the mobility of the electrons and*
2. *decreasing the device size and separation*

MINIATURIZATION

*Current flow I ~ 1.4 * 10 ^{6} m.s^{-1}*

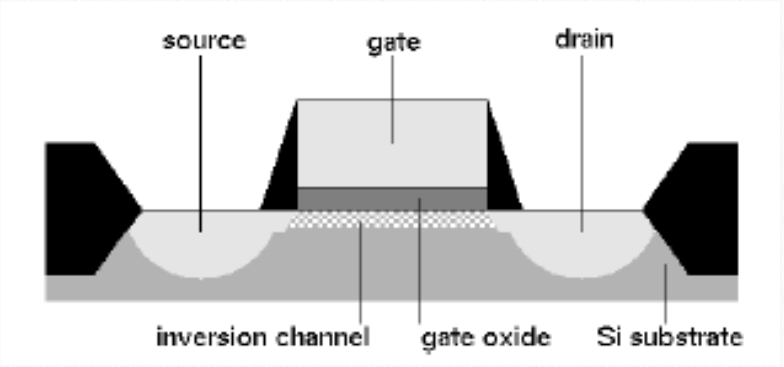


FETs are held together than mean free path, the processor speed can be increased two orders of magnitude, as the carriers are traveling at the Fermi velocity

At this length scale, the phase coherence of the conduction electrons causing quantum interference effects and conductance fluctuations, and capacitive effects causing Coloumb Blockade.

Fundamental Limit – tunneling process

Gate dielectrics (1.1 nm for 45 nm technology node)
have already been reduced to a thickness in which tunnelling processes take place and the device voltage cannot be reduced as quickly as the transistor dimensions



Moore's law facing a critical challenge as the dimension reduces!

Need of alternate ?

We need a device that will assist in processing and transferring huge amounts of data, and also certain that computer and hence

NANOELECTRONICS!

will be essential in developing Genetic Age!.

Is Nano new to Indian Community?

இந்தியர்களுக்கு பொதுவாகவே தங்கத்தின் மீது அதிகமாக காதல் உண்டு. உயிரினினும் மேலான காதலியை தங்கமே என்று அழைக்கும் காவிய வரிகளும் உயிருக்கு உயிரான குடும்ப வாரிசுகளான குழந்தைகளை பொன்மயமான நிறத்தில் தூரிகை கொண்டு வரையும் ஓவிய வரிகளும் இந்தியாவில் மட்டும் தான் காணலாம்.

தங்கத்தை அழகான ஆபரணங்களாக மட்டுமல்ல நாட்டின் பொருளாதார முதுகெலும்பாகவும் கொள்ள துவங்கியது இந்தியாவில் தான்.

இதனால் தான் இந்திய ரசவாதிகள் சுலபமாக தங்கம் மக்களுக்கு கிடைக்க இரும்பை பொன்னாக்கும் கலையில் விற்பன்னர்களாக திகழ்ந்தார்கள். தகரத்தை தங்கமாக்கும் கலையை அதிகமான நபர்களுக்கு அவர்கள் கற்று கொடுத்திருந்தால் இன்று உங்கள் வீட்டு குளியல் தொட்டியை கூட சிமெண்டால் செய்வதை விட மிக குறைந்த விலைக்கு தங்கத்தில் செய்து விடலாம்.

கிரேக்கத்திலிருந்து தேலியஸ், எம்மடாக்கிலிஸ், டிமாக் ரீட்டஸ் முதலிய அறிஞர்கள் இந்தியாவிற்கு வருகை தந்து இந்திய தத்துவ ஞானத்தையும், இந்திய விஞ்ஞான முறைகளையும் கற்று கிரேக்க நாடு முழுவதும் பரப்பியதாக பல கிரேக்க இலக்கியங்கள் அழுத்தி சொல்லுகின்றன. மேலும் கி.மு. 327 க்கு பிறகு அதாவது அலெக்ஸாண்டரின் இந்திய படையெடுப்பிற்கு பிறகு இந்திய அறிவுத் துறைகள் மேலை நாடு முழுவதும் பரவியது எனலாம்.

கி.பி. ஏழாம் நூற்றாண்டிற்கு பிறகு அரேபியர்களின் எழுச்சி கிரேக்க மற்றும் எகிப்தில் ஏற்பட்ட பிறகு இந்திய ரசாயண அறிவை அரபுக்களும் பயன்படுத்த துவங்கினர். ஹரூன் என்ற அரபு கலிபாவின் உத்தரவுப்படி சரக சம்ஹீதை, சுசுருத சம்ஹீதை, பதம், அஸங்கா, நிதான அஸ்டாங்கா போன்ற வடமொழி ரசாயண நூல்கள் அரபு மொழியில் பெயர்த்து எழுதப்பட்டது. அல்பெருனி என்ற இஸ்லாமிய அறிஞர் இந்த நூல்களை அரபு மொழியில் எழுதியுள்ளார்.

தங்கம் செய்வதில் மட்டும் இந்திய ரசவாதிகளின் கவனம் இருந்தது என்று சொல்லி விட முடியாது. மனிதர்களை தாக்கும் பலவித நோய்களை விரட்டி அடிப்பதற்கும் ரசாயண அறிவை பயன்படுத்தினர். உயிர்காக்கும் மருந்து பலவற்றை பாதரசம், செம்பு, இரும்பு போன்ற உலோகங்களை கலந்து செய்தனர். மருந்தின் மூலப்பொருட்களை அப்படியே பயன்படுத்தும் போது அதன் வேகம் மட்டு பட்டுத் தான் இருக்கும். அதே வேளை உலோகங்களை கரையும் பொருளாக புடம் போட்டு மருந்தில் கலக்கும் போது அதன் வீரியம் பல மடங்கு அதிகக்கிறது. ஆயுர்வேத மருந்துகளில் சாராயம், கஞ்சா போன்றவைகள் எந்தளவு பயன்படுத்தப்படுகிறதோ அந்தளவு உலோகங்களையும் ரசாவாதிகள் பயன்படுத்தி இருக்கிறார்கள். இன்றும் அந்த முறையில் தான் ஆயுர்வேத மருந்துகள் பல உருவாக்கப்படுகிறது.

இன்னும் ஒரு உண்மையை இந்த இடத்தில் சொன்னால் நன்றாக இருக்கும் என்று நினைக்கிறேன். இன்று ஐரோப்பிய நாடுகள் ரசாயண துறையில் பெற்றிருக்கும் வளர்ச்சிகள் அனைத்திற்கும் இந்தியா தான் மூல காரணம் என்றால் அது மிகைப்படுத்தி கூறியதாக இருக்காது.

Is Nanotechnology really new?

- *"Moses took the [golden] calf and burned it in the fire; then he ground it to powder, scattered it on the water and made the Israelites drink it." Exodus 32:20*

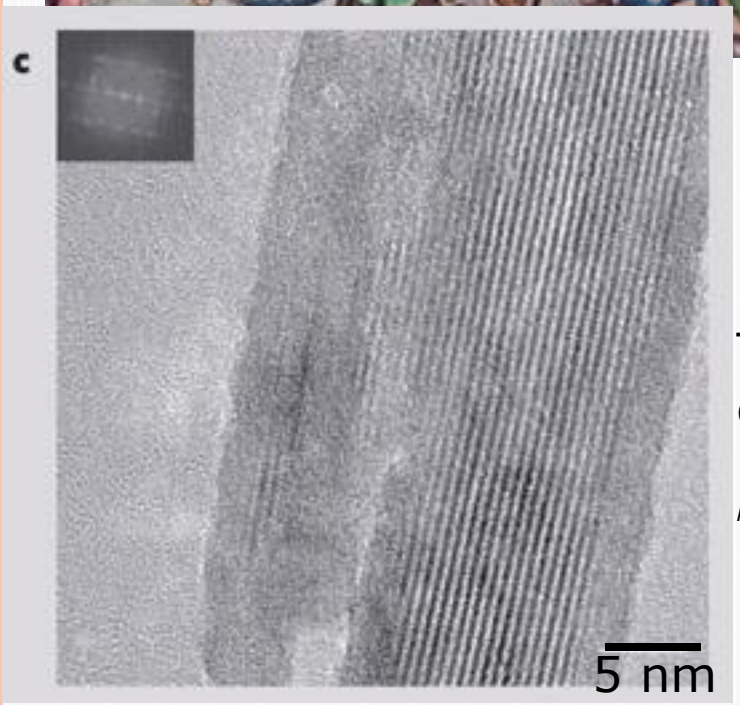
- Gold nanoparticle can be suspended in water to make a colloidal gold, used for centuries as a medical treatment that reportedly *cleared the mind, increased intelligence and will power, and balanced the emotions*.

- Is Moses Father of

http://www.allflexinc.com/PDF/IPC_Nanotech-1_GilleoREV1.pdf

Is Nanotechnology really new?

During the middle ages, the Muslims who fought crusaders with swords of Damascus steel had a high-tech edge - carbon nanotubes and nanowires in their sabres. Damascus sabres were forged from Indian steel called *wootz*. It is likely that the sophisticated process of forging and annealing the steel formed the nanotubes and the nanowires, and could explain the amazing mechanical properties of the swords



TEM image of cementite nanowires

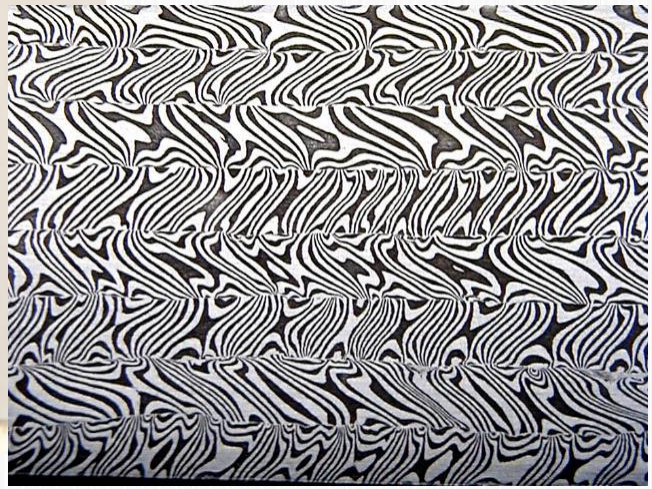
Nature, vol. 444, p 286

http://technology.newscientist.com/article/mg19225780.151-secrets-out-for-saracen-sabres.html

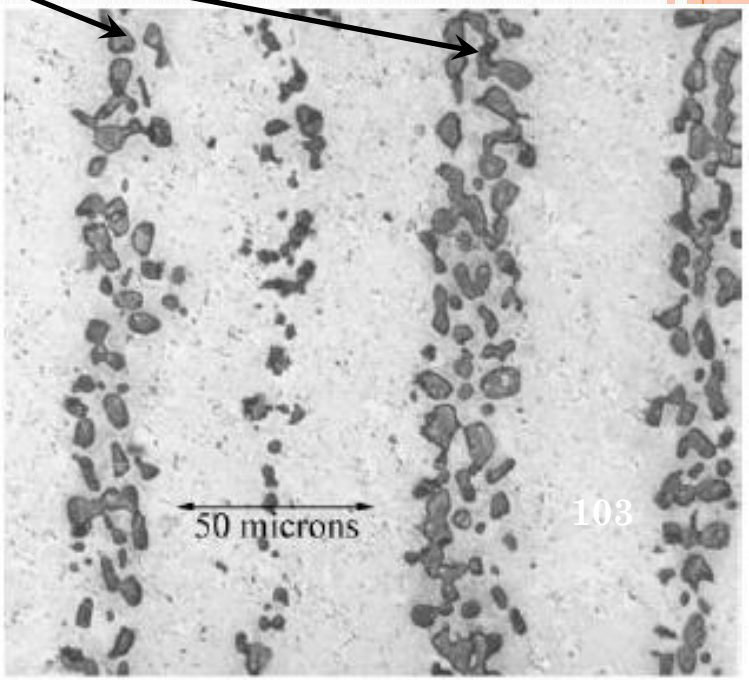
Damascus Steel

Damascus blade showing the Damascene surface pattern containing a combined Mohammed ladder and rose pattern

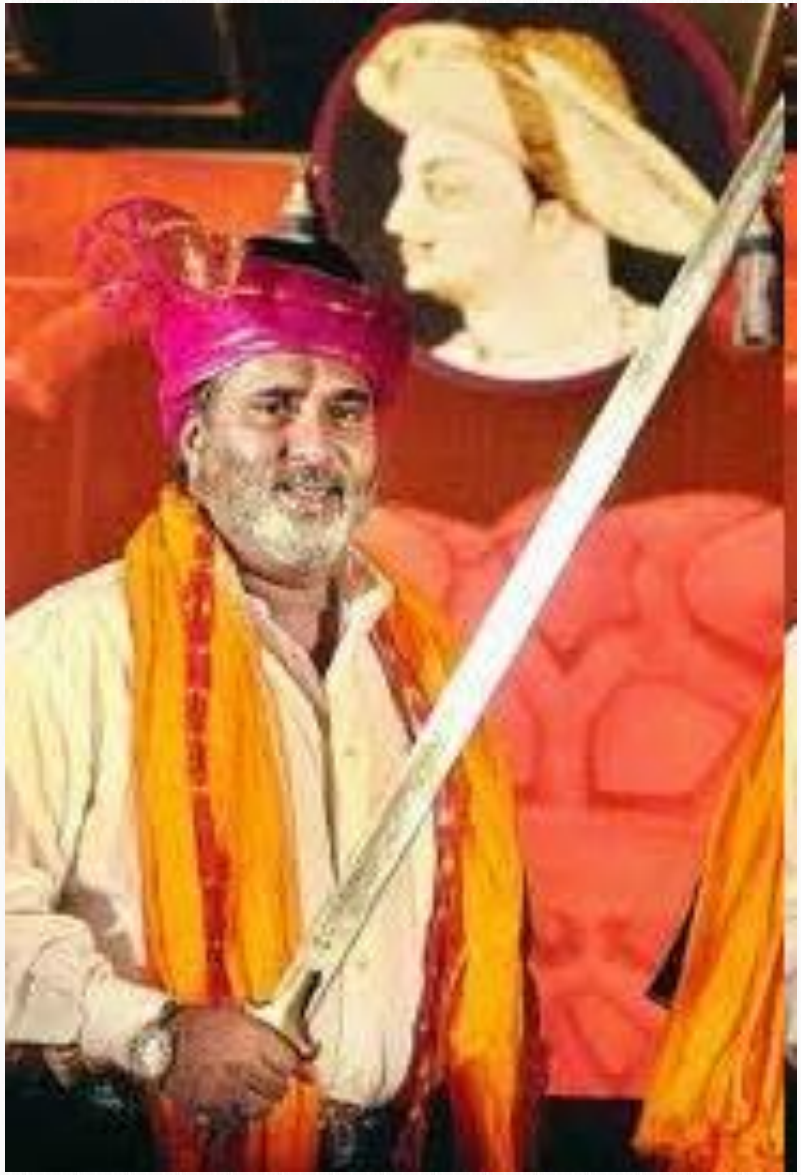
http://www.tms.org/pubs/journals/JOM/9809/Verhoeven-9809.html



Cementite bands



Wikipedia.org



அருள்மிகு தண்டாயுதபாணி சுவாமி திருக்கோயில், பழனி.

திருக்குட நன்னீராட்டுப் பெருவிழா - 27-6-1988

போகர்

தவயோக ஆற்றலால் அணிமா, மகிமா, இலகுமா, கரிமா, பிராப்தி, வசுத்தவம், பிராகாமியம், ஈசத்துவம் எனப்படும் அட்டமா சித்திகளைப் பெற்றவர்கள் சித்தர்கள். மருத்துவம், மந்திரம், சோதிடம், மெய்யுணர்வு ஆகிய துறைகளில் இவர்கள் சிறந்து விளங்கினர். நவநாத சித்தர்கள் பதினெண் சித்தர்கள் எனப்பெறும் இவர்கள் தமிழ்நாட்டில் வாழ்ந்தவரேயாம். மூலர், காலாங்கி, போகர், கொங்கணர், கோரக்கர் ஆகியோர் குறிப்பிடத்தக்கவர். மனிதகுல நல்வாழ்வில் நாட்டம் கொண்டு தொண்டு புரிந்த இச் சித்தர்கள் நாட்டவர் தம் நன்மதிப்பைப் பெற்றிருந்தனர். சித்தர் பாடல்கள் தத்துவக் களஞ்சியங்களாக உள்ளமை காணத்தக்கது.

திருத்தத் தேவரே பல்வகைப் பிறப்புற்றுப் பின்பு போகராகப் பூமியில் தோன்றினார் என்பர். இவரது காலம் 5000 ஆண்டுகட்கு முன்னதாகலாம். போகர் ஏழாயிரம், போகர் வழிநூல் எனப் பெறும் மருத்துவ, ஞான நூல்கள் போகரால் எழுதப்பட்டவை. வானவழியில் சீனம், உரோமாபுரி, மக்கா, மதினா ஆகிய இடங்களுக்குச் சென்று தம் சீடர் புலிப்பாணியுடன் தாயகம் திரும்பியவர் போகர். யோகம், மருத்துவம், இரசவாதம், காயகற்பம், கணிதம் போன்றவற்றில் இவர் சிறந்து விளங்கினார். தம் சீடருடன் இறுதிக் காலத்தில் பழனிமலையில் தங்கியிருந்த இவர், பழனி மலையின்மேல் தாம் அமைத்த திருக்கோயிலின் கண், நவபாஷாணக் கட்டினால் அருள்மிகு தண்டாயுதபாணி சுவாமியின் அருள்திருமேனியை நிறுவினார். பழனியாண்டவன் [illegible] அழைக்கப்பெறும் ஆண்டவன் வலக்கரத்தில் உள்ள தண்டம் [illegible] சிறப்பைக் கருதும்படி [illegible]. பழனியாண்டவரின் திருமேனியில் பட்டதும் விபூதி, பால், சந்தனம், தேன், பஞ்சாமிர்தம் முதலிய பொருட்கள் அனைத்தும் மக்களின் உடற்பிணி, உள்ளப்பிணி நீக்கும் அருமருந்தாய் விளங்குகின்றன. மலைக்கோயில் உட்பிரகாரத் தென்மேற்கு மூலையில் போகர் சந்நிதி உள்ளது. இதுவே போகர் சமாதி அடைந்த இடம். போகர் வழிபட்ட அருள்மிகு புவனேசுவரி அம்மை, மரகதலிங்கம் இங்கு இன்றும் பூசையில் உள்ளன. இச்சந்நிதியிலிருந்து தண்டாயுதபாணி சுவாமி திருவடி நிலைக்கு ஒரு சுரங்கவழி உள்ளது. கடைசியாக இதனுட் சென்ற போகர் திரும்பாமல் அதனுள் அமர்ந்துவிட்டார் என்பர்.

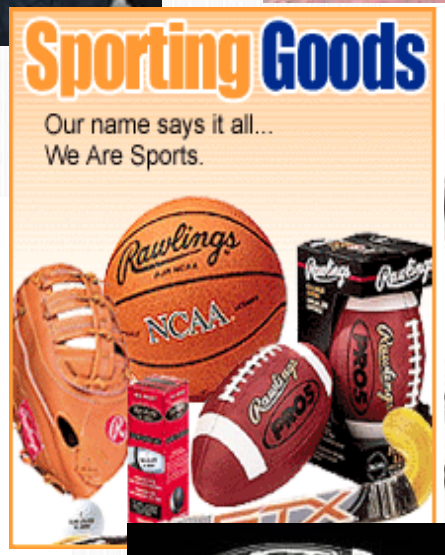
மக்கள் அனைவரும் நலம் பெற வேண்டும் என்ற நோக்குடன் நவபாஷாணக் கட்டினால் அரிதின் முயன்று அருள்மிகு தண்டாயுதபாணி சுவாமியை நிறுவிய போக சித்தர் தம் அருள்திறத்தைப் போற்றுவோமாக.

1. Avarai, Chittamurutti - With this fuels they will heat for disease caused by heat.
2. Usil, Ilandai - By heating with this fuels, they cured discapes of eye, nose, ear and feet.
3. Iluppai, Tamarind - For oils for external use.
4. Vembu (Neem), Pooarasu, Arasu - for diseases of Vadha.
5. Nuna, Vanni, Mavilangam - for Vadha diseases external and internal.
6. Nelli (Amla), Vembu (Neem), Vila for Pitha ills.
7. Usil, Vel, Konrai, Vengai; for Phlegm.
8. Panai (Palm), Thennai (coconut), Vembu (Neem); for all medicines which contain Rasa.
9. Vel, Vengai; for medicines which contain iron.

2. After heating with the obove 9 types of fuel they will filter 9 times.

1. Excrement of Kadai 1
2. " Kowdri 3
3. " Kukkudam 10
4. " Varaham 50
5. " Peacock 100
6. " Elephant 1000
7. " Manal (sand) 90
8. Earth 4 finger measure
9. Garm 800

Which one are actual nano-products?



This slide is adapted from the presentation on "An Introduction to Nanotechnology," by Terry Bigioni, posted at http://www.homepages.utoledo.edu/tbigion/BigioniGroup/Outreach_Home.html

Which one are actual nano-products?

Here they are!

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Nano-products

Display Screens
Motorola (NTs)

Cars - Hummer
GM (Nanocomposites)

Nano SilverSeal Refrigerator
Samsung (nanoparticle-coated)

Tennis Rackets
Wilson (C fibers)

Nano-Products on the Market Now

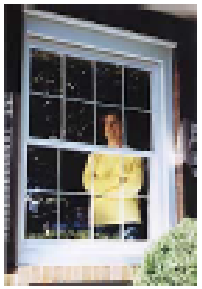
Nano-products

Shemen Industries
canola oil by NutraLease, an Israeli startup, using 30 nm capsules

Nano-Care fabric

wrinkle-resistant, stain-repellent

(Eddie Bauer, Lee, Old Navy, Tiger W Bass, Nike)



SunClean self-cleaning windows (Photocatalytic coating)

Superhydrophobic nanoscale coating applied to fabric

Plenitude Revitalift

Loreal

LAUFEN
bathrooms

Laufen Mylife floor-standing bidet with Wondergliss (Superhydrophobic coating)

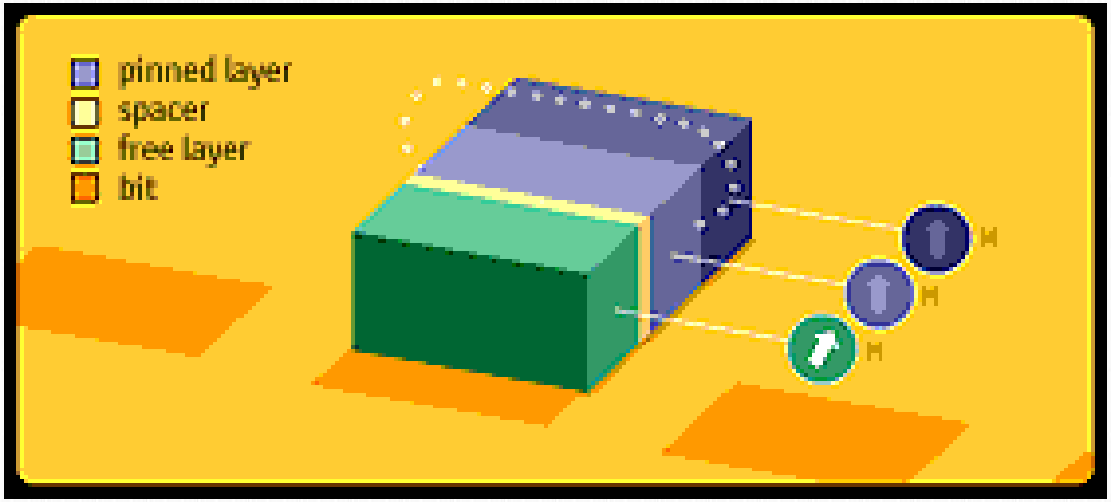
Clay nanocomposite barrier coating

This slide is adapted from the presentation posted at www.toxicology.org/isot/rc/allegheny/Savage2006SOTRegional.ppt

Nanodevices - Magnetic Storage

The hard drive in your computer uses a nanotechnology innovation called giant magnetoresistance.

Giant magnetoresistance is an effect where small magnetic fields can be detected as a change in resistance.



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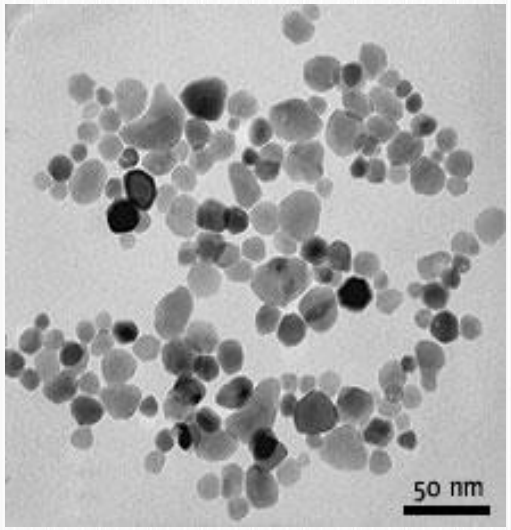
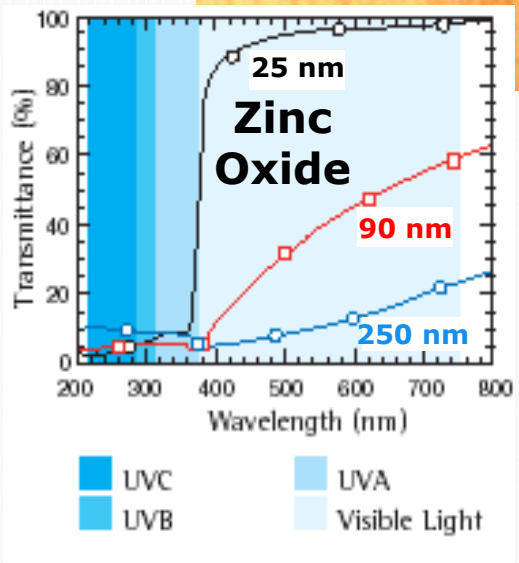
Nanomaterials - UV Protection

Small = Transparent

Advanced Powder Technology Pty Ltd

Zinclear in Wet Dreams sunscreen





This slide is adapted from the presentation on "An Introduction to Nanotechnology," by Terry Bigioni, posted at http://www.homepages.utoledo.edu/tbigion/BigioniGroup/Outreach_Home.html

Nanomaterials - Catalysis

Gold nanoparticles are used to make bathrooms smell better in Japan.

Gold nanoparticles can turn smelly amines into odorless nitrates when they are put on metal oxide surfaces.

This slide is adapted from the presentation on "An Introduction to Nanotechnology," by Terry Bigioni, posted at http://www.homepages.utoledo.edu/tbigion/BigioniGroup/Outreach_Home.html

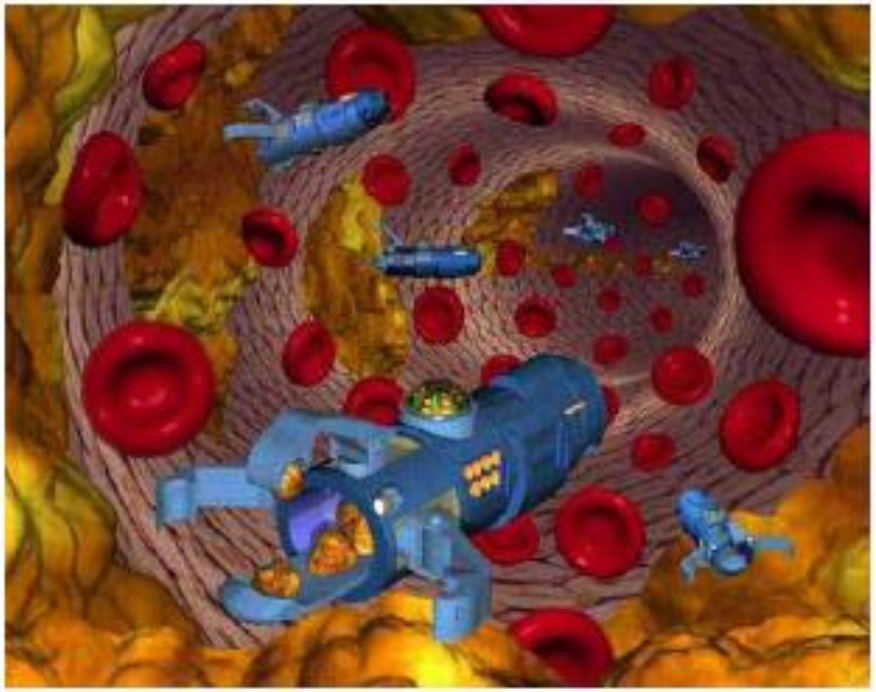
What is Nanotechnology?

Tiny machines in your body curing cancer?

http://smalley.rice.edu/emplibrary/SA285-76.pdf

This slide is adapted from the lecture notes posted at http://www.physics.unc.edu/~falvo/Phys006D_Fall07/ by Professor Michael Falvo

Injectable Nanobots?



This slide is adapted from the lecture notes posted at http://www.nanohub.org/courses/nanomaterials by Prof. Mark Hersam

Composites: Definitions and Examples

- Mixing two or more chemically dissimilar materials
- The goal is to achieve properties that are otherwise unreachable in individual components
- Some advantages: High strength/light weight, low cost, environmentally resistant, electrically and thermally conductive
- Natural Composites:
  - Wood: mixture of flexible cellulose fibers and stiffer lignin
  - Bone: mixture of soft collegen (protein) and brittle apatite (mineral)

Composite Examples

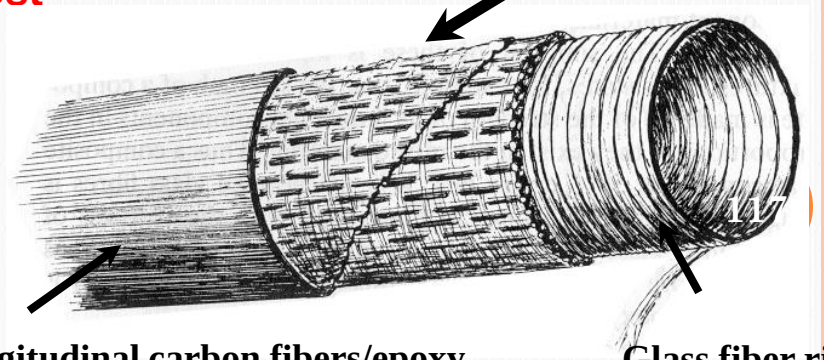
Bontrager's **Race XXX Lite Carbon-Fiber Fork**
http://pedpow.com/page.cfm?pageID=84

Braided and unidirectional glass and carbon fibers are used to produce forks with different stiffness

High Strength
Weight Reduction
Design Flexibility
Cost Performance

Photo by Matthias Schimmelpfennig
http://www.olympicsports.org.uk/2007_05_01_archive.html

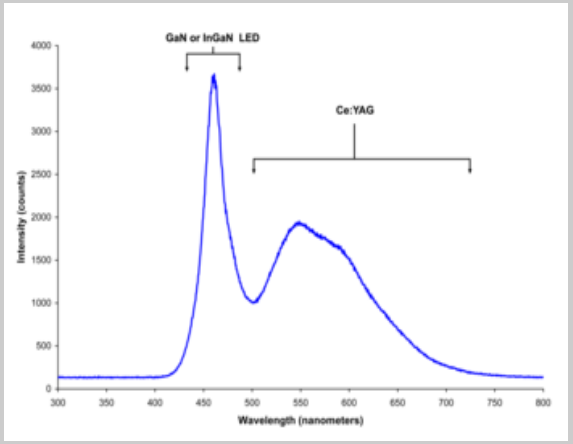
Lightweight - low density
Buckling resistance - stiffness
Strong - yield strength
Minimal twisting
Cost

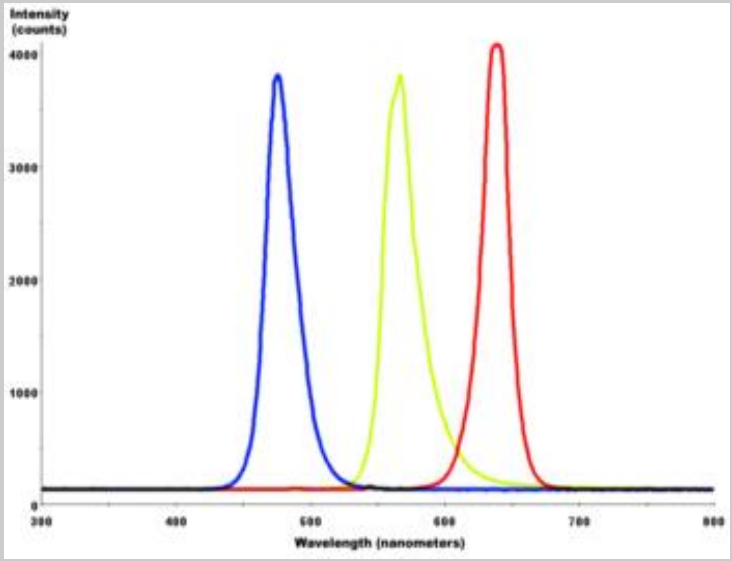


Pole Image Courtesy of K.E. Easterling
http://www.tms.org/pubs/journals/JOM/9702/Froes-9702.html

Applications of III-Nitrides

Applications of GaN nanostructures






Thank you ...