

Nanotechnology and Its Various Applications.

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Presentation at:

**“18th Symposium, "Nanotechnology for the
Economic Prosperity & Security of Pakistan“**

Pakistan Academy of Engineering,

Karachi. September 26, 2020

Scheme of presentation

---Life.

---Basics.

---Importance

---Applications:

(i) Soio-Economic

(ii) Security

---Importance of Human Resource.

---Future:

(i)PicoTechnology

(ii)Convergence :Sci+Engg+Social

My Life

- **M.Sc(1957) : Roll of Honour-- Govt College Lahore.**
- **Ph.D: Phys-(1965) & D.Sc (1993)- Birmingham Univ., U.K.**
- **1966-1996: PINSTECH: (Chief Scientist/D.G Rtd 1996)**
- **Scientist Emeritus P.A.E.C (1996---- Life)**
- **2003-2008 : Chairman, National Commission on Nano Science and Technology (NCNST), Govt of Pakistan.**
- **2005-2008 : Chairman ,Pakistan Science Foundation**
- **2009--- :Chairman PINSAT,Preston University,Islamabad.**



Pakistan Institute of Nuclear Science & Technology (**PINSTECH**)-Islamabad





10 MW-Swimming Pool Research Reactor PINSTECH



Preston University

Preston Campuses in Pakistan



1984:
Rawalpindi



1994:
Islamabad



1996:
Karachi



1996:
Lahore



1996:
Peshawar



2002:
Kohat



2010 --Islamabad
PINSAT, Preston University Kohat,
Islamabad Campus



Only BS (Nanoscience and Nanotechnology) Degree in Pakistan

Nanotechnology

“There’s Plenty of Room at the Bottom”

Richard P. Feynman December 1959



The classic talk that Richard Feynman gave on December 29th 1959 at the annual meeting of the American Physical Society at the California Institute of Technology (Caltech).

- I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle.
- Furthermore, a point that is most important is that it would have an enormous number of technical applications.
- What I want to talk about is the problem of manipulating and controlling things on a small scale. 9

Nanotechnology?

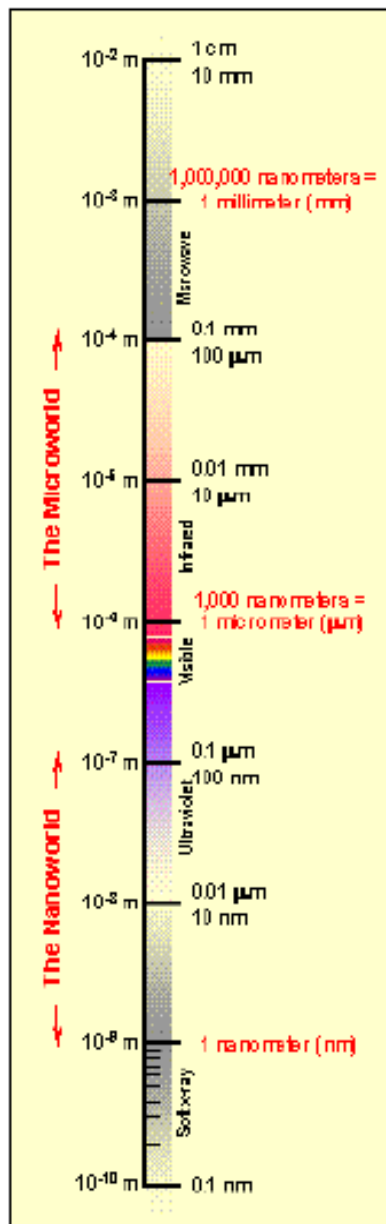
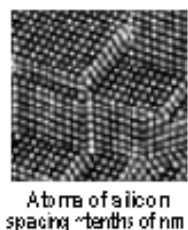
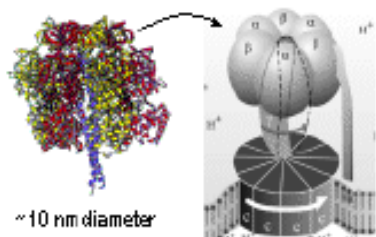
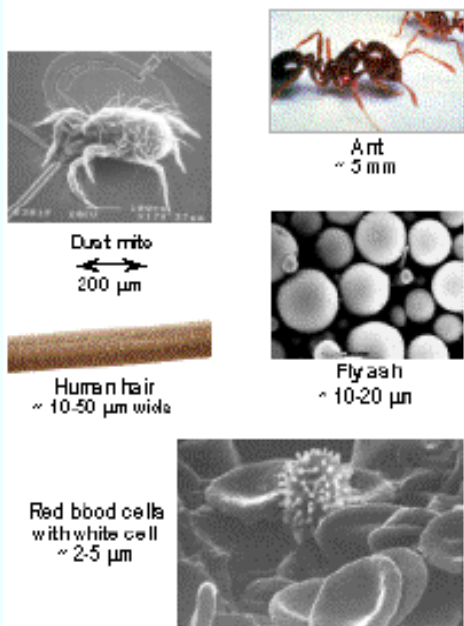
“Nanotechnology is the study, manipulation, control and use of nanomaterials and their structures at nanoscale sizes i-e sizes between 1 - 100 nanometers.

(1nm is one billionth of a meter. The sizes of atoms and molecules are at nanoscale).

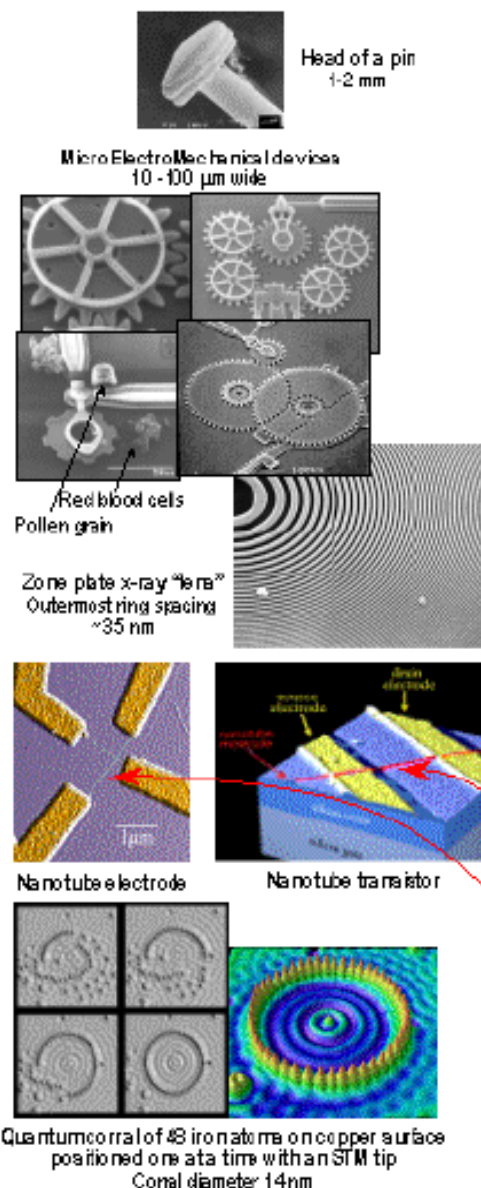
Source: *(Butt,N.M-2009)*

The Scale of Things -- Nanometers and More

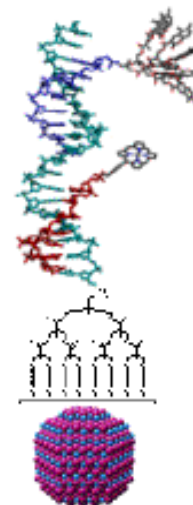
Things Natural



Things Manmade



21st Century Challenge



Combine nanoscale building blocks to make novel functional devices, e.g., a photosynthetic reaction center with integrated semiconductor storage

Scientific & Socioeconomic Importance

- Scientific:
 - ❖ Surface to Volume Ratio of Particles
 - ❖ Quantum Science at nano scale.
 - ❖ Multidisciplinary
- Socio Economic:
 - ❖ Society— Public Acceptance
 - ❖ Economy- Investment and Industry
 - ❖ Safety, Standards and Regulations.
 - ❖ Intellectual Property Rights (IPRs).

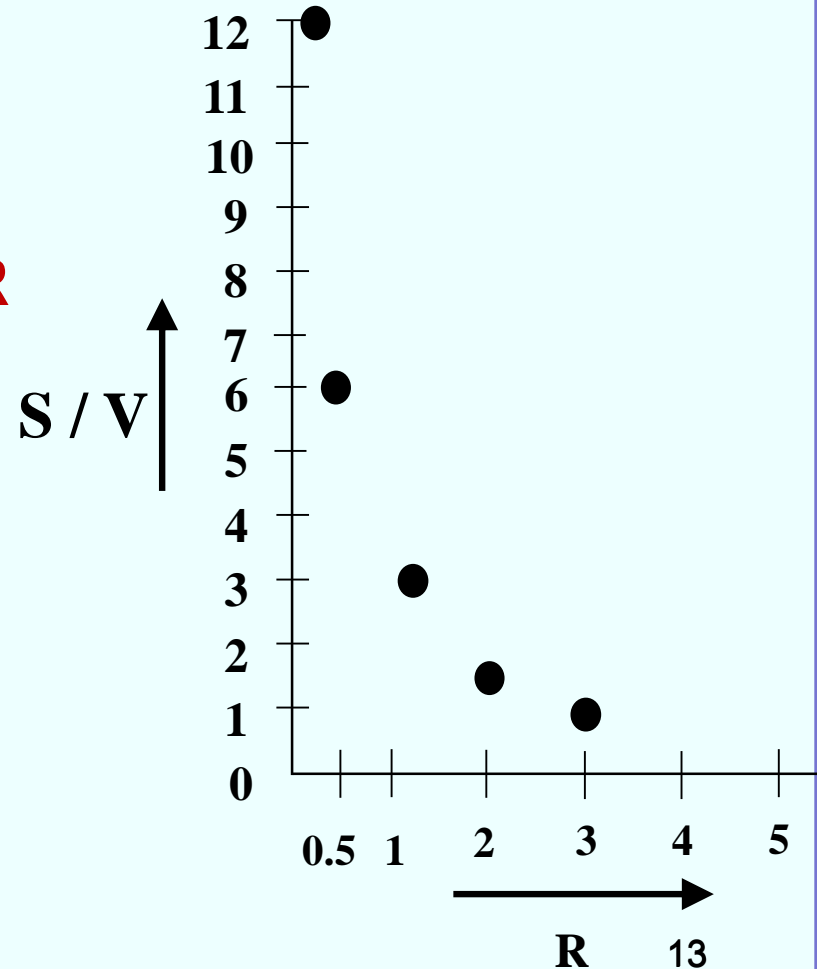
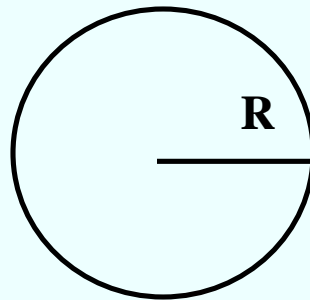
Why nano size will change the properties of materials?

Smaller the size:larger the surface to Volume Ratio.

Sphere Particle:

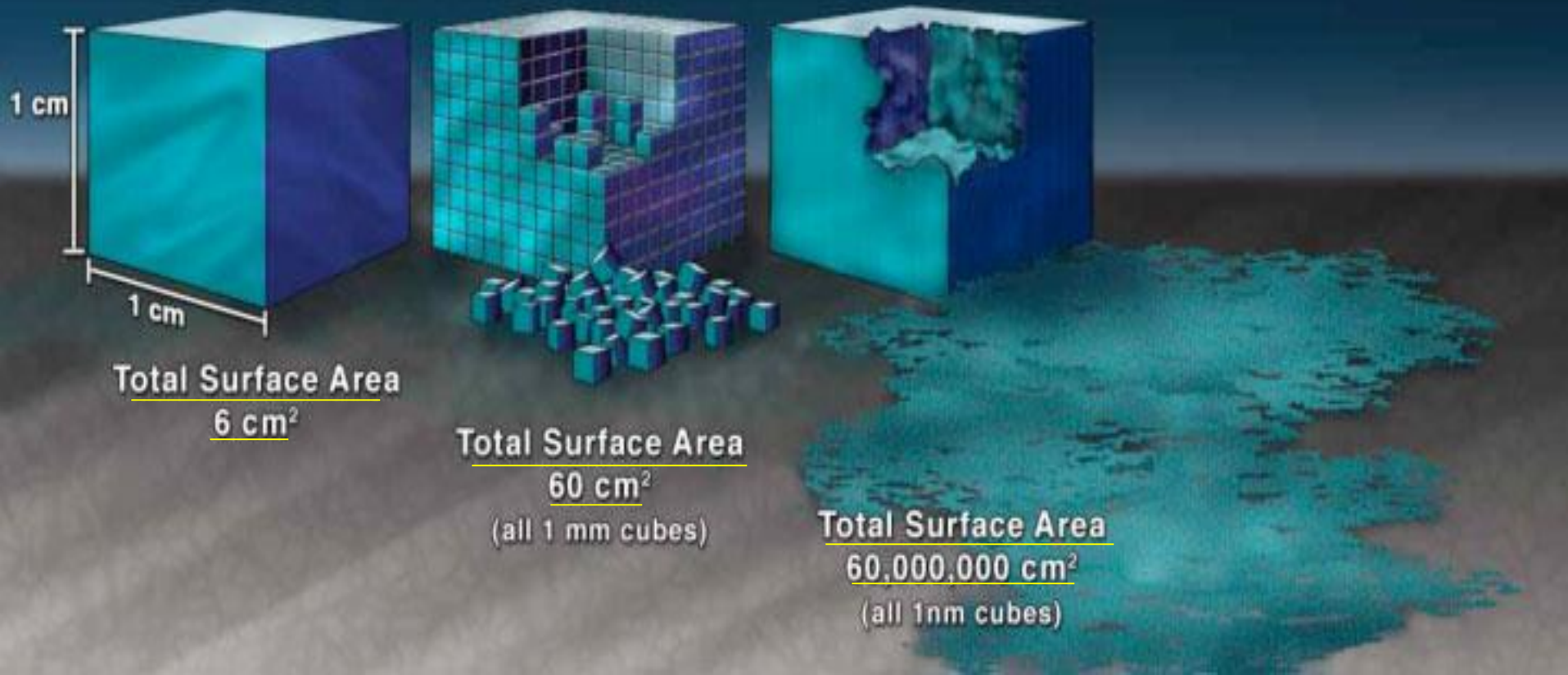
- Volume, $V = \frac{4}{3} \pi R^3$
- Surface Area, $S = 4\pi R^2$
- Ratio $S/V = 3/R \propto 1/R$

R	S/V
3	1
2	1.5
1	3
0.5	6
0.25	12
0.125	24



Nanotechnology and Its scientific Importance

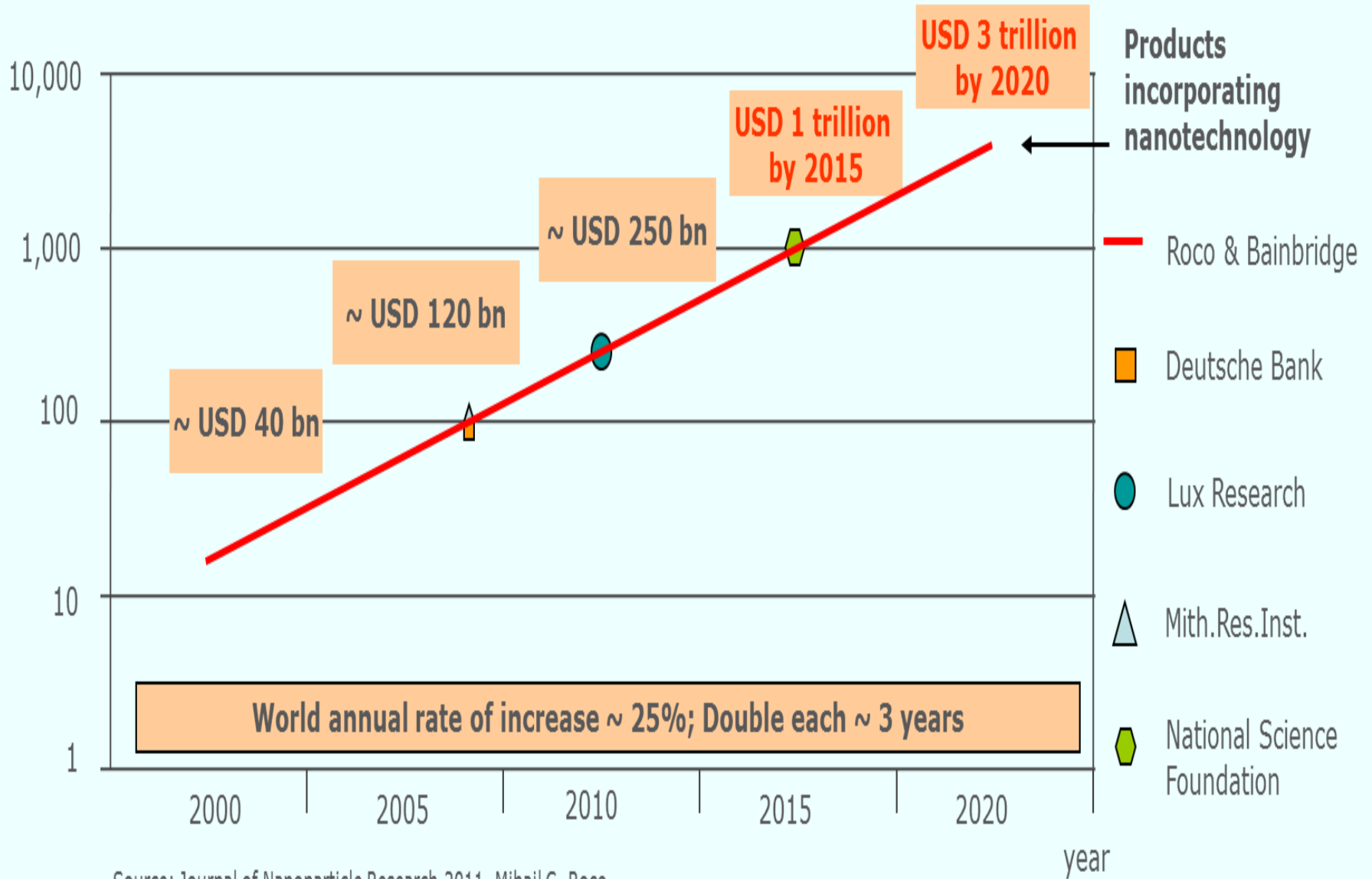
Another reason nanomaterials behave differently from bulk materials of the same chemical is because of surface area – or the area of an object that is an exposed surface.



GLOBAL IMPACT- Industry/ Economy

- Applications of nanotechnology have developed multibillion dollar product lines.
- Potential of 3.1 trillion dollar market by 2015. It was \$147 billion products in 2007 (www.luxresearchinc.com).
- 2586 nanoproducts already in the market by Nov 2009 (Ref: Helmut Kaiser Consultancy, Germany).
- Another “Industrial Revolution” in the making.
- Profound effect on the socio-economic scenario of the world for 40-50- years.

WORLD MARKET INCORPORATING NANOTECHNOLOGY (billion USD)



Source: Journal of Nanoparticle Research 2011, Mihail C. Roco

Indicator of Nanotechnology development

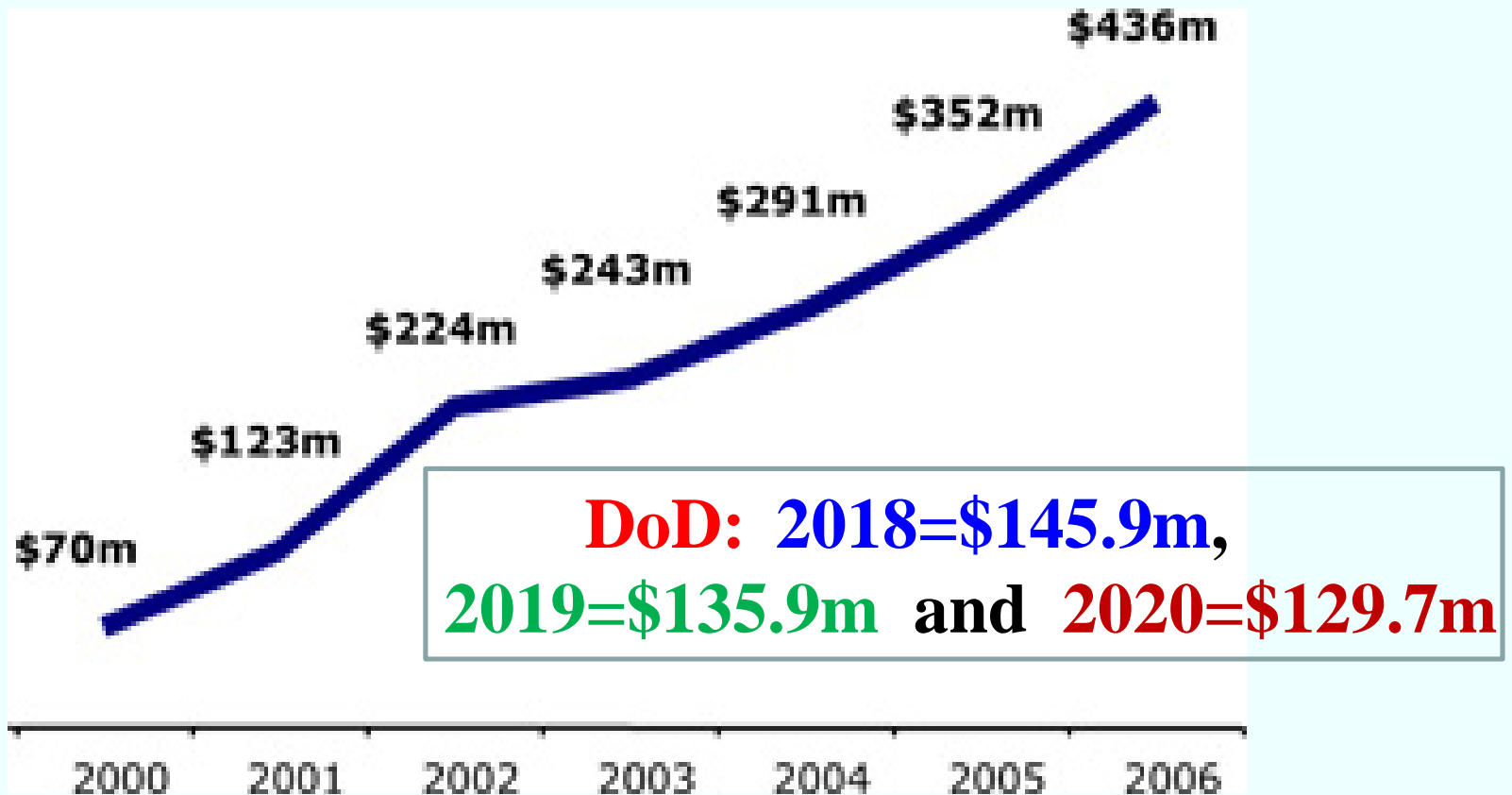
	Primary workforce	Papers in SCI-indexed journals	Patent applications	Market value of final Product	Public and private R&D funding	Venture capital
2000	60,000	18,000	1,200	\$30B	\$1.2B	\$0.21B
2010	600,000	80,000	20,000	\$300B	\$18B	\$1.3B

Source: World intellectual Property organization
November 2015.

US Funding for Defence Nanotechnology

Annual **DoD** Investment in Nanotechnology; 2006 estimated.
DoD, USA “Defence Nanotechnology Research and Development Programs”,

May 8, 2006



The Wall Street Journal news department was not involved in the creation of this content.

Nanotechnology Market Outlook 2017

NEW YORK, May 15, 2013 .

Nanotechnology has been the greatest impetus to technological and industrial development in the 21st century and has been recognized as the resource for the next industrial revolution.

Nano Truck—Germany-2013

[Nano Exhibits= 80[40 Interactive]



**NanoTruck – Meeting Place
Nanoworlds” information
campaign.**

**Nanotechnologie interaktiv
erleben im nanoTruck**



Das Obergeschoss des nanoTrucks: Kino und mehr²⁰

Career in Nanotechnology

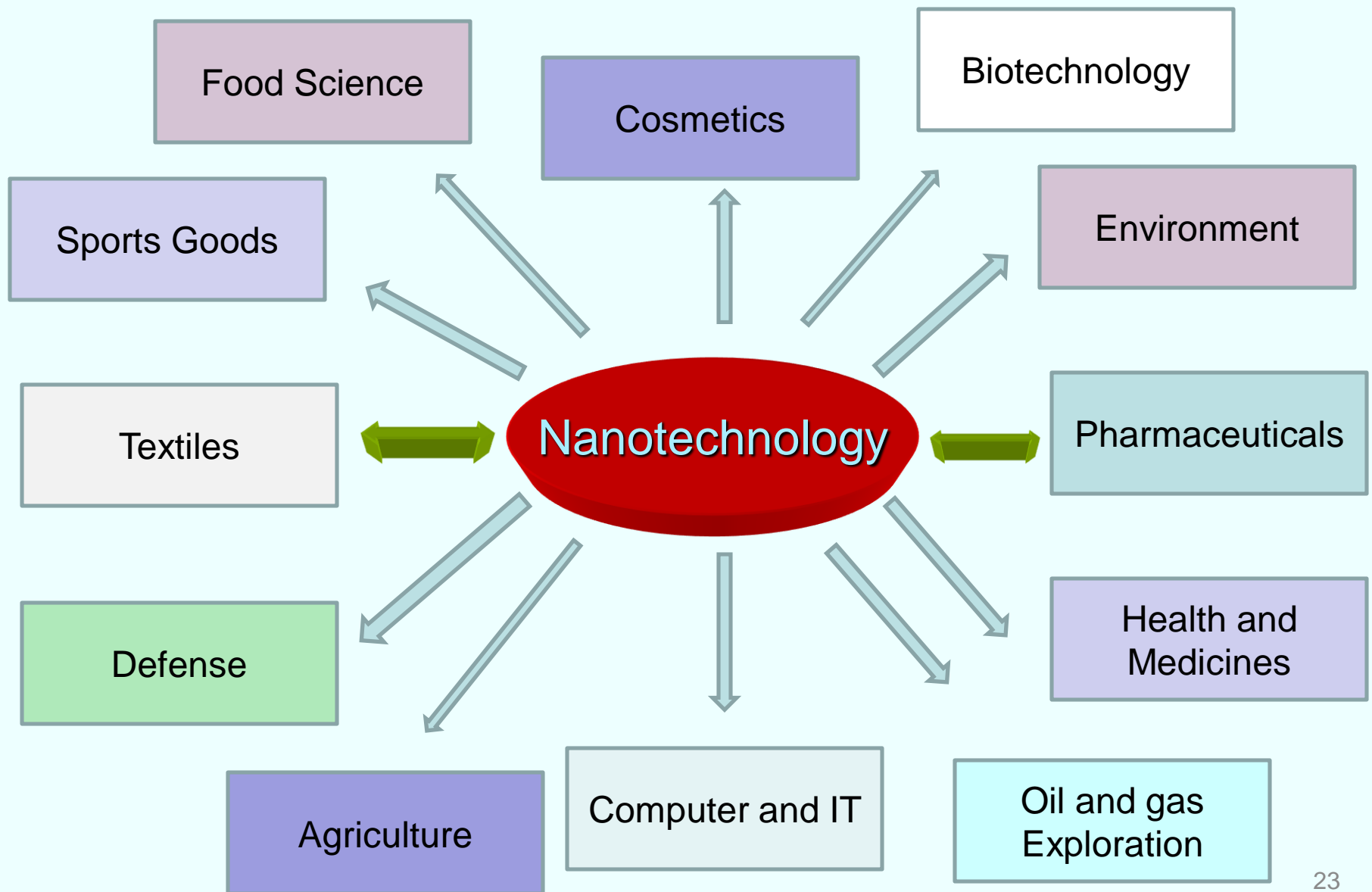
1. Electronics/semiconductor industry
2. Materials science including textiles, polymers, packaging.
3. Auto and aerospace industries
4. Sports equipment
5. Pharmaceuticals including drug delivery, cosmetics.
6. Biotechnology
7. Medical fields
8. Optoelectronics
9. Environmental monitoring and control
10. Food science including quality control and packaging
11. University lab research/R&D in govt and private research Institutes
12. National security
13. Military
14. Agriculture
15. Academic & Teaching
16. Forensic science & many other new industries emerging as a result of advances in nanotechnology.

http://www.nnin.org/nnin_careers.html

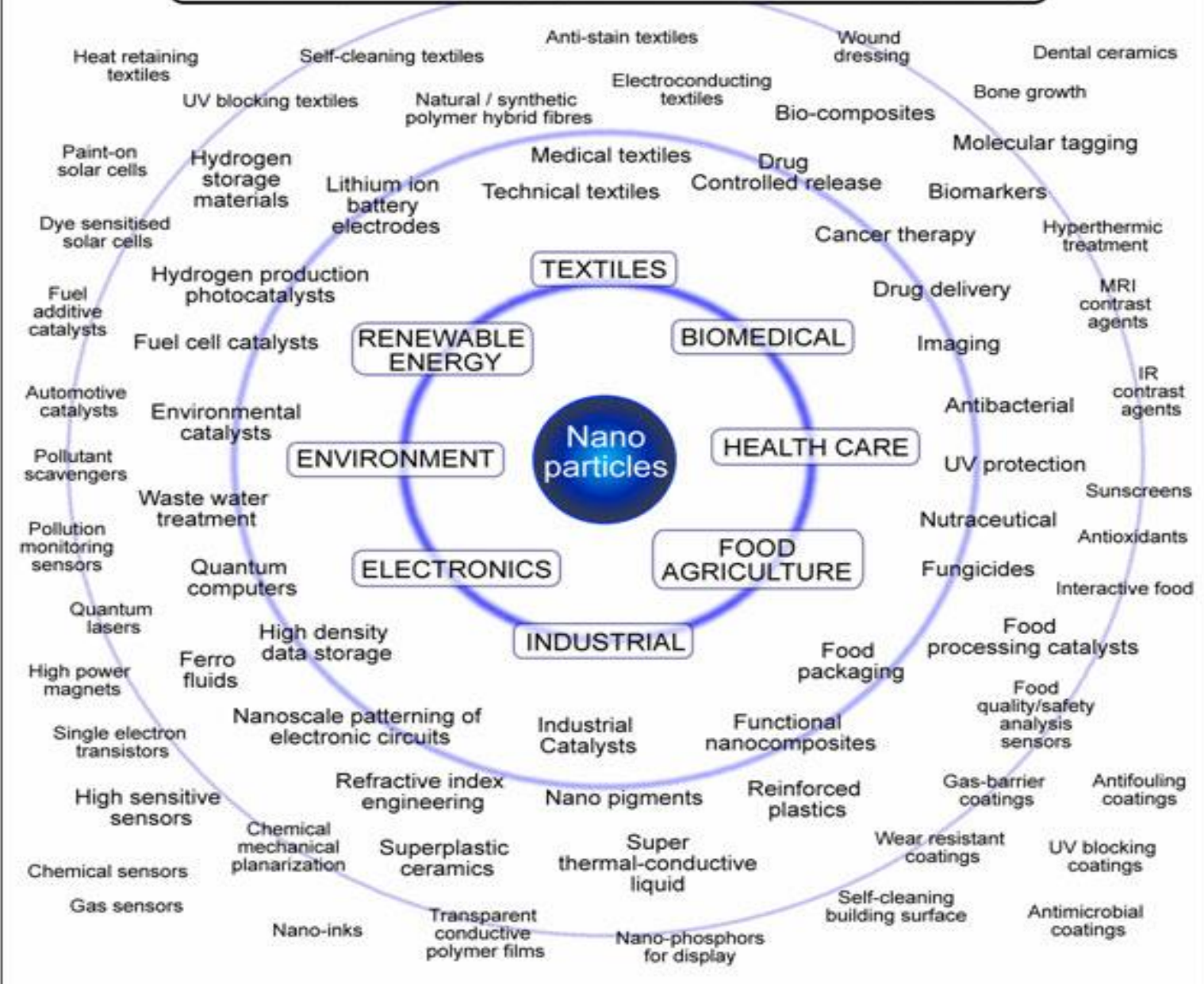
Applications of Nanotechnology

Nanotechnology and Industries :

Need of Nano-Qualified Graduates



APPLICATIONS OF NANOPARTICLES



Nanotechnology Areas-- 53

[New materials: nanomaterials](#)

[What are synthetic nanoparticles?](#)

[What are quantum dots?](#)

[What is graphene? \(w/infographic\)](#)

[Two-dimensional \(2D\) materials](#)

[---What is nanoengineering?](#)

[What are nanobots?](#)

[What are MXenes?](#)

[-----What is a MOF \(metal-organic framework\)?](#)

[What are metamaterials & metasurfaces?](#)

[van der Waals heterostructures](#)

[-----Carbon Nanotubes 101](#)

[How nanoparticles are made](#)

[Nanomaterials and Nanoscience](#)

[----Nanofabrication](#)

[DNA Nanotechnology](#)

[Nanotechnology and the Concept of -----](#)

[-----Friction](#)

[-----Atomic Force Microscopy \(AFM\)](#)

[Memristors](#)

[Metric Prefix Table](#)

[-----Nanotechnology Standards](#)

[Nanotechnology Education](#)

[Nanotechnology Applications](#)

[Applications of Nanomaterials](#)

[Nanobiotechnology](#)



[-----Nanoelectronics](#)

[-----Nanocoatings](#)

[Nanoplasmonics](#)

[Nanosensors](#)

[Food and Agriculture](#)

[Detection of foodborne illnesses](#)

[-----Energy](#)

[Energy \(graphene only\)](#)

[Graphene Batteries](#)

[-----3D Graphene](#)

[Furniture](#)

[-----Space](#)

[Cosmetics](#)

[-----Automotive Industry](#)

[-----Cement Industry](#)

[-----Construction](#)

[Displays](#)

[Nanomedicine](#)

[Fight against Alzheimer's](#)

[HIV/AIDS treatment](#)

[To fight and cure cancer](#)

[Surgery](#)

[-----Environment](#)

[Disaster relief and development cooperation](#)

[Green Industries](#)

[Sports Equipment](#)

[Nanotechnology Images](#)

Applications of Nanotechnology

- i. Medical and Health Care:**
Anti-cancer drugs, Bio-sensors, Implants, Dental Pastes, Cancer treatment, Targeted drug delivery, Pharmaceuticals, Nano detergents for hospitals, Diagnostics and Therapeutics
- ii. Energy:**
Capture, storage, & use; Solar, Fuel cell, Bio-fuels, Long life Batteries
- iii. Automobiles:**
Lubricants, Glass Coatings, Resins, Phosphors, Fog and dust free wind screens and glass
- iv. Industry:**
Ceramic, Insulation, Phosphors, Hard Materials, Mechanical, Spray, Sensors
- v. Computer/Information Technology:**
Bio-molecules for electronics, Large Memories
- vi. Defence:**
Special Materials, Sensors, Intelligent Clothing, Soldier Camouflage,

Applications of Nanotechnology Continued

vii. **Cosmetics:**

Anti aging creams, Skin Creams

viii. **Agriculture:**

Food Safety, food preservations, Quality Assurance, water purification

ix. **Environment:**

Filters, anti toxicants

x. **Textiles:**

Special clothes, Bullet proof shirts, Anti- smelling socks

xi. **Sports:**

Sunglasses, Rackets, Tennis and Golf balls, Hockey sticks

xii. **Aerospace:**

Communication, High strength light weight materials, Space elevator

Xiii. **Nanotechnology in Oil and Gas Exploration**

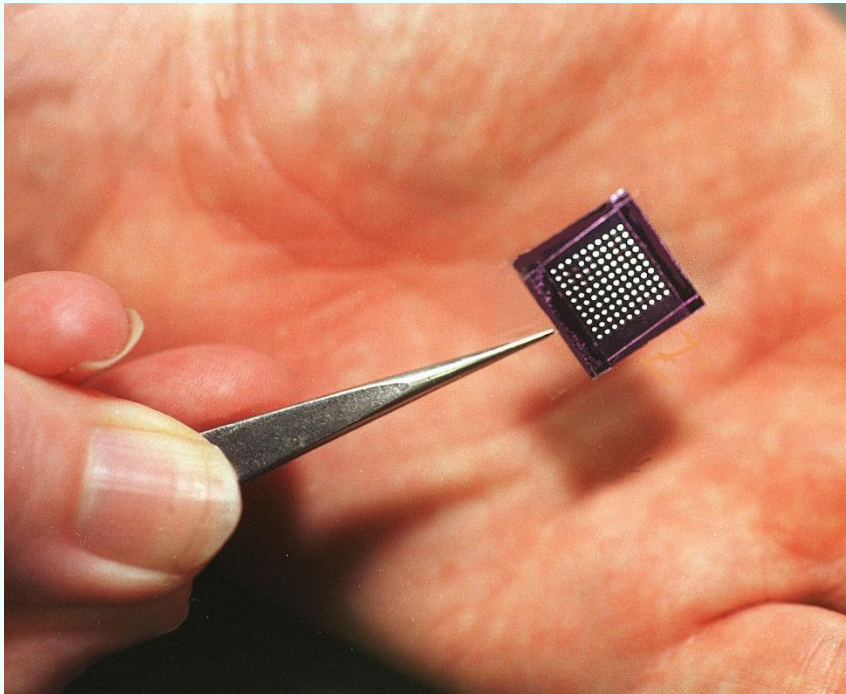
50% more exploration due to oil extraction, diesel, oil cleaning

Smart Windows

➤ **Due to efficient heat and light management, the need for cooling and lighting can thereby be optimally balanced.**



Nano-Electronic Tongue



Nano-Electronic Tongue



**Quality control for beverages
by electronic tongue**

Source: Kraft Foods

Industry Interaction Pakistan:

**1.Sialkot City Exports: Sports Goods-Surgical instruments
and Leather Goods**

2. Fasilabad City Exports : Textiles Exports

Sports – Surgical-Leather
Industries -100yrs Export.
SIALKOT City.

Sialkot Chamber of Commerce & Industry



Hockey Factory

Leather Jackets Factory

TEXTILE Industries

Faisalabad City

Fasilabad Textile Industry



**Ring Spinning Section of
M/s J.A Textile Mills,
Faisalabad**



**Bleaching Section of
M/S.A.R Corporation Pvt Ltd.
Faisalabad**

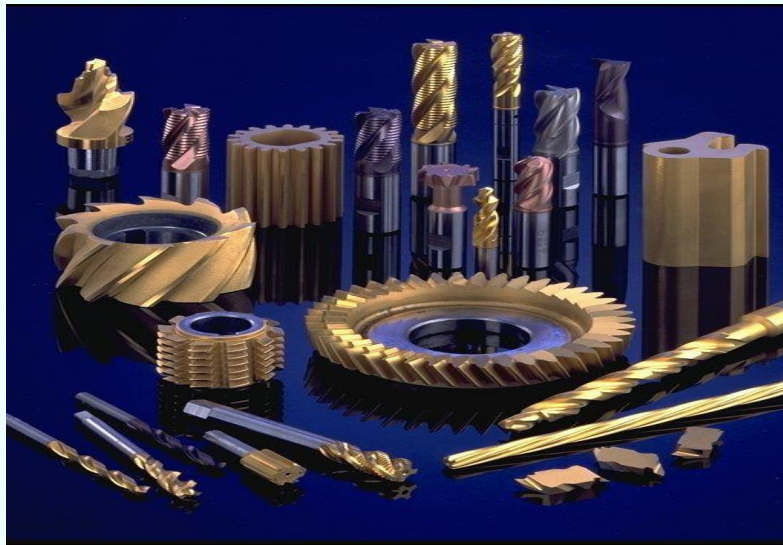
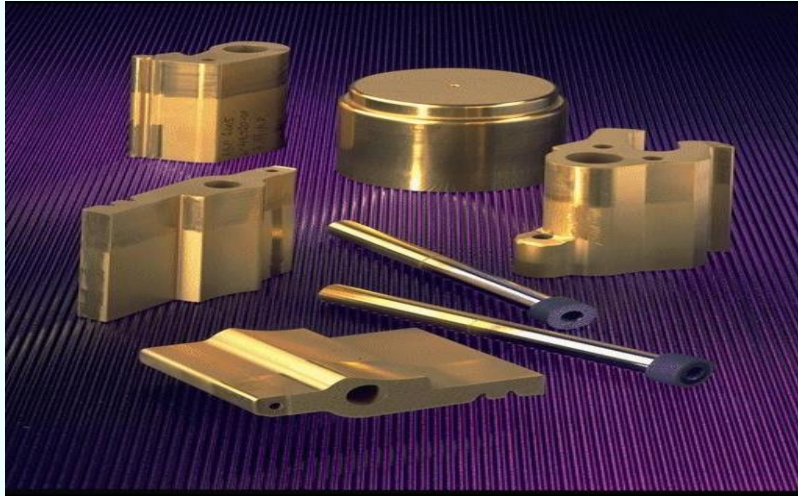


TiAIN



AlTiN

TiN Coated Samples



Security



Bullet Proof Jacket-Demonstration



Bullet Proof Jackets-.MP4

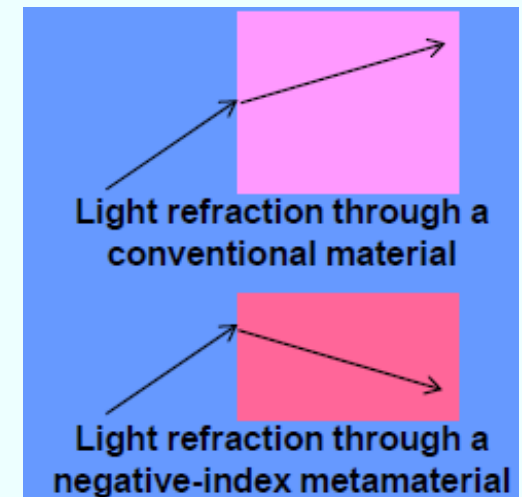


Super hydrophobic-spray--1-2 min.webm

C. Applications of Nanotechnology In Defence

Progress towards Invisibility cloak

- **Nanocomposites** are being studied at Purdue University to produce **metamaterials** that can be a step towards “invisibility cloak” for humans ?



Camouflage Nano Sheet



VID-20180328-WA0000 (1).mp4

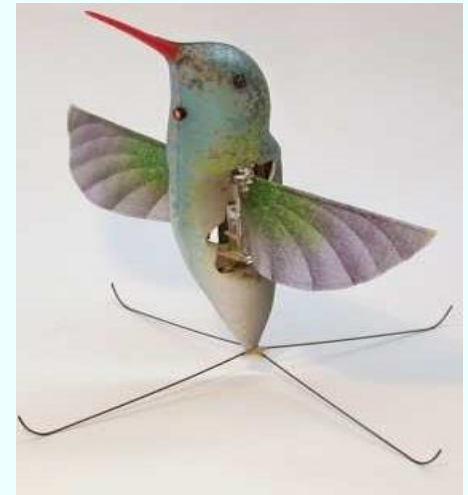
Applications of Nanotechnology In Defence

➤ 1. Nano-Air Vehicle-- A Humming bird like aircraft

Named one of the "50 Best Inventions of 2011" by TIME Magazine.

- ✓ A continuous hover endurance : 8 mins with no external power source.
- ✓ Flight : 11 miles per hour.
- ✓ Flying from outdoors to
- ✓ indoors.

- **Bee-size Drone (Israel)–**
Project in Progress.



- Drone outside



OutdoorIndoorFlight.mov



Drones - 2 min- of army-bee size.webm

Nano-Human Resource Development

➤ NEED FOR NANO EDUCATION : ?

1. Nanotechnology as **INDUSTRIAL REVOLUTION** to influence the **Society** for next 40-50 years.
2. Therefore need of properly qualified and trained Human Resource in nanotechnology for the best contributions.
3. To meet the needs of industry, R & D Institutions, Universities, IPRS. Patent offices, Legal offices, Society Awareness and Acceptance etc, ,the field of Nano Education is essential for all the countries .

Nano Degree Programs Worldwide

(BS, MS, Ph.D)

Country wise Breakup

Country	BS	MS	PhD	Country	BS	MS	PhD
Australia	12	05	2	Malaysia	02	01	01
Belgium	-	02	-	Mexico	09	07	06
Brazil	03	04	03	Netherlands	-	05	03
Canada	09	01	01	New Zealand	02	01	-
Czech republic	01	01	-	Norway	03	04	-
Denmark	05	05	05	Russia	05	05	-
Egypt	-	02	-	Singapore	01	-	-
France	-	10	09	Spain	01	03	-
Pakistan	01	04	01	Singapore	01	01	01
Germany	07	05	01	Poland	02	02	01

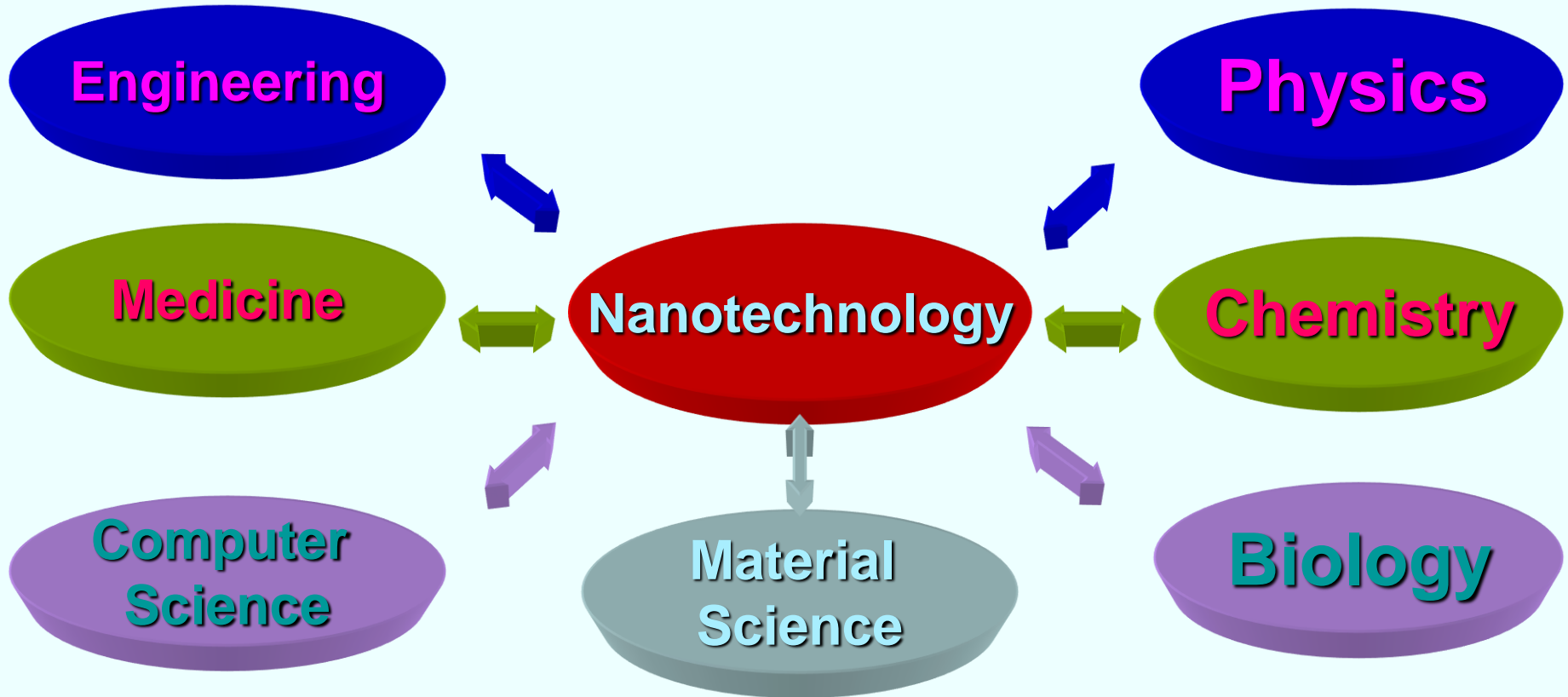
Greece		01	-	Switzerland	01	02	02
Sweden	02	04	-	U S A	14	10	09
Hong kong	-	01	01	Taiwan	-	02	01
Srilanka	-	-	01	Hongkong	-	-	01
India	03	28	06	Thailand	01	03	02
Ireland	02	-	-	Turkey	01	07	06
Israel	-	04	03	UK	04	15	07
Japan	-	01	01	Egypt	-	02	-
Italy	-	01	-				
Korea	08	06	02	<u>Total</u>	<u>100</u>	<u>155</u>	<u>76</u>

Nanotechnology Education in Pakistan

B.S(4 year) Degree

***First initiative in Pakistan
Fall-2010***

Nanotechnology is Multidisciplinary



Undergraduate(4 yr BS) Degree Programme

Nanoscience/Nanotechnology is inherently multidisciplinary:

Year1-2: Maths, Physics, Chemistry, Biology and Nanotechnology Applications in industry / Engineering. The basic subjects will be compulsory for the first two years.

- **Year 3 : Elective subjects in different fields of Nanoscience and Nanotechnology.**
- **Summer semester : Internship in Industry.**
- **Year4 : (i)Major Research Projects, (ii)Elective subjects.**

Subjects

Science Subjects

CH

1. Mathematics		3+3
2. Basic IT		2 +1
3. Chemistry		3+3+3+1
4. Physics		3+3+3
5. Nanoscience and its Industrial Applications		3 +0
6. Nanomaterials -I,II,III (Materials Science)	3+3+3	
7. Cell Biology		2+1
8. Synthesis and Characterization Techniques of Nanomaterial's	3+1	
9. Biochemistry		2+1
10. Electronics		3+1
11. General Microbiology		3 +0
12. Environment & Ethics in Nanotechnology		2 +0
13. Nanocomposite Materials		2 +0
14. Nanochemistry		3 +0
15. Nanobiotechnology		3 +0
16. Nano Sensors and Devices		3 +0

18. Quantum Mechanics	3 +0
19. Nanocatalysis	2 +0
20. Social Impact of Nanotechnology	3 +0
21. Nanoelectronics	3 +0
22. Applied Mathematics	3 +0
23. Laboratory-I,II,III	2+2+2
25. Nanobiology	2+0
26. Research Projects	6+0
27. Research Methods	3+0
28. Internship	6+0
Total CH	107

Social Subjects

29. Introduction to Psychology	3+0
30. English	3 +3+3
31. Pakistan Studies	3+0
32. Islamic Studies	3+0
33. Statistics	3+0
34. Technical Project Managemet	3 +0
35. Seminar	1+0
Total CH	25

BS(Nano): A success story:Switzerland

Christel Möller and Christian Schönenberger

- Benefits of studying a bachelor's degree in nanoscience at the University of Basel.

REF:Nature Nanotechnology,11,908(2016) Dated:05 October 2016.

Bachelor's degree in nanoscience launched in 2002.

- The bachelor's programme intake ; 40 students per year.
- Lectures in physics, chemistry and biology, the curriculum includes nano-specific courses and events.
- As Mangold explains “As a nanoscience student, I enjoyed a broad basic education in natural sciences with a specialization during the Master's program.
- Now, as a founder of IRsweep, the scope of my basic studies helps me to understand the biological and chemical processes of my future customers in industry. Thanks to the specialization,

PINSAT Success Story

Total Credit Hours (CH)

Break up per year:

- **1st year (2 semesters):** **18+18 =36 CH**
- **2nd year (2 semesters):** **16+17 = 33 CH**
- **3rd year (2 semesters):** **16+16 = 32 CH**
- **Internship** **6 CH**
- **4th year(2 semesters):** **15+10= 25 CH**
- Total (8 semesters) :** **132 CH**

PRESTON INSTITUTE OF NANO SCIENCE AND TECHNOLOGY(PINSAT)
PRESTON UNIVERSITY ISLAMABAD , PAKISTAN

BS (4 Yrs): Nanoscience & Nanotechnology

Multidisciplinary BS Degree: (Phys, Chem. Bio, Materials
Science)

MS/Ph.D Foreign Scholarships/Admissions : 2010- 2019(6 batches)

Total graduates passed = 55

Foreign Funded MS/Ph.D Scholarships = 36

Percentage of Foreign Funded Scholarships= $36/55=$ 65.5 %

MS/Ph.D Scholarships

**(i) China : 27(ii)South Africa: iThemba Labs: 5 Research Fellowships(iii)Hong Kong: 2
(iv)Belgium : 1-EU Erasmus Mundus(v)Russia: -1-**

Total MS/Ph.D scholarships = 27+5+2+1+1= 36

**Areas of MS/Ph.D:(i)BioPhysics (ii)Materials Engineering(iii)Textile
Engineering(iv) M.S. Nanoscience & Technology(v) Cancer Research(vi)
Graphene research(vii)Polymer Composites(viii) Energy- Solar Cells (ix)
Energy-Life of Batteries(x) Mechanical Engineering with Nanotechnology.**

MS Admissions Abroad.

**Germany : Biophysics, Norway : Materials,Italy : Textile
Engineering**



Preston University Islamabad

PINSAT Faculty-2017



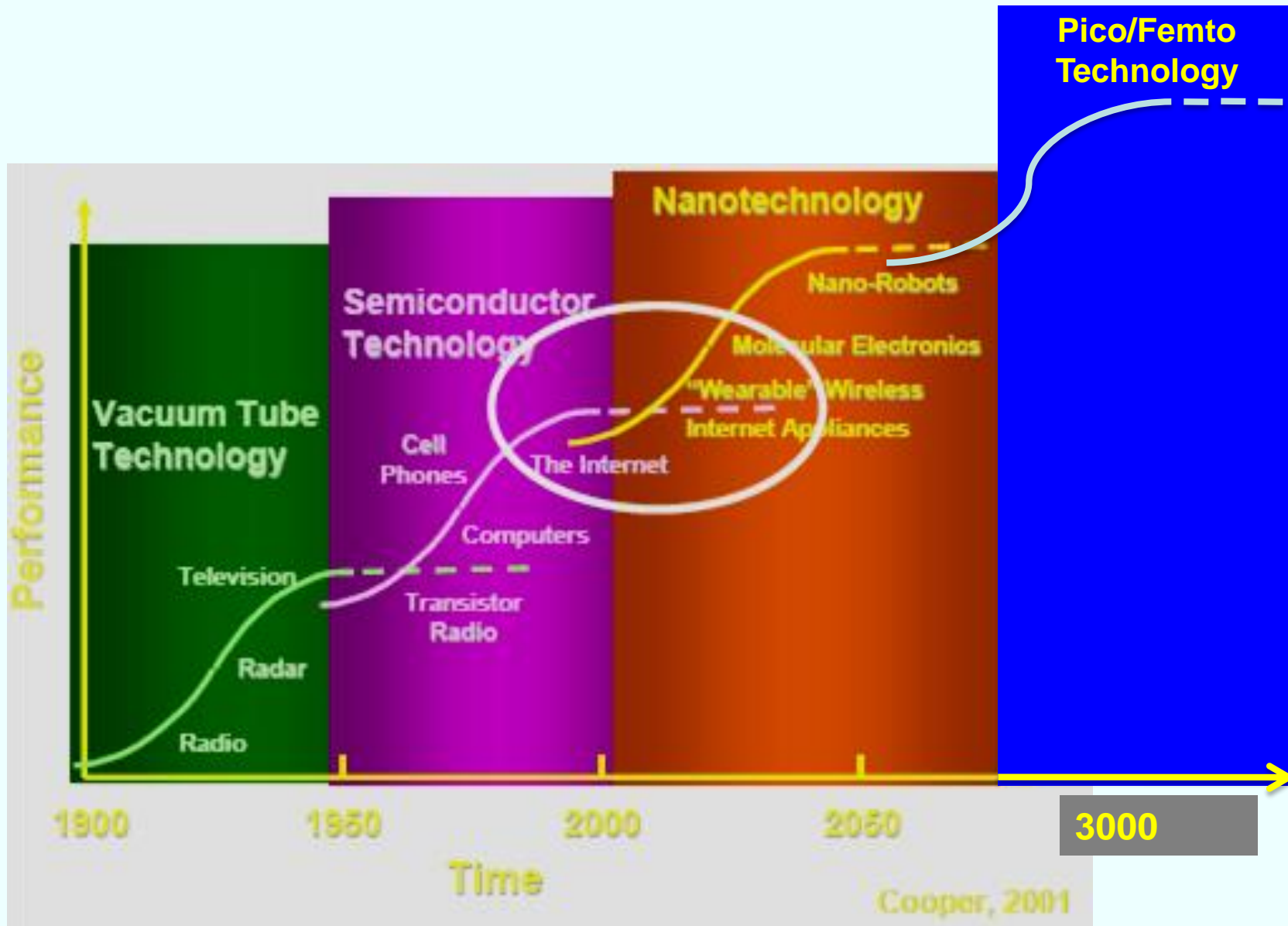
L to R : Mr Asad Ali, Lecturer, Prof.Dr.M.Fayyaz Ch (QAU-Dean Retd), Prof.Dr.M.Javed Iqbal (QAU Prof .Retd), Prof.Dr.K.Yaldram(Chief Scientist PAEC- Retd), Prof.Dr.N.M.Butt(Chairman PINSAT), Prof.Dr.J.I.Akhter(D.G Pinstech-Retd), Prof.Dr.Qamar Javed(QAU Prof -Retd), Visiting Prof.Dr.M.Afzal Sh(Chief Scientist PAEC-Retd), Assoc Prof.Dr.Shahid Bilal Butt(Chief Scientist PAEC-Retd).

Nano Future

Future: CONVERGENCE--Foresight

- Different disciplines of science are converging as scientists have common and overlapping interests.
- Scientists and engineers are learning the same language.
- They are using common instruments and tools.
- NT will promote the unification of most branches of Science, Engineering, Technology, based on unity of nature at the nanoscale and Social Sciences. CURRICULA for INTEGRATED Degrees.
- Social, Ethics, Safety, Standards, Regulaions, IPRS

Evolution of Technologies



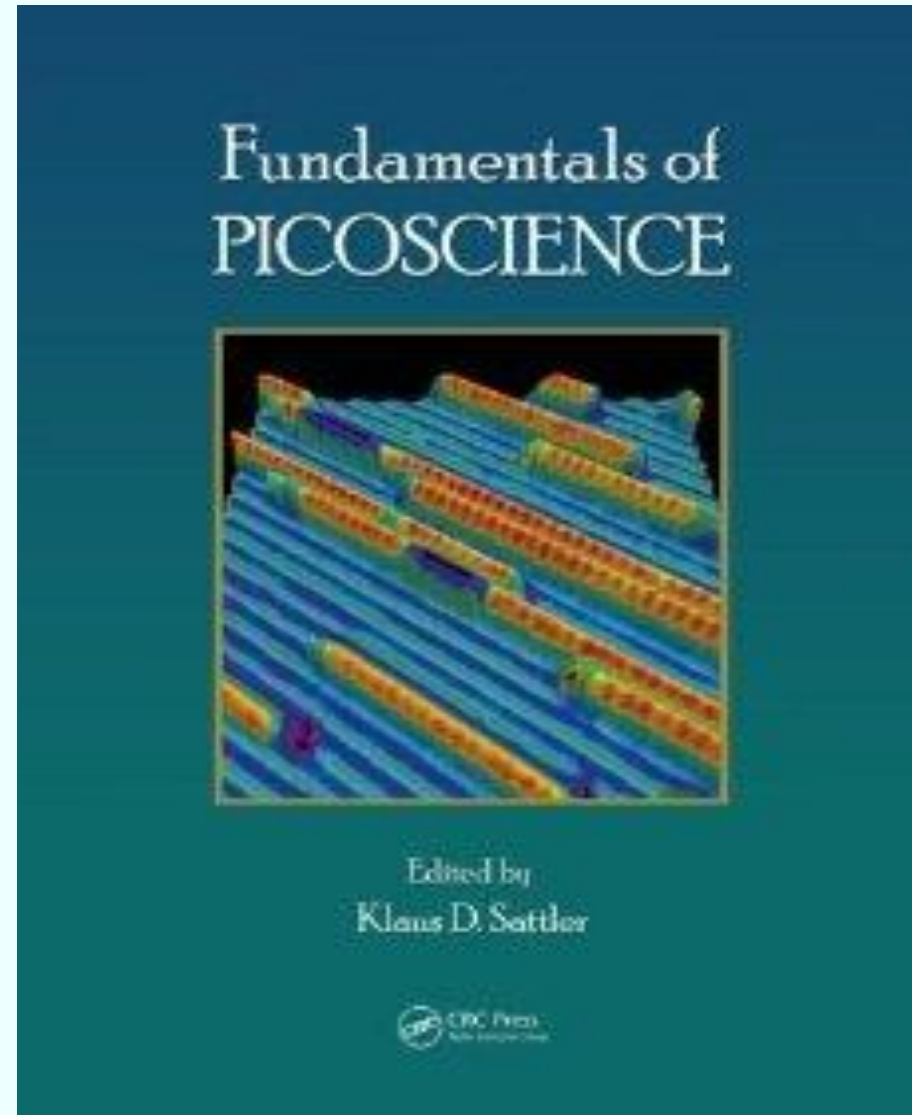
PICOSCIENCE Book

756pp .

Published:

September 2013.

Publishers: CRC- Div. of Taylor & Francis.



“Picotechnology :1000 time smaller than Nano”
Its Future advanced Applications

Picotechnology

1. The cutting-edge science and technology Nanoscience has generated many advances and inventions :
New quantum mechanical methods to far-reaching applications in electronics and medical diagnostics.

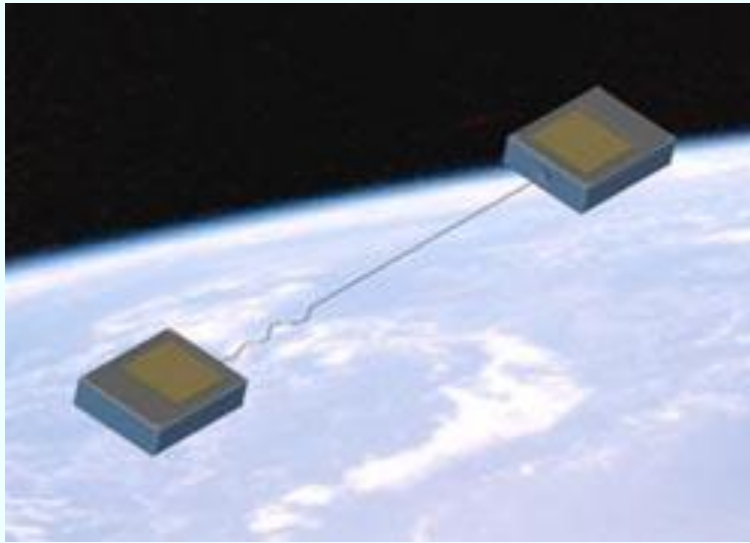
2. Ushering in the next technological era :

Fundamentals of Picoscience .

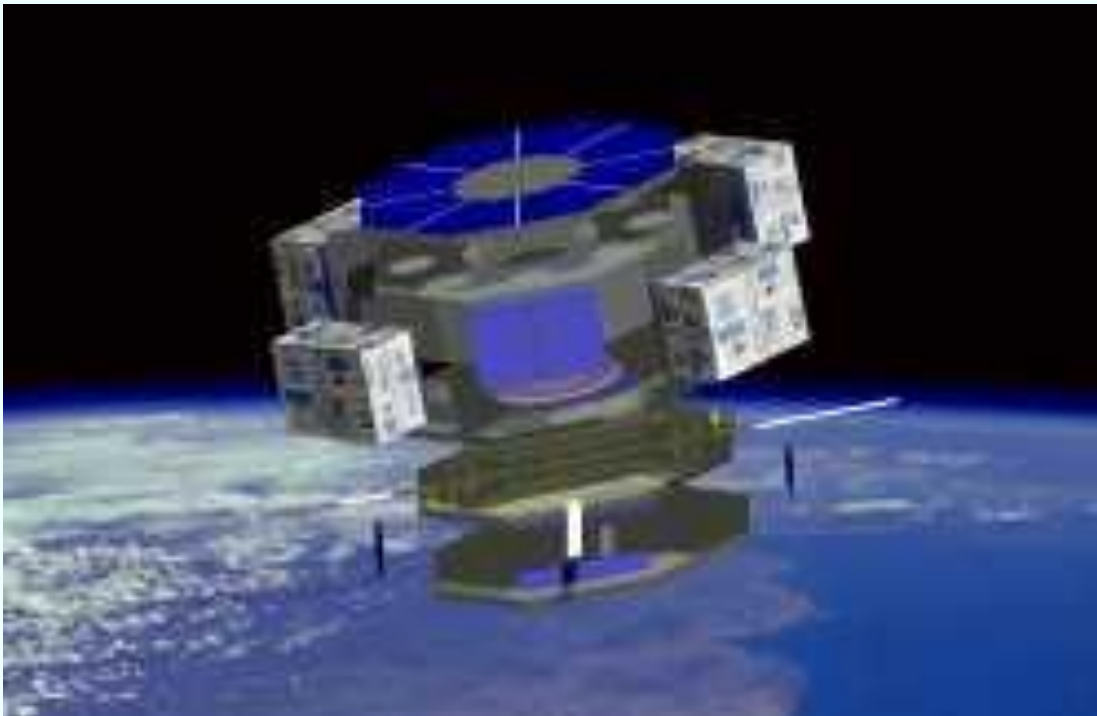
Fundamentals of Picoscience focuses on the instrumentation and experiments emerging at the picometer scale (10^{-12}).

Picotechnology Applications in Medicine

- The majority of biological processes occur at the atomic and subatomic level.
- The Pico-scale is at the atomic and subatomic levels.
 - Biological systems,
 - Medicine,
 - Imaging,
 - Computing,
 - Printing,
 - Chemical catalysis,
 - Materials synthesis
- With Pico technology we will be able to dive into structures on a pico-molecule level



AERO-tethered-picosats-sm



AERO-picosatellite-sm

Future Applications

- Pico technology may make it possible to manufacture **lighter, stronger, and programmable materials** that require less energy to produce than conventional materials.
- The material which produce less waste than with conventional manufacturing, and that **promise greater fuel efficiency in land transportation, ships, aircraft, and space vehicles.**
- **Medical Pico technology** may be able to **extend our lives** in two ways.
 - (i) It can **repair our bodies at the cellular level**, lengthening the telomeres; **reverse aging** and providing a certain version of the fountain of youth,
 - (ii) It can help the medical community **to eradicate life - threatening diseases** such as **stroke, heart attack, HIV or cancer.**

- By curing life threatening disease, **pico tech can extend the average lifespan** far beyond the remarkable achievements of the last century.
- For instance, the **Pico technology** applications in **healthcare** are **likely to minimize the number of deaths** from conditions such as heart disease and cancer over the next decade or so.

Future Exotic Technology:

The brain   machine Interface

The Cyborg Warrior:

Fortified Soldier of Future: 2030 or 2050
(With Human & Machine Brains)

Chinese or American---?

Cyborg Warrior: Will USA OR CHINA win ?

- While the Defense Department is aiming at 2050, inventor and futurologist Ray Kurzweil sees **the mind-machine interface** happening by 2030.
- Where the **300 million** or so “very general” pattern “**recognizers**” in the brain can be expanded by **creating a synthetic neo-cortex linking the brain to the cloud** and **merging artificial and human intelligence together.**
- . Lieber and his colleagues were awarded a number of patents, but the most important one appears to be a **2015 patent award** called “Systems and Methods for [nano-scale] **Injectable Devices.**” The idea of the 2015 patent was **to inject a nano-scale matrix into the brain and creating a brain interface that could be linked to machines.**

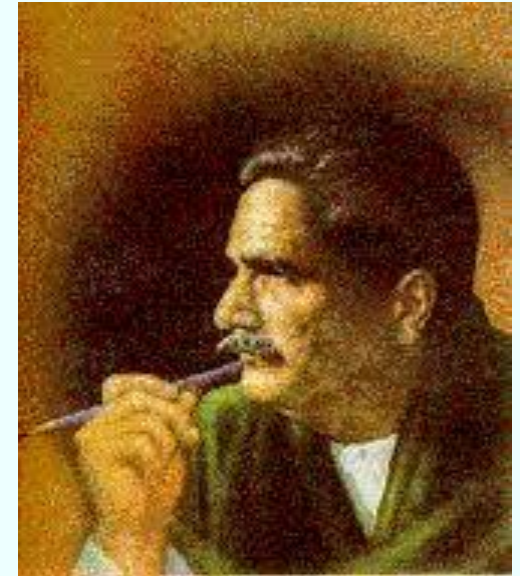
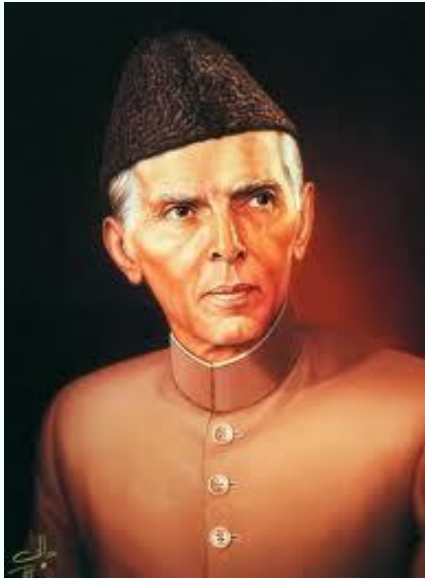
Cyborg technology is also being commercialized.

Whether 2050 or 2030 or in the next few years the first Cyborg Warrior may actually appear.

Will it be an American Cyborg or **from China? No one knows.**

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**Thank you
&
God Bless you**