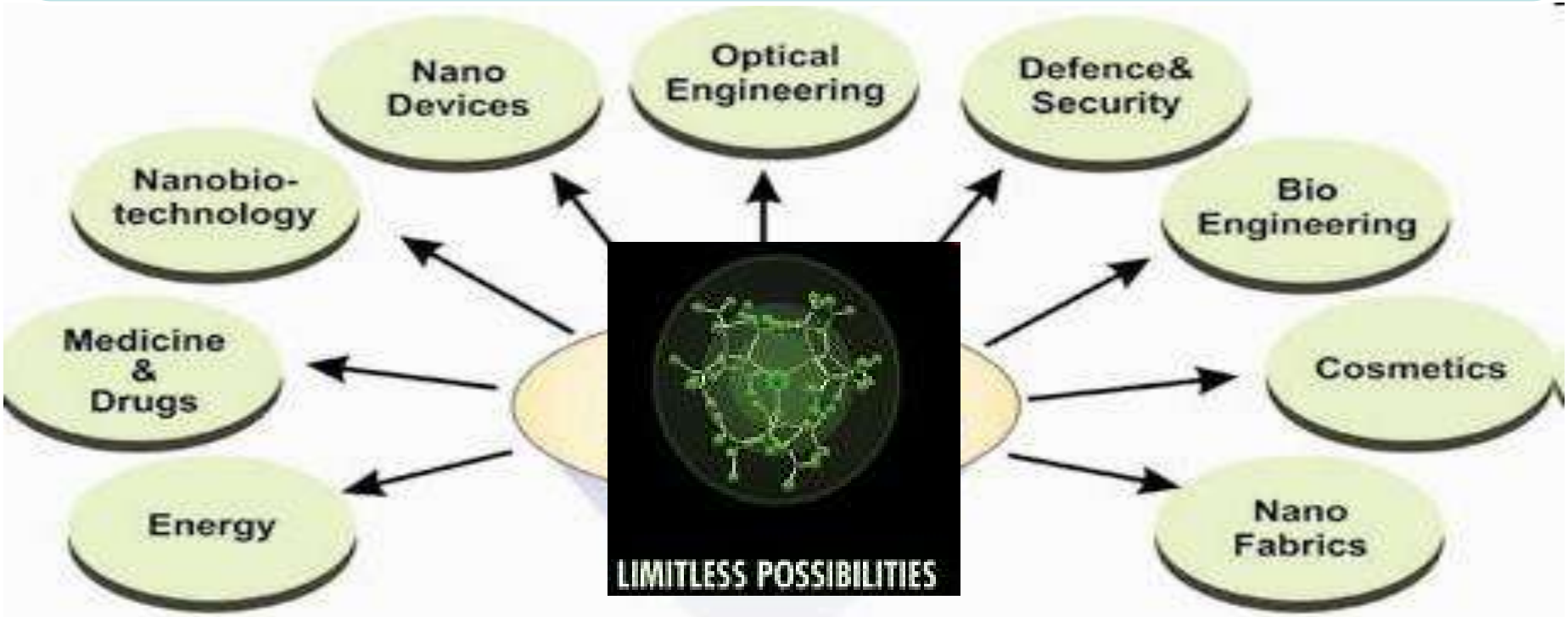
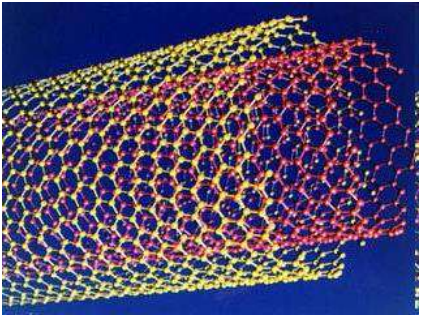
NANOTECHNOLOGY



Multilayered Nanoparticles for Drug/Gene Delivery in Nanomedicine

- Dr. Rajeshwara Achur



What Is All the Fuss About Nanotechnology?

Google™

Any given search engine will today produce >60 million hits

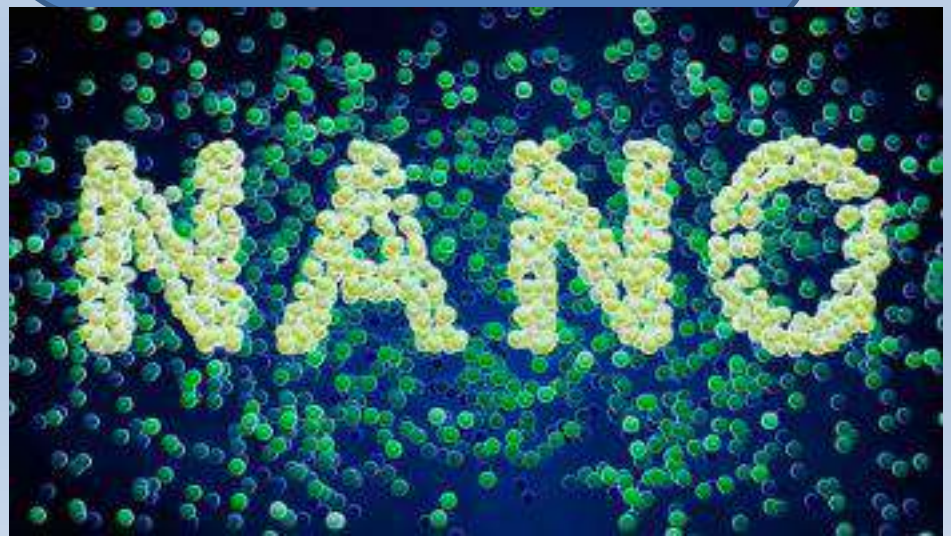
Nanotechnology is on the way to becoming the FIRST trillion dollar market

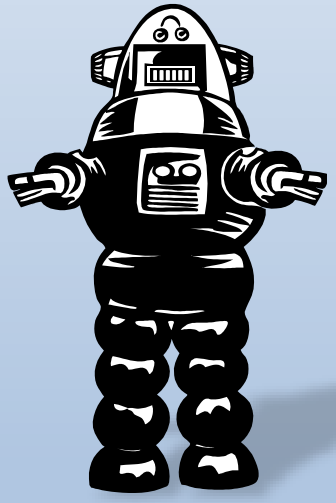
Nanotechnology influences almost every facet of every day life such as security and medicine.

OUR FUTURE - NANOTECHNOLOGY

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

Welcome to Nanoworld!





The challenges of new technology

The challenges of new technology

Product safety - the lessons of history

The challenges of nanotechnology

- Spectacular promises, benefits for all
- ...but at what price?
  - these questions arising in a world in which consumers are increasingly intolerant to risk

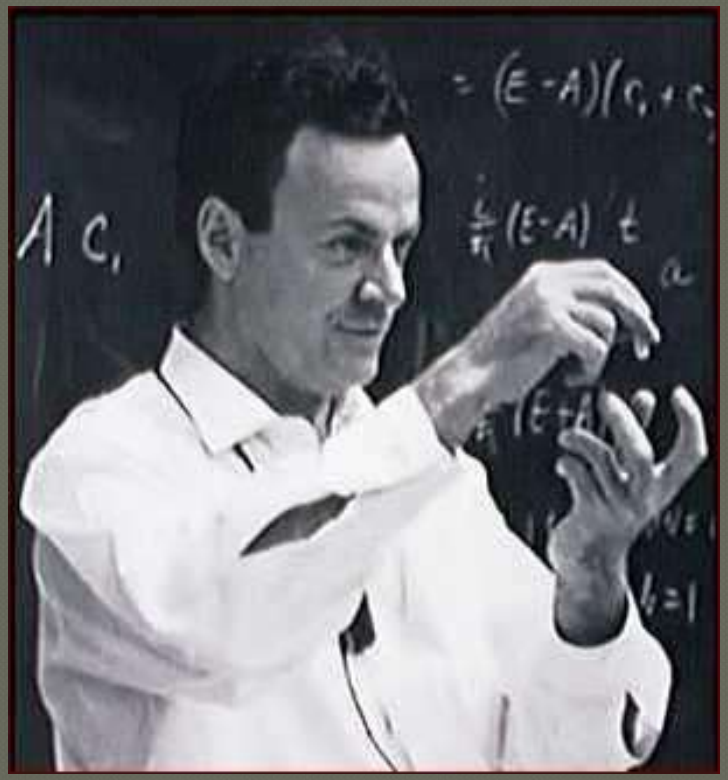
Nanoscience will change the nature of almost every human-made object in the next century.

National Science and Technology Council, 2000

ASME
SETTING THE STANDARD

The Idea

- Proposed by Richard Feynman in his book titled *There's Plenty of Room at the Bottom*
- Feynman considered the possibility of direct manipulation of individual atoms as a more powerful form of synthetic chemistry than those used at the time.
- The idea of nanotechnology was born.

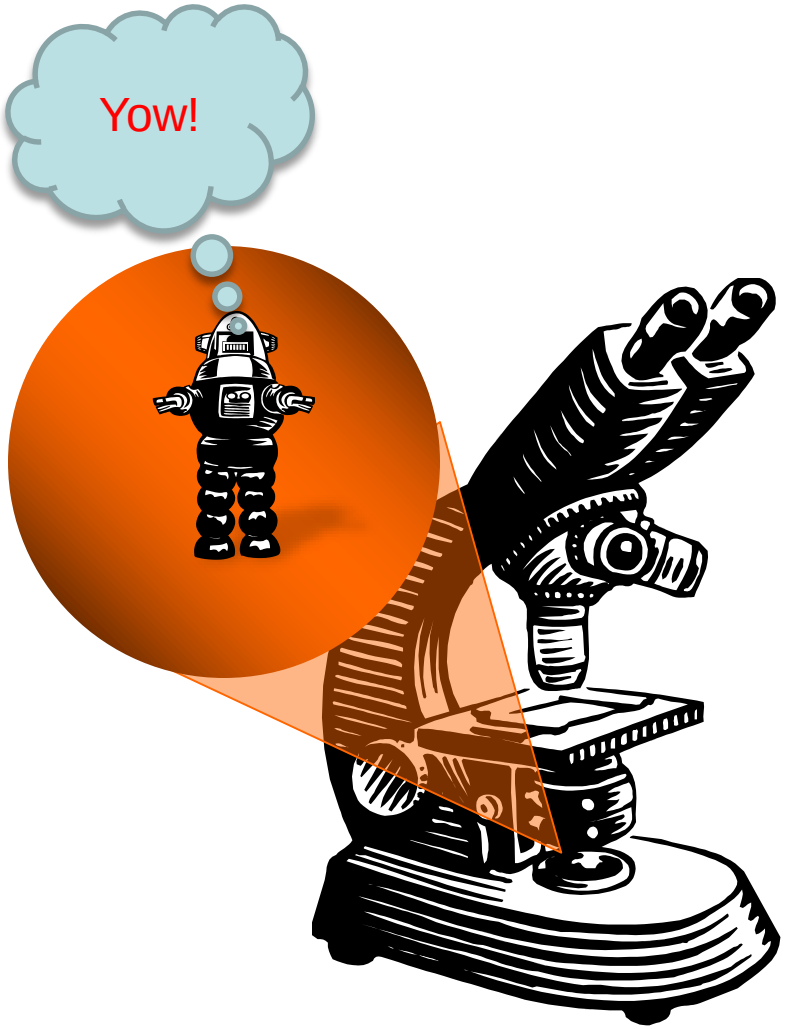


Richard Feynman - “Grandfather” of Nanotechnology

- 1959 - Richard Feynman - Nobel Prize in Physics
- “There’s plenty of room at the bottom” - an invitation to enter a new field of physics
- Offered two $1000 prizes:
  - Build an electric motor in a 1/64 inch cube
  - Reduce a page of a book by a factor of 25,000; read using an electron microscope
- 1960 - engineer claimed the first prize
- 1985 - graduate student wrote a page from A Tale of Two Cities 1/160 millimeter in length using Ebeam lithography

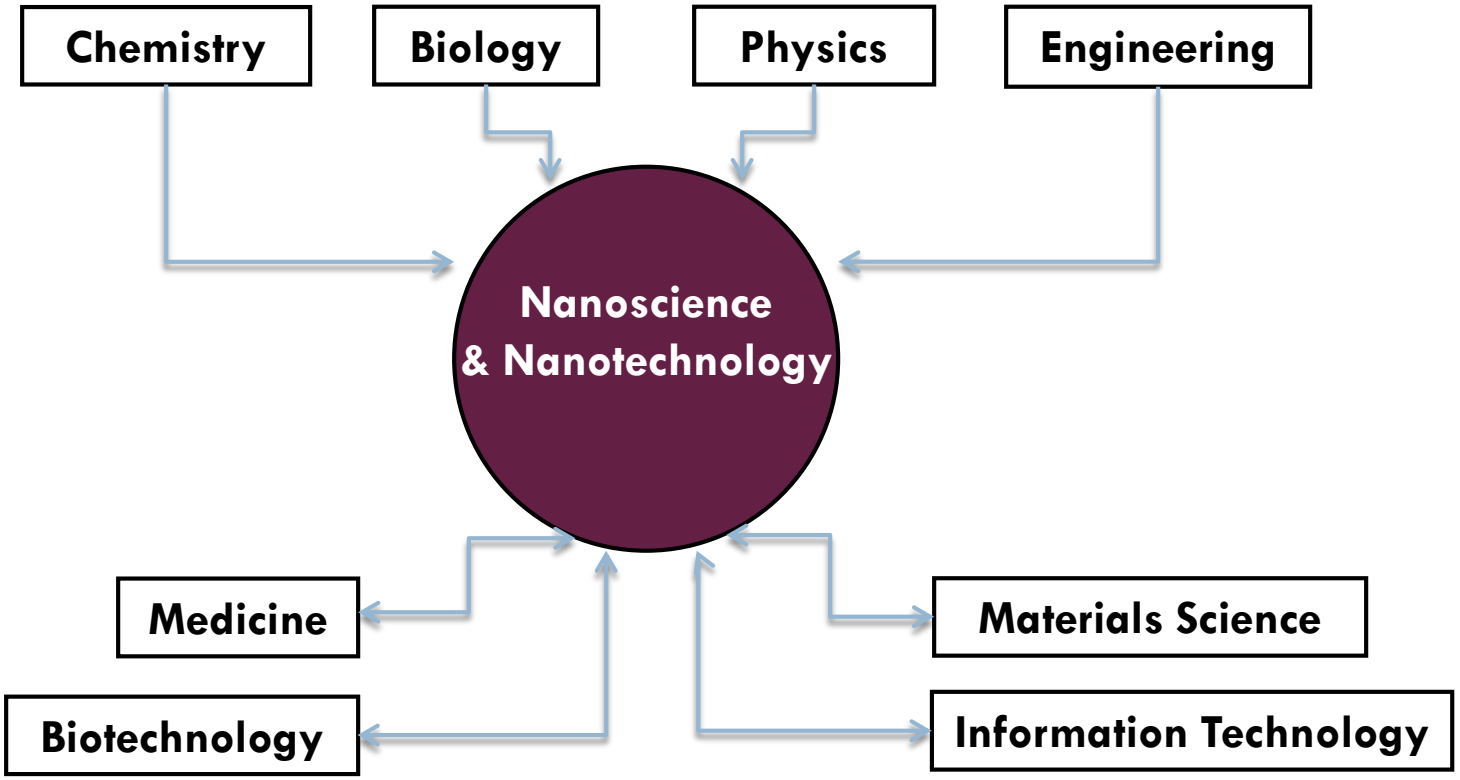
RICHARD FEYNMAN predicted the rise of nanotechnology in a landmark 1959 talk at Caltech. "The principles of physics," he said, "do not speak against the possibility of maneuvering things atom by atom." But he also anticipated that unique laws would prevail; they are finally being discovered today.

Nanotechnology Language



- *Nanobio*
- *Nanodots*
- *Nanowires*
- *Nanoelectronics*
- *Nanobots*
- *Nanomaterials*
- *Nanochondria*
-
- *etc.*

An Interdisciplinary Endeavor



What is nanotechnology?

- **Creation** of functional materials, devices, and systems.
- **Control** of matter on the nanometer (1-100 nm) length scale.
- **Exploitation** of novel properties and phenomena developed at that scale.

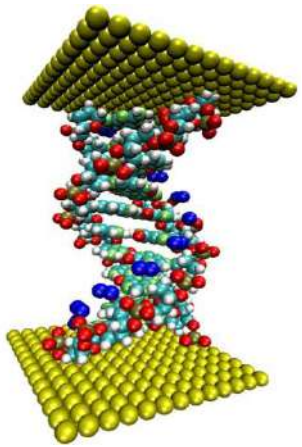
Definition

- Most widely used definition:

  - ***Nanoscience*** is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

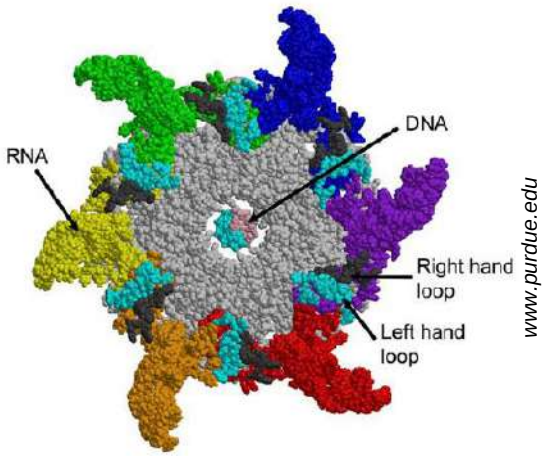
  - ***Nanotechnologies*** are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale.

What is Nanotechnology?



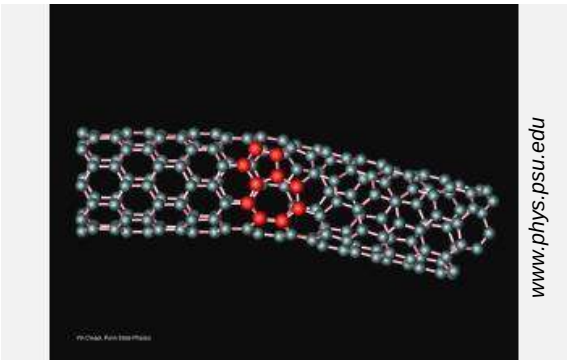
www.nasa.gov

An engineered DNA strand



www.purdue.edu

pRNA tiny motor



www.phys.psu.edu

Semiconducting metal junction formed by two carbon nanotubes

Nanotechnology is the creation of functional materials, devices and systems, through the understanding and control of matter at dimensions in the nanometer scale length (1-100 nm), where **new functionalities and properties** of matter are observed and harnessed for a broad range of applications.

What is Nanotechnology?

The creation of useful, functional materials, devices, and systems through:

1. Controlling and manipulating matter on the nanometer-length scale (1-100 nm), and
2. Exploiting novel phenomena and properties (physical, chemical, biological, mechanical, electrical) at the nanoscale.

"Going Small for Big Advances"

What Is Nanotechnology?

(Definition from the NNI)

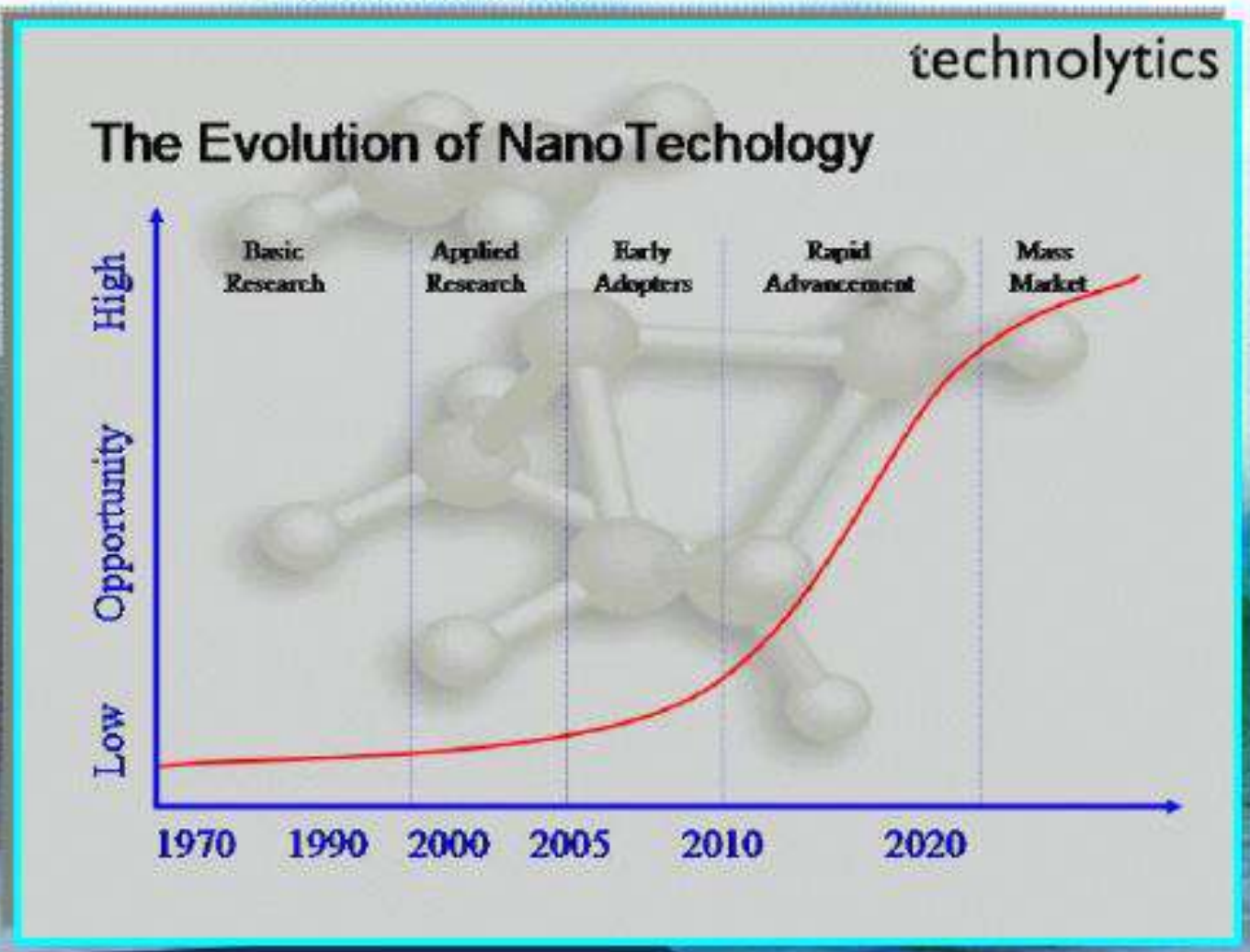
- Research and technology development aimed to understand and control matter at dimensions of approximately 1 - 100 nanometer – the nanoscale
- Ability to understand, create, and use structures, devices and systems that have fundamentally new properties and functions because of their nanoscale structure
- Ability to image, measure, model, and manipulate matter on the nanoscale to exploit those properties and functions
- Ability to integrate those properties and functions into systems spanning from nano- to macro-scopic scales

What Nanotechnology Can Address?

Nanotechnology Idea	Area
The idea of "Nano" – being small	Structure of Atoms
Nanomaterials have a high surface area (nanosensors for toxins)	Structure and properties of matter, Personal and Community Health
Synthesis of nanomaterials and support chemistry (space propulsion)	Chemical Reactions
Shape Memory Alloys	Motion and Forces, Abilities of technological design, Understanding about science and technology
Nanocrystalline Solar Cells	Conservation of Energy and increase in disorder (entropy), Interactions of energy and matter, Natural Resources
Nanocoatings resistive to bacteria and pollution	Personal and Community Health, Population Growth, Environmental Quality, Natural and human-induced hazards

What Nanotechnology Can Address?

Nanotechnology Idea	Area
Nanomaterials, such as MR (magneto-resistive) fluids in security	Science and technology in local, national, and global challenges
Richard P. Feynman's talk, "There is plenty of room at the bottom". Feynman had a vision.	Science as a human endeavor, Nature of scientific knowledge, Historical perspective
Nanocosmetics and nanoclothing	Science as a human endeavor, Science and technology in local, national, and global challenges
Nanotechnology and Science Ethics	Science and technology in local, national, and global challenges, Science as a human endeavor, Historical perspective, Natural and human-induced hazards, Population Growth, Personal and Community Health



Potential market for nanotechnology ?

$1 trillion business within the next 10 to 15 years.

What is nano?

Power	Prefix	Origins
10^{12}	tera	teras: monster
10^{9}	giga	gigas: giant
10^{6}	mega	megas: large
10^{3}	kilo	chilioi: thousand
10^{-3}	milli	milli: thousand
10^{-6}	micro	mikros: small
10^{-9}	nano	nanos: dwarf

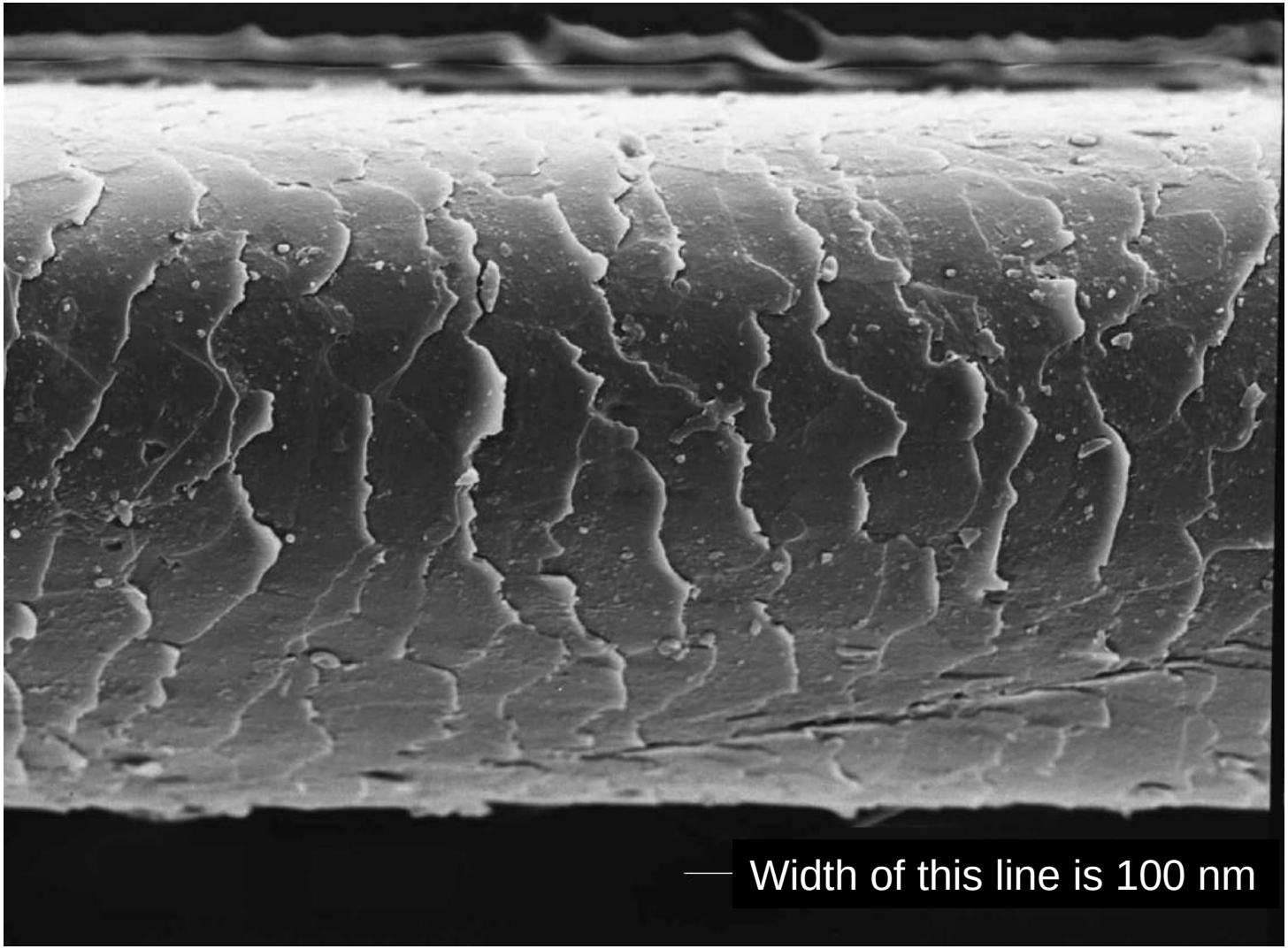
What is Nano?

- Nanoscience is the study of objects measured in nanometers
  - 1-billionth of a meter
  - ~80,000 times smaller than the diameter of a single human hair

What is Nano?

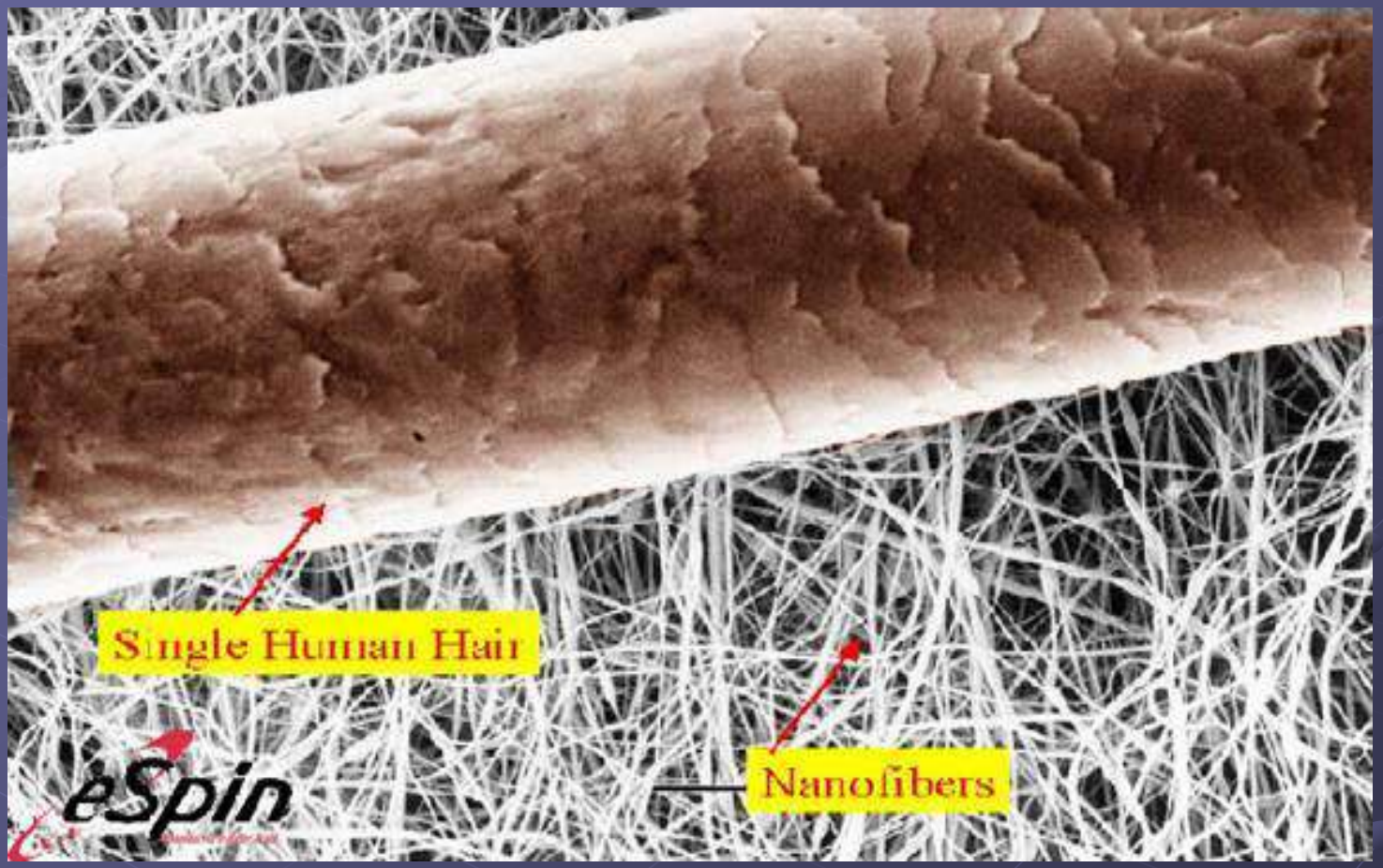
- Nanoscience is the study of objects measured in nanometers
  - 1-billionth of a meter
  - ~80,000 times smaller than the diameter of a single human hair
  - New properties emerge at the nanoscale
    - **Size and shape matter**

Closer Look at a Human Hair



http://www.aber.ac.uk/bioimage/image/uwbl-0411-w.jpg

Compared to Human Hair

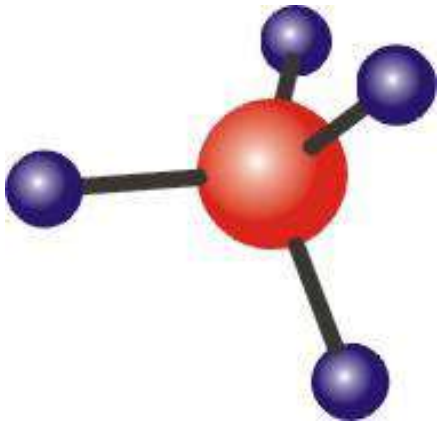


A Human Hair is about 100,000µm wide

0.000 000 001 metre

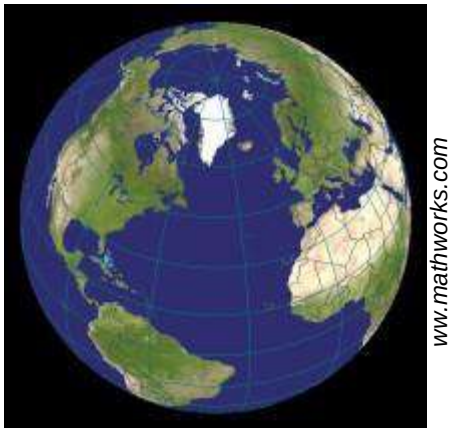
One **nanometer** is thus one billionth of a metre (or one millionth of a millimetre, etc.). It can be expressed as 10^{-9} metres and shortened to ***nm***.

The radius of one atom of **gold** is 0.14 nm.



Half a nanometre is the linear dimension of a small molecule like **methane** (CH_4). One human ***hair*** is around 100 thousand times bigger.

What is Nanoscale ?

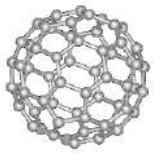


www.mathworks.com

12,756 Km

22 cm

Fullerenes C_{60}



0.7 nm

www.physics.ucr.edu

1.27 × 107 m → **0.22 m** → **0.7 × 10-9 m**

10 millions times smaller

1 billion times smaller

What is Nano?

Prefixes for SI Units			
Prefix	**Symbol**	**Meaning**	**Notation**
exa-	E	1,000,000,000,000,000,000.	1.E+18
peta-	P	1,000,000,000,000,000.	1.E+15
tera-	T	1,000,000,000,000.	1.E+12
giga-	G	1,000,000,000.	1.E+09
mega-	M	1,000,000.	1.E+06
kilo-	k	1,000.	1.E+03
hecto-	h	100.	1.E+02
deka-	da	10.	1.E+01
		1.	1.E+00
deci-	d	.1	1.E-01
centi-	c	.01	1.E-02
milli-	m	.001	1.E-03
micro-	μ	.000001	1.E-06
nano-	n	.000000001	1.E-09
pico-	p	.000000000001	1.E-12
femto-	f	.000000000000001	1.E-15
atto-	a	.000000000000000001	1.E-18

How Big is a Nanometer?

Prefixes for SI Units			
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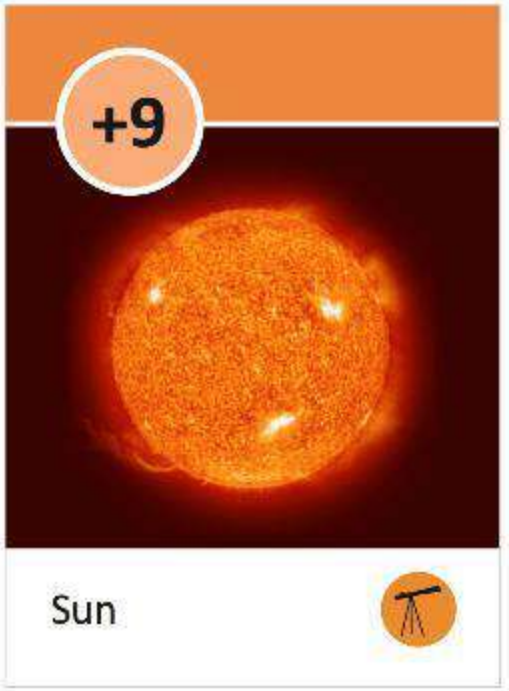
giga-	G	1,000,000,000.	1.E+09
mega-	M	1,000,000.	
kilo-	k	1,000.	
hecto-	h	100.	
deka-	da	10.	
		1.	
deci-	d	.1	
centi-	c	.01	
milli-	m	.001	
micro-	μ	.000001	
nano-	n	.000000001	
pico-	p	.000000000001	
femto-	f	.000000000000001	
atto-	a	.000000000000000001	



http://www.nisenet.org/catalog

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giga-	G	1,000,000,000.	1.E+09
mega-	M	1,000,000.	1.E+06
kilo-	k	1,000.	
hecto-	h	100.	
deka-	da	10.	
		1.	
deci-	d	.1	
centi-	c	.01	
milli-	m	.001	
micro-	μ	.000001	
nano-	n	.000000001	
pico-	p	.000000000001	
femto-	f	.000000000000001	
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kilo-	k	1,000.	1.E+03
hecto-	h	100.	
deka-	da	10.	
		1.	
deci-	d	.1	
centi-	c	.01	
milli-	m	.001	
micro-	μ	.000001	
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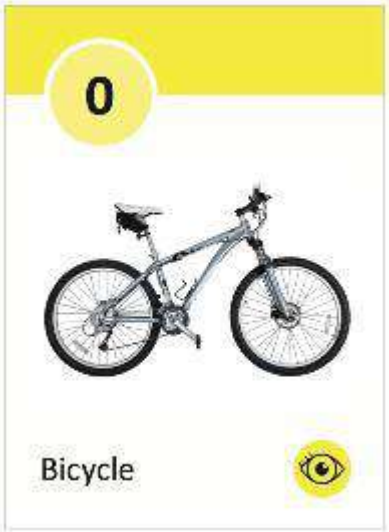

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	M	1,000,000.	1.E+06
	k	1,000.	1.E+03
	h	100.	1.E+02
deka-	da	10.	1.E+01
		1.	1.E+00
deci-	d	.1	1.E-01
centi-	c	.01	1.E-02
milli-	m	.001	1.E-03
micro-	μ	.000001	1.E-06
nano-	n	.000000001	1.E-09
pico-	p	.000000000001	1.E-12
femto-	f	.000000000000001	1.E-15
atto-	a	.000000000000000001	1.E-18

http://www.nisenet.org/catalog

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LECTURE 1A