Wondrous Nanotechnology

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Summary: In the last two decades, a lot of progress has been made in Nanotechnology and Nanoscience, an exploitation of matter on atomic, molecular and supermolecular scale. Nanotechnology because of its size is widely used in such varied fields as surface science, molecular biology, organic chemistry, semi-conductor physics, micro fabrication, medical sciences, electronics, biomaterials, energy production, etc. Using nanotechnology, Researchers have been able to develop new materials with nanoscale dimensions to directly control matter on the atomic or molecular scale. Due to the range of many potential applications, both industrial and military, many governments boast invested billions of dollars in nanotechnology and nanoscience research. This brief review deals with the fundamentals of nanotechnology and nanoscience and its application in various fields. It also discusses the future of nanotechnology and the risks involved in it.

Keywords: Nanotechnology, Nanoscience, Nanoparticle, Fullerene, Military and Civilian uses, Risks and Ethical Problems.

Introduction

Nanotechnology has originated from the Greek word Nannos, which means very small. Nano is the unit of length in metric system that is equal to 1 billionth of a meter (10^{-9} m). Technology means the manufacturing, practice, knowledge of tools, medicines and techniques to solve a problem or perform a specific task (function). Nanotechnology is a broad field that needs expertise in Physics, Chemistry, Material Science, Biology, Mechanical and Electrical Engineering, Medicine and their united knowledge. It is a border between atoms, molecules and macro world where the property is dictated by the elementary behavior of atoms, viz. quantum mechanics. Fig. 1 (https://www.cancer.gov/research/progress/snapshots/nanotechnology) shows the sizes of various items, *i.e*. from macro-materials to atoms, nano-materials and nano-devices.

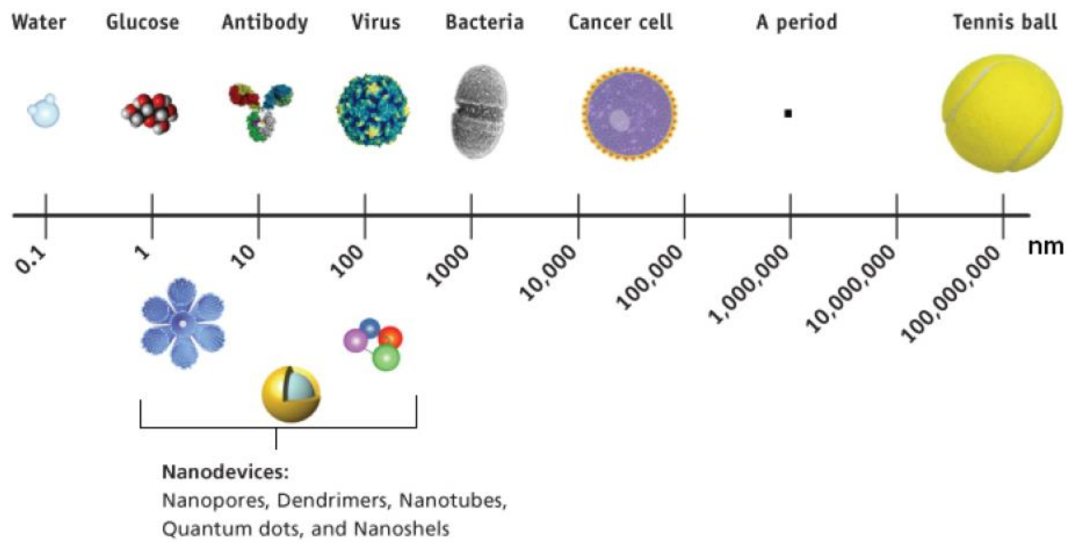

Fig. 1: From macro-materials to atoms: nanomaterials and nano-devices that are of interest in nanotechnologies are at the lower end of the scale (1-100nm).
(Image adapted from “A snapshot of nanotechnology”. National Cancer Institute)

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The first person to give some idea about nanotechnology was the Scotish scientist, James Clerk Maxwell in 1867, Fig. 2 (https://thecuriousastronomer.wordpress.com/2013/08/page/2/), by an experiment known as Maxwell's demon which was capable to hold individual molecules [1]. As a matter of fact the credit for measurements of nanoparticles goes to Professor Dr. Richard Adolf Zsigmondy, Fig. 3(https://en.wikipedia.org/wiki/Richard_Adolf_Zsigmondy) (Nobel Prize in Chemistry in 1925), who published a book [3] in 1914. For particles having the size of less than a wavelength of light, he used an ultramicroscope since it employed the dark field method. Therefore system of classifications, which was based on the size of the particles, was developed by Prof. Dr Richard Adolf Zsigmondy.

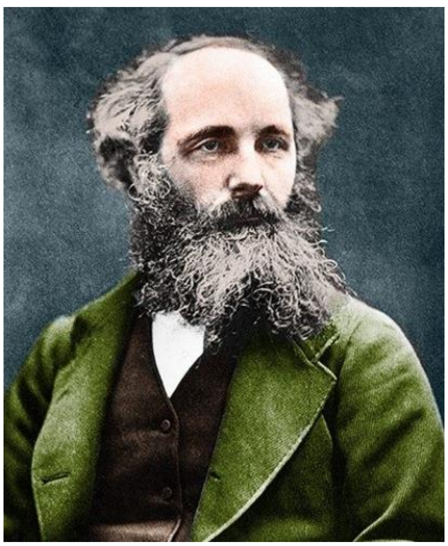

Fig. 2: James Clark Maxwell.

However, Nobel Laureate Physicist Richard Feynman, Fig. 4 (https://play.google.com/store/infoname/ Richard _ Feynman?id=06crk), is credited with the idea and concepts behind nanotechnology and nanoscience and is regarded as the father of nanotechnology. In a lecture at the American Physical Society conference at the California Institute of Technology (CALTECH) on December 29, 1959, long ago the word nanotechnology was coined, Feynman gave a talk entitled, "There is abundance of room at the bottom and had described a procedure in which researchers would be proficient to manipulate and handle individual atoms and molecules [4]. The definition of nanotechnology was, however, given by Norio Taniguchi, Fig. 5 (http://www.y-nakamr.net/), of Tokyo Science University in an article [2] in 1974 at a Physical Conference in London. He described nanotechnology as a process of division, consolidation and buckle of material by one atom or another molecule.

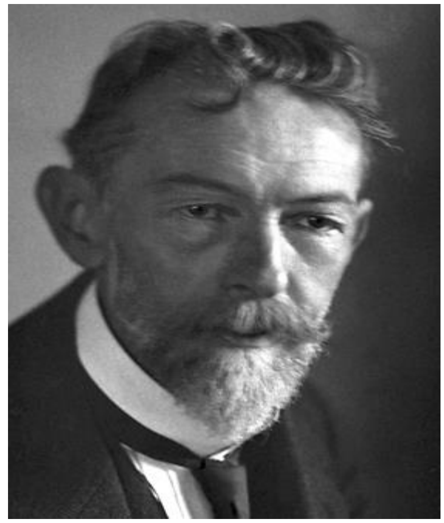

Fig. 3: Richard Adolf Zsigmondy.

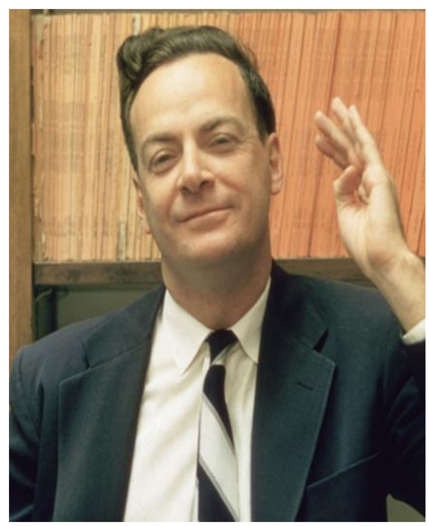

Fig. 4: Richard Feynman.

The first book on nanotechnology, "Engines of Creation: The upcoming time of nanotechnology" was written by Eric K. Drexler, Fig. 6 (https://en.wikipedia.org/wiki/K._Eric_Drexler), in 1986, in which he explain the valve of nano-scale devices [5]. The discovery of Scanning Tunneling Microscope (STM – an apparatus for imaging surfaces at the atomic level) in 1981 by Gerd Binnig and Heinrich Rohrer at IBM Zurich Research Laboratory [6]. They got Nobel Prize in Physics in 1986. It was successfully use in 1985 to the discovery of Fullerene, C_{60}, by Harry Kroto, Richard Smalley and

Robert Curl [7]. The three got the Nobel Prize in Chemistry in 1986 [8].

Fig.5: Norio Taniguchi.

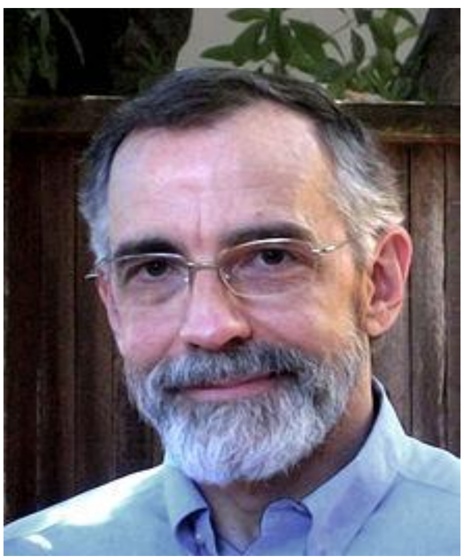

Fig. 6: Erik Drexler.

Binnig, Quarte and Gerber also invent the Analogous Atomic Force Microscope (AFM) in 1986. It is the most extensively used scanning probe instrument. It combines surface topography and scanning tunneling microscopy. It can be used to control atoms mechanically.

The two major breakthrough, viz. the invention of STM and the discovery of Fullerenes gave quantum jump to the development of nanotechnology.

Nanotechnology is a hybrid science that combines engineering with chemistry or in other simple words can be defined as component of science and technology that characterize the structure of materials between 1 nm to 100 nm. Alternately, it may be defined as, "The design, characterization, production and application of structures, devices and systems by controlled manipulation of size and shape at the nanometer scale. As mentioned earlier, one nanometer is one billionth of a meter. It is used to measure the size of atoms, molecules and smallest particles. For example:

1. About 400000 nm is the diameter of human hair
2. The human eye can see is 10.000 nm
3. The size of red blood cell is 5000 nm
4. The typical germ size is 1000 nm
5. The wavelength of visible color is 400 to 700 nm
6. The width of tiny switches in the computer are only 100 nm wide
7. The size of quantum dots is 5 nm
8. Width of DNA molecule is 2 nm
9. The size of nanotubes of carbon is 1.3 nm
10. The size of water molecule is >1 nm
11. 1 nm is the size of buckyball
12. The diameter of hydrogen atom is 0.1 nm

Nanotechnology enables us to develop materials with enhanced or totally novel properties. It is the great challenges for humans which control the material at atomic level are possible. A nanomaterial clears many fascinating properties which may be exploited to produce a variety of structural and non-structural applications.

Nanomaterials

Nanotechnology and nano science involve the capabilities to observe and to influence individual atoms and molecules (when atoms get together by chemical bonds and form a definite structure they form a molecule. Since there are more than 90 atoms, all roughly round but different in size, they are able to make many many molecules. Most of the similar atoms cluster together making huge molecule structures).

Everything in this world is made up of atoms, our bodies, clothes, buildings, houses etc. The problem, however, was that everything as small as an atom was impossible to see with the naked eyes. As a matter of fact, it was not possible to see with the conventional microscopes used in schools. The microscopes required to see things at nano scale were invented about 30 years ago [9]. They were Scanning Tunneling Microscope (DTM) and the Atomic Force Microscope (AFM)) mentioned earlier. Once these powerful tools were invented, the age of nanotechnology began. Even though the modern nanotechnology and nanoscience are recent, nanoscale material is unknowingly used everywhere for centuries. Different sized gold and silver particle were used to create color in the blemished glass windows used centuries ago in Churches, Fig. 7 (https://www.nano.gov/timeline).

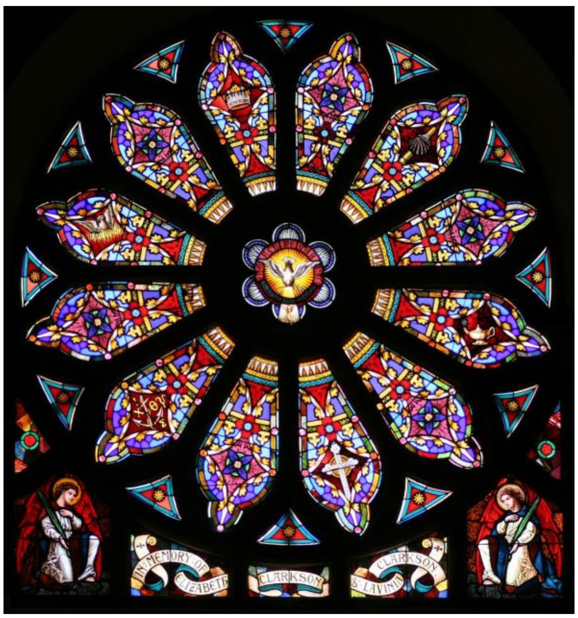

Fig. 7: Medieval stained glass windows are an example of how nanotechnology was used in the pre-modern era. (courtesy: NanoBioNet).

We know that nanomaterials are materials possessing grains of about a nano size (10^{-9} meter). We also know that all materials in our universe are composed of atoms which are no visible to the naked eye whereas the normal conventional materials are made up of grains varying from many microns (10^{-6} meter) to millimeters. Atoms and molecules attach together because they have matching shape that hold them collectively just like (±) changes which are attracted to each other. A positively charged atom will attract to a negatively charged atom. When millions of atoms and molecules joined to each other by machines that grab the atoms and move them to a required position. The aim of nanotechnology, thus, is to manipulate atoms and molecules individually, arrange them in a desired model to make a desired item [10].

Nanocrystalline materials consist of grains 1 - 100 nanometers. The average size of an atom is about 1 - 2 Ångstrom (0.10 – 0.20 nm) in radius and therefore we may have 3 – 5 atoms in one nm, depending upon the atomic radii [11]. By convention, nanotechnology is adopting as the scale range 1 – 100 nm following the definitions used by the National Nanotechnology Initiative (NNI) in the US. The lower limit is set by the size of the atom (hydrogen as the smallest atoms about 0.25 nm in diameter) since nanotechnology must assemble its devices from atoms and molecules. The upper limit is more or less random but is around the size that phenomena not observed in bigger structures start to become obvious and can be completed in the nano device [10]. Let us look that scale in one more context: the comparative size of a nanometer to meter in similar to that a marble to the size of the earth. Or looking it in another way: a nanometer is the magnitude of a normal man's head growth in the time it takes to raise the shaving blade to his face [12].

Regarding Fullerene discovery, it was during a concentrated working week in 1985, that Sir Harry Kroto, Richard Smalley and Robert Curl [7] made the completely sudden discovery that the element carbon could also exist in the form of constant spheres. They term these new carbon balls as Fullerenes. The spheres consisted of 60 carbon atoms, for that reason, they were designed C_{60}. The geometry which they formed consisting of 12 pentagons and 20 hexagons, Fig. 8 (https://en. wikipedia.org/wiki/Fullerene), just like a soccer ball [13]. Coincidentally, the implosion-type nuclear device is also spherical with the same configuration, the pentagons and hexagons being explosive lenses (shaped charges) with detonators at the centre of pentagons and hexagons. Fullerenes can be considered as variants of graphite. Graphite consists of infinite flat sheets of carbon atoms in which each atom is hundreds to thousands carbon atoms, so the pattern of bonds consists of tilted regular hexagons. In fullerenes, some hexagons are replaced by pentagons, so that the resulting sheet is curved. In case of C_{60}, the pattern of hexagons and pentagons is such that the molecule is spherical. In 1990, a technique produces a large quantity of C_{60} developed by resistively heating graphite rocks in helium atmosphere.

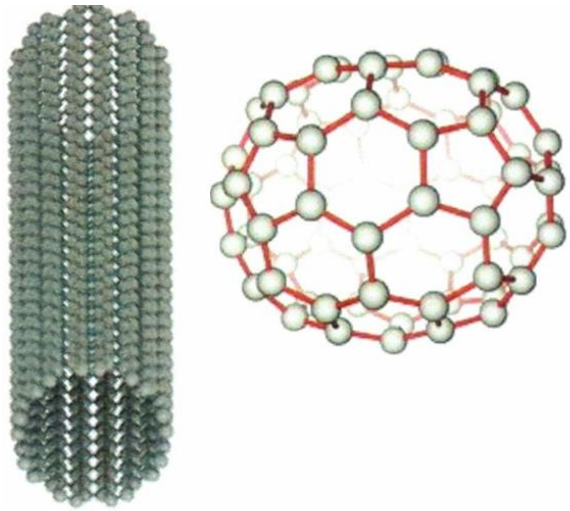

Fig. 8: Buckminsterfullerene C_{60}. Also known as the buckyball, is a representative member of the carbon structures known as fullerenes. Members of the fullerene family are a major subject of research falling under the nanotechnology umbrella.

A building designed (Geodesie Dome) of the Fullerene shape, Fig. 9 (http://www.vikingdome.com/geodesic-domes/), was exhibited in 1967 World Exhibition in Montreal by the famous American architect Buckminster Fuller, Fig. 10 (https://en.wikipedia.org/wiki/Buckminster_Fuller). Therefore, the C_{60} was dubbed as Fullerene or Buckyball.

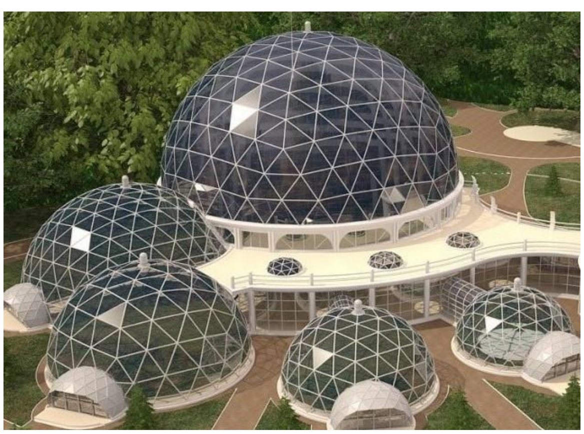

Fig. 9: Geodesic Dome.

The molecule of Buckyball is tremendously rugged, competent of surviving collision with metals and other materials at speeds higher than 20,000 miles per hour. Due to the speed property, Buckyballs show promise in the development of fuel cells probably capable of powering automobiles in the future. Scientists are also working on the possibility of using Buckyballs as tiny dry delivery system [14]. Fig. 11, 12 (https://en.wikipedia.org/wiki/DNA_nanotechnology)and 13 (https://www.google.com.pk)

Fig. 10: Richard Buckminster Fuller.

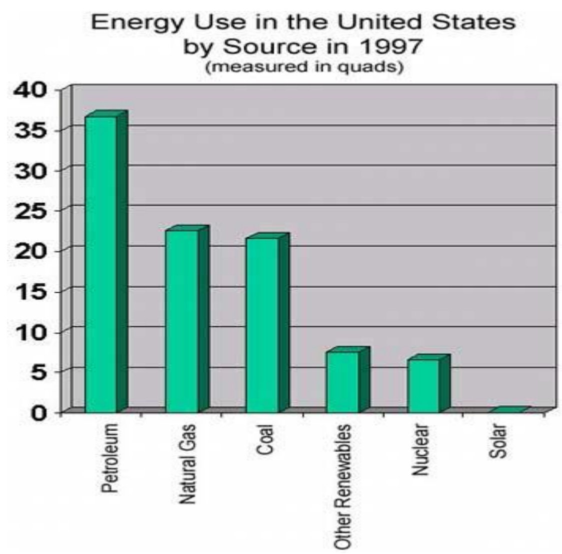

Fig. 11: Energy used in the United States. If the total amount of solar energy that falls on the United States in one year were added to the graph, the line would be 400 feet long.

When you get to the nanoscale, the materials show different properties due to smaller size, quantum mechanics and coulomb blockage. These new properties are controllable with special applications.

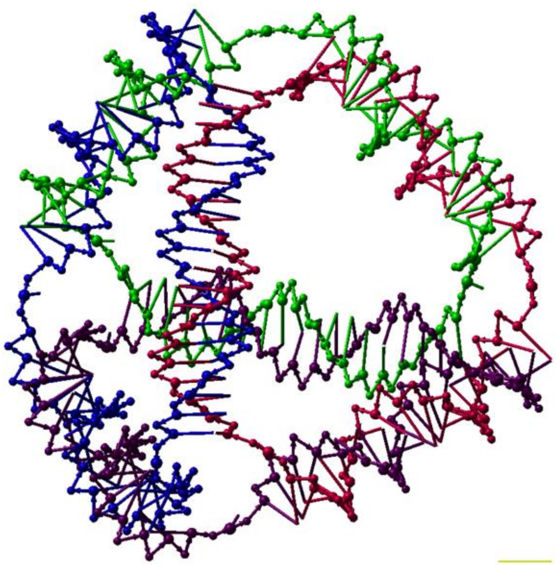

Fig. 12: This DNA tetrahedron is an artificially designed nanostructure of the type made in the field of DNA nanotechnology. Each edge of the tetrahedron is a 20 base pair DNA double helix, and each vertex is a three-arm junction.

The biggest advantage and benefit is drawn when the materials are used at nanoscale. It is because nanomaterials have comparatively larger surface area as compared to the ~~one~~ weight of material in a larger form. This help the materials to become extra reactive chemically (some materials which are used in larger form become reactive in nano type. Secondly, quantum mechanics starts playing a predominantly role in the properties of materials in the nanoscale, affecting the optical and magnetic properties of materials. Nanomaterials be capable of manufactured in one dimension (their surface coatings), in two dimensions (nanowires and nanotubes) and in three dimensions (nanoparticles).

Nanotechnology enables us to develop materials with enhanced or totally novel properties. It is one of the great challenges for humans, in which the control of material at atomic level is possible. Nanomaterials manifest many fascinating properties which may be exploited to produce a variety of structural and non-structural applications. Figs. 14 (http://science.howstuffworks.com/nanotechnology.htm, http://science.howstuffworks.com/nanotechnology2.htm ,http://science.howstuffworks.com/nanotechnology5.htm), 15, 16 (Nanotechnology, a gentle introduction to the next big idea by mark ratner and Daniel ratner), 17 (https://www.researchgate.net/Figure/225896825_fig2_Fig-2-Graphical-representation-of-a-rotaxane-useful-as-a-molecular-switch) ,18 (http://en.academic.ru/dic.nsf/enwiki/282999), 19 (reference on the figure), 20(http://www hellopro.co.uk/fiche_societe_php_images_images_produit_3_3_4_1_Agilent_Technologies-5254-noprofil-1001471-31125-0-1-1-fr-societe.html) , 21, 22, 23, 24, 25 show various examples of how nanotechnology works.

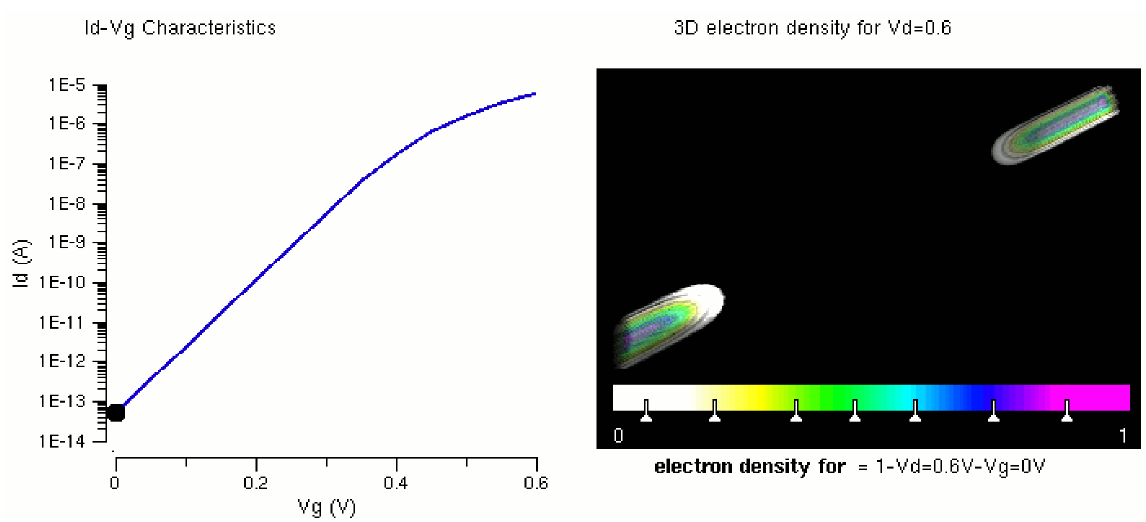

Fig. 13: One of the major applications of the nanotechnology is in the era of nanoelectronics with *MOSFET's* is being made of small nanowires ~10nm in length. Here is a simulation of such a nanowire.

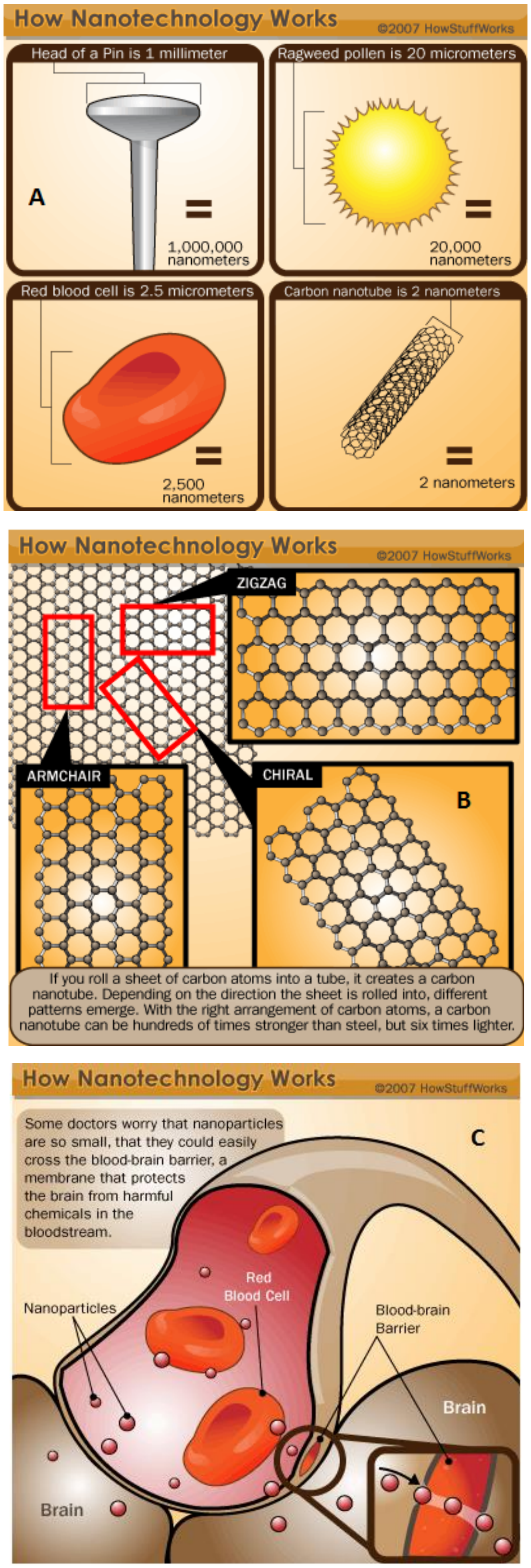

Fig. 14: How nanotechnology works.

Now if we take a one 100 cm cube as an example. Cut it into 50 cm cubes. Continue cutting 16 of 25 cm cubes, 64 of 12.5 cm cubes all have similar properties as the parent cube. If we take gold and keep cutting from cm to mm and from mm to micron level, no change in properties will be noted but a stage will arise when we'll not be able to see this from naked eye. We will need some sophisticated tool like microscope or scanning electron microscope etc. Still all the cubes will have same physical and chemical properties. This according to or existing real world knowledge – The physical and chemical properties are not size dependent. It doesn't matter cubes are from brass, silver, ice or gold.

It is astonishing observation that at nano-scale the color of silver, gold and alloy, Figs**.** 22-24 (links mentioned on the figure), chemical properties and melting point changes. This may be due to the change in the nature of connections amongst the atoms that makes a material e.g. gold at nano-level. These interactions may be averaged at the macro scale. Nano gold does not act as bulk gold. The nano-particles of gold may have different colors depending on their size [15].

Unique Properties of Nanomaterials

At the nanoscale, property of material behaves in a different way; govern by atomic and molecular formulae. Scientists are utilizing the singular property of material at this modest shell to produce raw and thrilling tools and develop in all fields of science and technology. Nanotechnology combine solid state physics, chemical science, electrical technology, chemical technology, biochemistry, biophysics, and materials science. Therefore, a highly interdisciplinary field – integrating in formations and techniques from a broad array of conventional subjects. Some universities started issue degrees in nanotechnology: others regard it as percentage of presented academic areas. Another way, many trained researchers, engineers, and technicians in these fields will be required in the next 30 years. Several predict that nanotechnology is the subsequently technical revolution and yield resulting from it will highly affect all regions of our economy and way of life. It is predictable that by 2016 this exciting field will require 7 million workers globally. The scientists will come from all fields of science and engineering and will comprise those with two-year technical degrees up to Ph.D. in universities and industry [16].

Fig. 15: Early nanotechnologist (Courtesy of Getty Images).

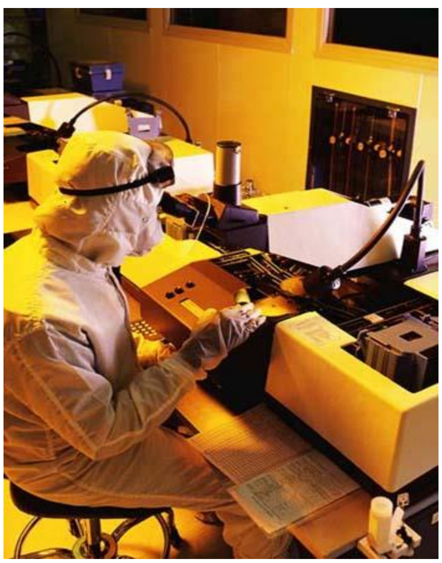

Fig. 16: Modern nanotechnologist (Courtesy of Getty Images).

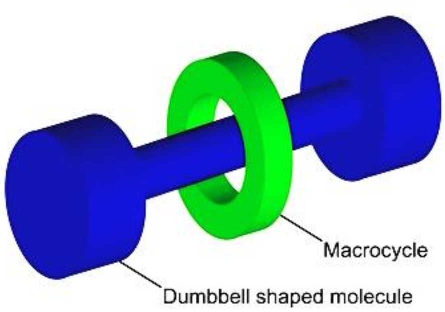

Fig. 17: Graphical representation of a rotaxane, useful as a molecular switch.

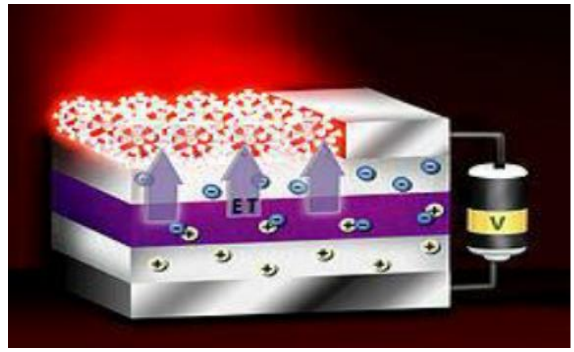

Fig. 18: This device transfers energy from nano-thin layer of quantum wells to nanocrystals above them, causing the nanocrystals to emit visible light.

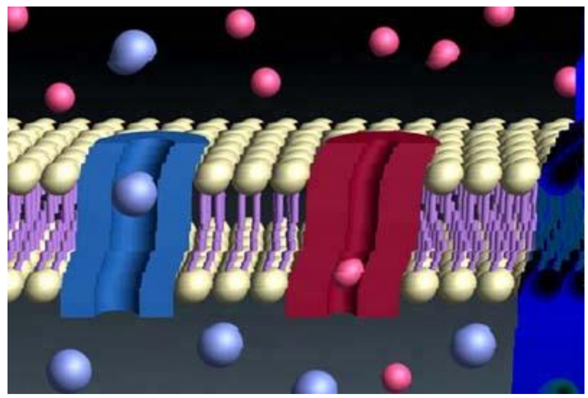

Fig. 19: A computer-generated model of a portion of cell membrane. The light balloons are hydrophilic, and the dark thin strands are hydrophobic. The cylinder structures are channels for moving ions through the membrane. (*From* General Chemistry, *8/e, by Petrucci/ Howard, © Pearson Education, Inc. Reprinted by permission of Pearson Education, Inc., Upper Saddle River, NJ).*

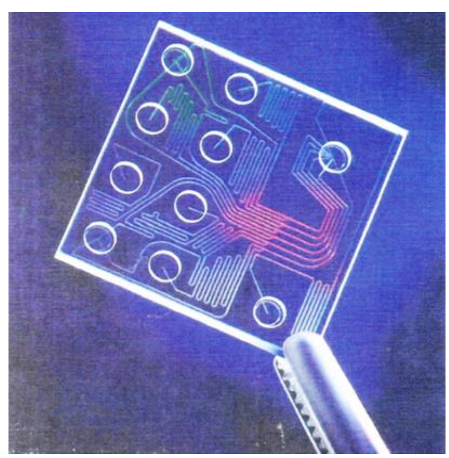

Fig. 20: A lab-on-a-chip (courtesy of Agilent Technologies, Inc.).

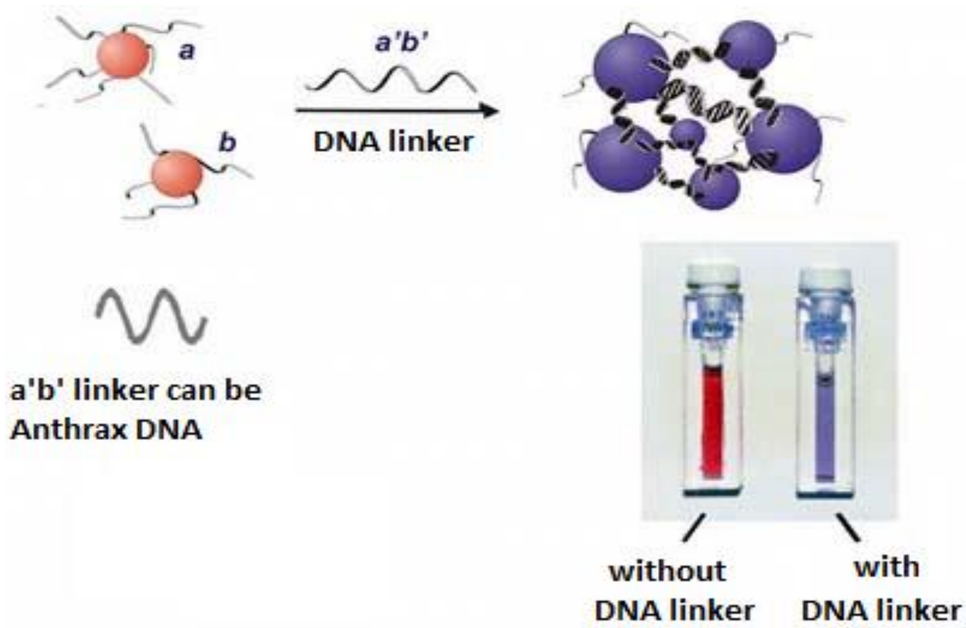

Fig. 21: The upper schematic shows how the nanodots in a colorimetric sensor are brought together upon binding to the DNA target (in this case anthrax). The clustered dots have a different color than the unclustered ones as is shown in the photograph in the lower right-hand corner (*Courtesy of the Mirkin Group, Northwestern University*).

Fig. 22: Silver nanoparticles in solution form (http://nanocomposix.com).

Fig. 23: Gold nanoparticles in solution form (http://nanocomposix.com).

Fig. 24: Alloy nanoparticles in solution form (http://nanocomposix.com).

As such nanotechnology is becoming an active field of research in material sciences. Nanotechnology is growing area covering all aspects of human life sciences, biomedical sciences, and biotechnology. In recent times the main aims of green chemistry are to eliminate or reduce the toxic effect of substance to human healthiness and the environment in the design, progress and accomplishment of chemical processes and products are becoming added and more significant [16, 17]. The use of hazardous chemical and solvents is reduced due to principles of green chemistry researchers avoid the use of such toxic chemicals and solvents they use natural material instead of these chemicals [18, 19]. Due to their exclusive chemical optical and mechanical properties use of nanoparticles is important. Metal nanoparticles become most important due to their massive use in the field of biomedicine electronics photonics catalysis optics antimicrobial activity [20, 21]. Nanotechnology is likely to open innovative ways to compete and avoid disease using atomic scale tailoring of materials. It is a difficult field of research with unlimited future projection. The use of phytochemicals in the production of nanoparticles is a vital process between nanotechnology and green chemistry [22, 23, 24, 25]. As the nano revolution exposed, this is very vital to produce "nano-natural" linked between nanotechnology and green domains of nature. Nanoparticles develops using nontoxic green circumstances is mainly vital to growing concern on the whole toxicity of nanoparticles for technological and biomedical application [26, 27]. Phytochemical have the potential of conversion of variety of chemicals within biological system [27, 28, 29, 30]. For example in soybeans, a high intensity of genistein is present which is act as phytoestrogen and also an antioxidant and has been widely used for the treatment of conditions affected by estrogen levels in the body [31,32]. In tea Polyphenolic flavonoid, of which epigallocatechin gallate (EGCG) is the main constituent, has anticarcinogenic activity [33]. Cinnamon, a general household spice which used for the treatment of diabetes mellitus [34]. While the heavenly medical advantages of substance mixed drinks present inside tea, soya, cinnamon are for from uncertainty, the genuine utilizations of the synthetic lessening force of the horde of chemicals present in herbs and flavors is still in earliest stages. Numerous biotechnological applications, for example, remediation of toxic metals use microorganisms, for example, microbes [35], Yeast [36], for the synthesis of nanoparticles [37] have prepared nanoparticles of gold silver and their alloys by the reaction of the parallel metal ions inside the cells of lactic acid bacteria present in buttermilk. The bacteria [38] and algae [39] have been utilized for the development of gold nanoparticles. Gold nanoparticles can be efficiently synthesized by customarily chemical and physical method. Nevertheless, these methods strongly depend on severe reaction conditions, for example, violent agents like sodium borohydride, hydrazinium hydroxide, cetyltriethylammnonium bromide, and destructive solvent system to environment and ecology, higher temperature and higher pressure have been applied. To seek after a sound life and space, it is basic to build up a perfect engineered approach utilizing the idea of "green chemistry" to acquire nanomaterials focused for various applications, especially in biomedical fields. In present years the AuNPs can be synthesized by using plants-medicated biological route is picking up significance because of its simplicity and eco-friendliness. Recently, plant-mediated biological synthesis of nanoparticles is gaining value due to its novelty and eco-friendliness. In recent times AuNPs synthesized by the help of plants extract such as Terminalia catappa [40] tea [41] lemongrass [42] has been reported. Along a more primal point, it would be attractive to inspect the nature of nanoparticles formed using extracts from different sections of the plant [43, 44]. Products made from nanoparticles have substantial improvement in the following properties:

1. Mechanical properties: strength, hardness, modulus and dimensional ability
2. Less permeability for water, hydrocarbons and gasses
3. Less smoke emissions and flame retardant
4. Chemical and water resistant
5. Wear resistant
6. Erosion resistant
7. Corrosion resistant
8. Chemically very active
9. Electrical conductivity
10. Optical clarity or different color at Nano level.

Three examples of exciting properties when particle gets transformed to nano-scale:

1. Copper usually stop light in large dimensions but at nano-scale level turn into transparent.
2. Gold is solid at room temperature but at nano scale level it transformed into liquid.
3. Silicon is usually insulator but it behave as a conductor at nano scale level

Production of Nanomaterials

There are two types of approach are used in the formation of nanomaterials that is; top-down and bottom-up. The second approach *i.e*. bottom-up has advantageous over the top-down approach because in this technique one has a better chance of producing more homogenous chemical composition, and less defects in the end product *i.e*. better short- and long-range ordering. We will describe both of them briefly [45, 46].

Top-down approach

In top-down approach the nanoparticles are produced from bulk material by mechanical means, chemical method etc. This may simply that in a top down synthesis technique; the nanostructures are synthesized by design out crystals planes (by removing crystal planes) which are previously there on the substrate. So a top-down approach can be view as an approach where the building blocks are detached from the substrate to form the nanostructure. In short, this approach dictates that you start with bulk structures and decrease the size. The advantages of the top-down method are the cost effective, better scalability and in general more uniformity of the product. Top-down method typically provides better control, but is limited to “countable” number of structures, though this number may be billions and billions. Thus in top-down, the structure is cut out from a bigger piece “manually” or by a kind of self-structuring process. All current microelectronics parts or components are fabricated using this approach.

Fig. 25: Biomedical Applications of AuNPs (http://benthamscience.com).

Bottom-up approach

The production by the bottom up method means that the nanostructures are produced through stack atoms onto each other on a substrate, which give rise to crystal planes. The crystal planes more stacked into each other, to make possible the production bigger stack of the nanostructures. A bottom-up approach can thus be view as a production approach where the building blocks are added onto the substrate to produce the nanostructures. So, it may be said that the bottom up method is synthesis (chemistry), while top down method is mainly nano-fabrication ("milling"). Generally speaking, in bottom up method one starts from homogeneous solution or gas and build up the nano-particle or nano-layer, nano-wire or whatever. Thus in bottom-up method the structure (not necessary on the surface and not necessarily crystalline) is created from smaller building blocks. Chemical synthesis of nanoparticles is a typical example of it. There are 5 widely known methods used by scientists to produce the nanomaterials [14]:

1. Sol-gel Synthesis,
2. Inter gas Condensation,
3. Mechanical Alloying or High Energy Ball Milling,
4. Plasma Synthesis and
5. Electrodeposition.

In bottom up approach the sol-gel synthesis is more popular. It is cost effective and environmental friendly. It has many advantages compared to the other methods. For example, this method can be used to produce nanoparticles of both metals and ceramics at low temperature in the range of 65-300 ^{O}C as compared to 100-3600 ^{O}C in conventional techniques. The advantages of this method are:

1. Commercially viable, large quantities may be produced
2. Relatively cheaper
3. All materials may be synthesized
4. Two or more materials may be synthesized simultaneously
5. Highly homogenous alloys or composites may be produced
6. Purity level up to 99, 99 may be obtained.
7. Composition may be tailored very accurately
8. The process make it possible to synthesize at atomic level
9. Precise control of the microstructure is possible
10. The final product may have desired physical, chemical and mechanical properties

The so-gel technique is very suitable for production of metal oxides with the hydrolysis of reactive metal precursors, resulting in corresponding hydroxides. Condensation of the hydroxide molecules by elimination of water lead to the production of a network of metal hydroxide. When the hydroxide species are linked in one network like structure, gelation is achieved and a dense porous gel is obtaining [46]. Elimination of the solvents and suitable drying of the gel results in an ultrafine powder of the metal hydroxide. The final step in this procedure is the heat treatment of hydroxide, which lead to the preferred ultrafine powder of metal oxide [47, 48].

The benefit of the sol-gel practice over other wet chemical synthesis is to facilitate scaled up to contain industrial scale production. Furthermore, surfactants or templates are not necessary to contain industrial scale production. Additionally, surfactants or templates are not essential [49]. A group of researchers working at COMSATS Institute of Information Technology, Islamabad, Pakistan modified sol-gel method to synthesize high purity nanoparticles of ferrites without water and surfactant called WOWS (Without water surfactant) method. We would like to describe it in some detail.

In the WOWS sol-gel technique, stoichiometric amounts of nitrates of the various preferred elements like $Fe(NO_3)_3.9H_2O$ or $Zn(NO_3)_2.6H_2O$ for the compositions which are dissolved in ethylene glycol. The molar ratio of ethylene glycol to metal salts is kept back generally at 14:1 as this ratio helped the salts to dissolve homogeneously. The solution is stirred for say 30 min at room temperature to get homogeneous solution. Temperature of the solution is then raised gradually to 100^{o}C with continuing stirring until the substantial gel is obtained. The temperature of the gel is then raised to 300^{o}C resulted auto combustion and gel is burned gradually then changed into fine powder.

In the WOWS sol-gel technique, water and other different chemicals avoided which results in improved purity. It is less time consuming and simple to handle as compare to co-precipitation and other chemical method. It can be easily used for industrial scale of ceramic or metallic nanoparticles. The WOWS sol-gel technique is step further simplification of US patented Pechini method [50]. In Pechini technique, metal salts are dissolved in aqueous solution of citric acid as chelating compound then ethylene glycol is added for gelation of the mixture, while in WOWS sol-gel method, metal salts are directly dissolve in ethylene glycol. More processing of these techniques is nearly similar.

The planned reaction for all the nitrates with ethylene glycol may be similar to following:

Ethylene Glycol + Iron Nitrate (Hydrated) ——— $[Fe(OH)_2] (C_2H_2O_2)_2. X.H_2O + NO + HNO_3$

The advantages of this method are

- simply shape materials into complex geometries in a gel state
- Gel does not take long period of time to dry
- Phase is always pure in this method
- Easily phase reproducibility
- Have low temperature sintering capability
- Simple, economic and effective method
- Easy to perform

This method is being used by many researchers [50, 51, 52, 53] to produce different ferries and other materials. So far we have discussed chemical methods. But another very frequently reported method in literature is biosynthesis of nanoparticles for medical applications. Now we would like to describe this in the following pages.

Synthesis of Nanoparticles by biological methods

Nanoparticles can be synthesized chemically and biologically. The chemical method has a much adverse effect caused by the occurrence of toxic chemicals immersed on the surface of nanomaterials. Biological synthesis of nanoparticles is an eco-friendly cost efficient and nontoxic technique by microorganism [54], Enzyme [55], Fungus [56], Plants or plants extract [57, 58], for the production of nanoparticles. The use of these eco-friendly methods for production of nanoparticles is developing into a significant branch of nanotechnology particularly gold nanoparticles which have many applications in diverse fields of science [59-61].

Mechanism of Biosynthesis

Biosynthesis of nanoparticles by use of microorganisms and plants is a green environment-friendly technology various microorganisms and plants are used for the production of metallic nanoparticles like platinum, silver, iron, titanium, cadmium, gold and metal oxides such as zinc oxide, etc. The plants used are Zizyphus Mauritania, Olive, Sesbania grandiflora, Pogostemon benghalensis, Rosa indicia, Ocimum sanctum [62]. These microorganisms comprises of fungi, bacteria, actinomycetes, and algae. The synthesis of nanoparticles possibly extracellular or intracellular [63].

Intracellular synthesis of nanoparticles

In this process transportation of ions occur into microbial cells (fungi, bacteria) to form nanoparticles in the existence of enzymes. The nanoparticles produce within the organism are smaller in size as compared to nanoparticles formed outside the cell [64].

Extracellular synthesis of nanoparticles

A nanoparticle formed outside the microbial cell (fungi, bacteria) has another application as compare to inside formed nanoparticles. Since, it is invalid of unimportant adjoining cellular mechanism from the cell. Mostly plants and fungi form nanoparticles outside the cell due to their huge secretory components, which is responsible for reduction and capping of nanoparticles [65].

Microbes for production of nanoparticles

Both types of multicellular and unicellular (fungi, bacteria) formed inorganic material either inside or outside the cell [66]. The ability of plants and microbes like bacteria and fungi to manage the formation of metallic nanoparticles is engaged in the search of new materials.

Synthesis of nanoparticles by plant extracts

Nanoparticles can be prepared through chemical or physical methods, but these procedures have many adverse effects on environment. Nanoparticles synthesis can be carried out through different chemical and physical procedures, other than the use of such procedures are risky in one or the other way. The photosynthesis of nanoparticles is emerging at the convergence of nanotechnology and biotechnology. Because of a growing required to form environmentally benign technologies in material synthesis, it has received much concentration [67]. This has forced the scientists to the formation of the nanoparticles using this itinerary that permit better management of shape and size for different applications of nanoparticles in different fields [68].

Silver and Gold Nanoparticles

Silver nanoparticles show a very effective antimicrobial activity against viruses, bacteria and other eukaryotic microorganisms [69, 70]. Silver nanoparticles are most widely used nanomaterials in textile industries, also used in sunscreen lotions and also for water treatment etc. [71]. Green synthesis of silver nanoparticles also reported by different studies, they can be synthesized by using plants for example Azadirachta indica [72], Capsicum annum and Carica papaya [73]. Fig. 22 indicates the different colors of silver nanoparticles in solution form.

Gold nanoparticles (AuNPs) are used for identification of protein connections and in immunochemical studies. In DNA fingerprinting they used as lab tracer to identify the presence of DNA in a sample. For detection of aminoglycoside antibiotics like streptomycin, gentamicin and neomycin they are also used. For the finding of cancer stem cells, Gold nanorods are being used and also valuable for cancer recognition and for identification of different bacterial classes [73, 74]. Fig. 23 shows the different color of gold nanoparticles.

Alloy nanoparticles having structural property that are much dissimilar from their bulk material form [75]. The electrical conductivity of silver is highest between metal fillers and unlike many other metals; the oxides of silver have better conductivity [77]. Silver flakes are most commonly used. Bimetallic alloy nanoparticles property is to determined by both metals and show more advantages over ordinary metallic NPs [77]. Magnetic: like Fe_3O_4 (magnetite) and Fe_2O_3 (maghemite) are Magnetic nanoparticles known to be biocompatible. They have been actively investigating for targeted cancer treatment (magnetic hyperthermia), stem cell sorting and manipulation, Guided drug delivery, Gene therapy, DNA analysis, and magnetic resonance imaging (MRI) [78]. Fig**.** 24 indicates different colors of alloys NPs.

Applications in Medical diagnostics

Nanomedicine has wonderful scenario for the betterment of the analysis and handling of human diseases such as malignant neoplastic disease. The role of microbes in the biosynthesis of nanoparticles is an environmentally acceptable process. Nanotechnology has possiblities to revolutionize a broad array of tools in biotechnology so that they are more personalized, portable, more inexpensive, more dependable, and easier to distribute.

Gold nanoparticles

One of the most interesting fields of research is the use of AuNPs in the recognition and treatment of cancer cells [78]. The method which is used presently for cancer cell detection and treatment is costly and had much adverse effect on the body. The method which is uses AuNPs for cancer cell detection and treatment; is supposedly to an inexpensive way to target just cancerous cells and healthy cells stay untouched [79]. Nanoparticles have extremely small size (<10 nm). They have a great surface to volume ratio, and have very different physical and chemical properties from those of the similar material in the bulk form. These properties let in improved or hindered particle aggregation depending on the type of surface modification, enhanced photoemission, high electrical and high-temperature conductivity, and improved surface catalytic activity [80, 81]. AuNPs have characteristic optical properties in the visible region, due to surface Plasmon oscillation of the electrons [82]. AuNPs are used as immunostaining maker particles for electron microscopy, and nucleic acid hybridization and as chromophores for immunoreactions in bioscience and medical fields [83, 84]. Strong absorption of AuNPs can also be used for the colorimetric detection of analytes by measuring changes in the refractive index of the environment of the AuNPs caused by adsorption of target analytes [85]. For DNA labeling, the AuNPs is used and also for proteins detection of biological targets with improved sensitivity AuNPs are primarily utilizing in molecular diagnostic applications and imaging [86, 87]. Finally, AuNPs used to build up sensitive electrochemical detection methods which can be coupled to enzymatic assays. Fig. 25 shows various medical applications of AuNPs.

Diagnostic Applications

In the recent time, nanomaterials have focused more significance because of promising applications in diagnostic imaging, biosensing, cancer therapeutics and targeted drug delivery [88]. The capabilities emerging by gold nanoparticles (AuNPs) rely upon their morphology and dimensions [89, 90] and therefore, controlling their size and shape remains the principal requirement. In common, size and shape controlled AuNPs are synthesized chemically in the presence of reducing agents like trisodium citrate, sodium borohydride and some thiol functionalized agents which might obstruct the surface modifications and functionalization of agents for fastidious applications [91, 92]. Generally speaking, size and shape controlled AuNPs are incorporated unnaturally within the sight of lessening specialists like trisodium citrate, sodium borohydride and a few thiol functionalized operations which might hamper the surface alterations and functionalization of specialists for specific applications.

Biogenic syntheses of AuNPs

The biogenic formation of AuNPs is famous and there are stories in the literature in which a mixture of microbes for example fungi, algae, bacteria, and plants are used. Metal NPs including AuNPs are known to further degradation of dyestuffs. AuNPs are identified to catalyze a lot of reductions [93]. Environmental hazards by the liberation of dyes from textile and other industries are view to be major reasons of business because of their impact on human health. In this manner, improvement of fresher advances for degradation of colors previous to their discharge into the environment will consistently be vital in the current day connection.

Why AuNPs are unique?

Among many metal NPs, gold nanoparticles (Au NPs) have vast application in diverse fields like life sciences, targeted drug delivery, finding of microbes, imaging, and therapy, medical diagnoses [94, 95]. Recently, procedures for “Green” synthesis include consumption of nonhazardous chemicals, bio-degradable polymers, and environmental giving solvents for example plant extracts [96, 97]. The significant advantages of using plant extract as biogenic source for the formation of metal NPs are easily accessibility of these plants, protocol pertinent at room temperature and pressure etc. The chemical and physical methods use for AuNPs formation which is expensive and has a poisonous effect on the environment [98]. With the expanding concentration for AuNPs, enhancement of clean, non-harmful and eco-accommodating procedures of their union has turned into a testing issue for scientists [93, 99].

In a food chain plants are the first level procedures by high biomass formation in the terrestrial environment. They change over just about 75% of light vitality into chemical vivacity, thus the development of plants and plant items as renewable property to integrate nanoparticles will be friendly advancement in material combination. Also, phyto-intercede amalgamation is more advantageous than microbial course which required elaboration and high-cost downstream handling [99]. Numerous earlier studies have depicted that biomolecules as protein, phenols, and flavonoids not just assume a part in diminishing the particles to nano size, additionally assume an essential part of the topping of nanoparticles [100]. In the earlier period, specialists from globally include effectively investigated different ethano-naturally and modernly essential plant elements for the era of various nanoparticles [101]. The size and state of biosynthesized nanoparticles be able to well-tuneable by modifying diverse parameter of response medium, such as, temperature, pH, the convergence of metal particle and the stoichiometric extent of a reaction mixture [102]. Dynamic ingredients present in plant extract, for the most part, go about like reducing and stabilizing agent, it likewise gives uncommon surface attributes to the nanoparticles. Couropita guianensis Aubl has a place with the family Lecythidaceae was regularly depicted as gun ball tree generally utilized as a part of conventional society medication for the treatment of an expansive range of illnesses. It claims spectacular antibacterial, antifungal, antibioflim, atimulant, germicide and pain relieving qualities. In particular, the organic product items can utilized to treat chilly and stomach throb, juice produced using the leaves were utilized to heal skin related ailments furthermore it was only used to cure intestinal sickness in shamans of South America [103].

Recently fabricated nanoparticles get massive attention because of their unique physiochemical properties especially AuNPs are most promising nanomaterial for biomedical and biological application due to their unique properties like dispersity, controllable size, stability, strong adsorbing capacity, biocompatibility [104]. Additionally AuNPs groups superb optical property and provide a spectral shift after fluctuating their size and shape, subsequently, they are utilized as a part of biolabeling, biosensors, drug conveyance, tissue/tumour imaging, photograph warm treatment and immunodiagnostics [105]. There are many ways to achieve metal nanoformulations like sonochemical [106] warm disintegration, microwave illuminations [107] electrochemical removal [108] synthetic decrease [109] and as of late green union. Unluckily, a hefty portion of these normal techniques were preserving by the utilization of perilous chemicals, low material change, high vitality necessities and troubles in decontamination of the real contaminants [110]. So that’s why there is a growing need to build up a cost-effective and environment-friendly and associated with life form procedure for formation of nanoparticles. Biological techniques by means of unicellular or multicellular organism for the synthesis of nanoparticles have been suggested as feasible easy eco friendly and alternative to chemical and physical procedures. Large scale industrial level production of nanoparticles can be done by using biosynthesis [111]. Unusually biological organisms as bacteria, fungi, algae, yeast and plants were extensively studied for their capability to form metal nanoparticles for a variety of pharmacological applications.

Recently one of the authors has successfully synthesized the gold nanoparticles for the first time from $AuCl_3$ and the Fortunella japonica (Fig. 26) extract and the Tagetes erecta Linn (Fig. 27) extracts which will be reported elsewhere [112].

Fig. 26: Fortunella Japonica Fruit (http://www.fruitipedia.com/round_kumquat_Fortunella_japonica.htm).

Fig. 27: Tagetes erecta Linn (http://www.123rf.com).

To conclude it may be said that uses of nanotechnology are enormous. Nanotechnology may be comfortably used in commerical products of cosmetics, food packing, medicine, industry and military materials. The size of appliances may be reduced by the use of nano-materials e.g. Cell phones screens etc. Furthermore cement, steel, wood, glass and coating industires, nano-materials are increasingly finding or capturing a permanent place.

The energy requires per day in the world come from oil, coal, gas, biomass, fusion and hydrothermal assets. Our necessities of energy are rising gradually. By 2050 it is expected that, our energy obligation will rise double as we are consuming now. Hence we requires novel source of energy to meet our necessities. Renewable energy source are solar, wind, geothermal and hydrothermal etc. on a daily basis 165,000 TW of solar power hit the surface of earth. We require cost effectual and competent solar energy collection, exchange, storage space and supply. Current solar panels are costly and they have 25% energy transformation efficiency. Solar energy is accessible in presence of Sunlight but appropriate storage can supply energy for use in dark. For solve future energy issues, we need advancement in the area of energy transformation, storage and energy save. Utilization of energy can be compact by improved insulation, use of light and strong materials in the transportation region. Only 5% of electrical energy can be transformed into light by the help of currently light bulb. Solar cells obtainable in market having competence 15-20 %.

It is also expected that carbon nanotubes transistors might change silicon transistors in computers. Carbon nanotubes consist of pure carbon having a hollow cylindrical shape and diamter about a nanometer. This will decrease the size of the microprocessor significantly. Nano-rods have less consumption of electricity and less heat emission. It is up in coming technology that may play an important role in the displaying techniques. Another most promising use of nanomaterials is its application in medical diagnostic and treatments which will bring a tremendous change in the medical treatment techniques.

It is once again reiterated that the research on nanomaterials should be funded in developing countries so that they can have their share in the coming scientific revolution based on nanotechnology.

Applications of Nanotechnology

Slowly but surely Nanotechnology is finding application in a number of industrial products, in medicines and in environmental field. Prof. M.H. Fuleker in his book, "Nanotechnology and Applications" [113] has mentioned the following fields where nanotechnology is already playing a significant role: (1) Consumer Electronics and Computing, (2) Chemical and basic materials, (3) Pharmaceutical and medical products, (7) House cleaning products, (8) Paints, Varnishes & Coatings, (9) Chemistry (tailor-made catalysts), (10) Information and Communication technology (nano-electronic), (11) Biomedical Applications (e.g., Lab-on-a-chip, bio-sensors, medical imaging, Prostheses

& Implants, drug delivery devices), (12) Environmental remediation technology, (13) Energy capture & storage technology (e.g., Solar cells, batteries, fuel cells, fuels & catalysts), (14) Agriculture (e.g., sensors, seed improvement), (15) Food (anti-bacterial powders, pathogen, contaminant sensors, environmental monitors, remote sensing and tracking devices), (16) Military technology, (17) Textiles, surface furnishing and lubricant agents, etc. Figs. 28-50, show many pictures covering most of the topics mentioned above.

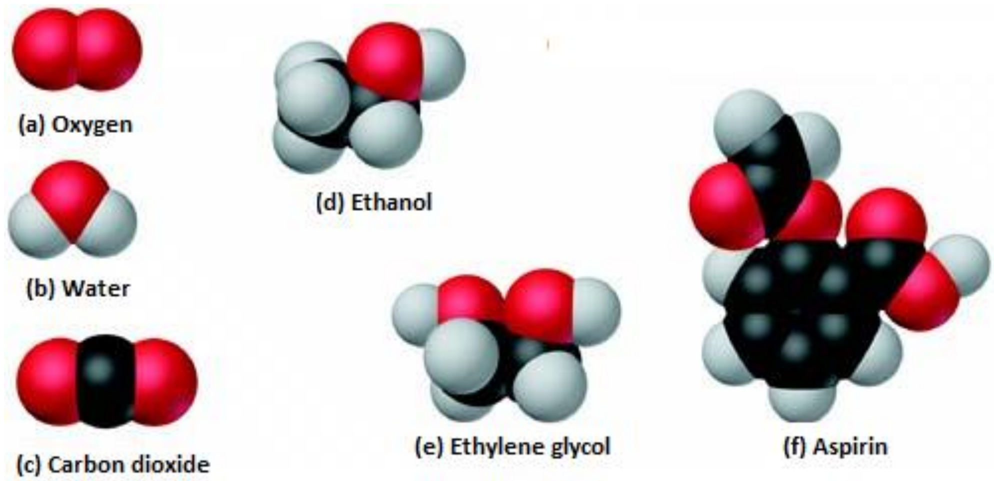

Fig. 28: Models of some common small molecules. The white, grey and red spheres represent hydrogen, carbon and oxygen, respectively. (From *Chemistry: The Central Science*, 9/e, by Brown/LeMay/Bursten, © Pearson Education, Inc. Reprinted by permission of Pearson Education, Inc., Upper Saddle River, NJ).

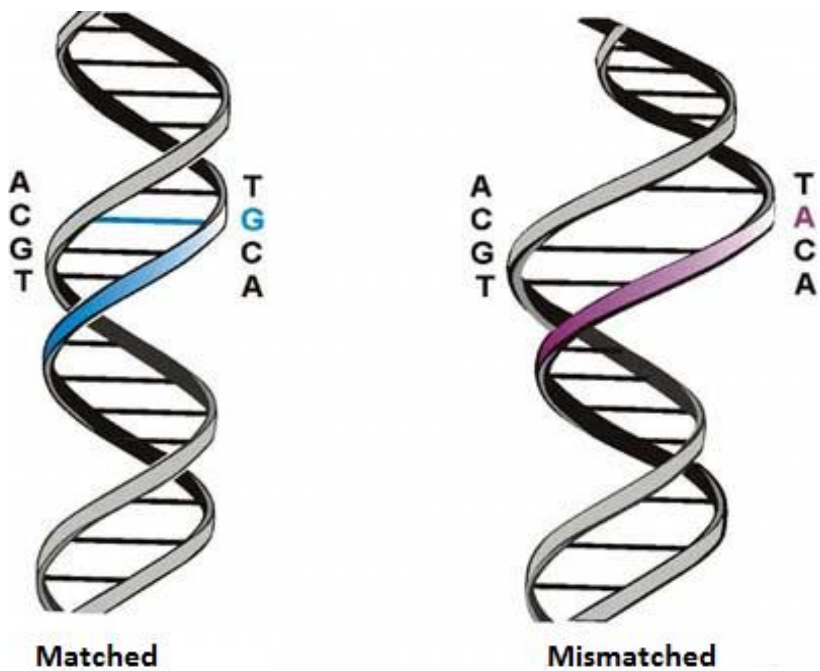

Fig. 29: Schematic of the DNA hybridization process. The "matched" side shows how a DNA strand correctly binds to its complement and the "mismatched" side shows how errors can prevent binding (*Courtesy of the Mirkin Group, Northwestern University*).

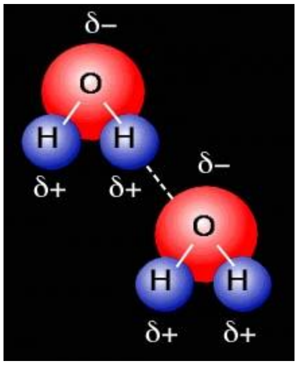

Fig. 30: Molecular binding of two water molecules. The symbols δ+ and δ– denote positive and negative charges, respectively (*Courtesy of the Advanced Light Source, Lawrence Berkeley National Laboratory*).

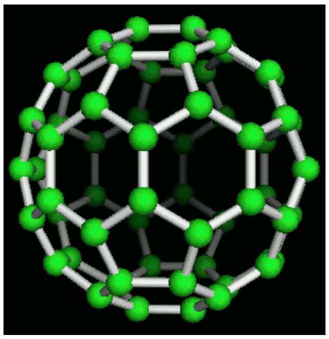

Fig. 31: Rotating view of C_{60}, one king of fullerene.

Fig. 32: A molecular model of a segment of the polyethylene chain. This segment contains 28 carbon atoms (dark), but in commercial polyethylene there are more than a thousand carbon atoms per strand.
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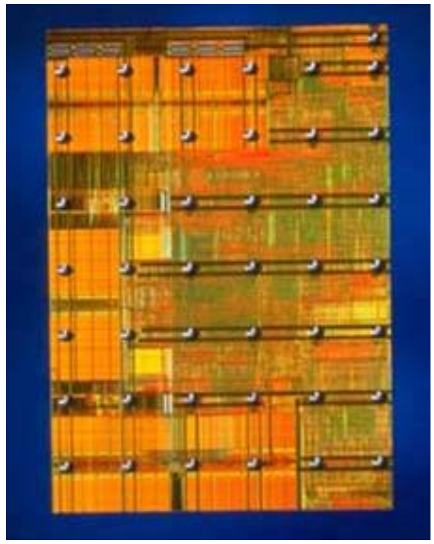

Fig. 33: A current CMOS chip surface (courtesy of Tom Way/IBM Corporation).

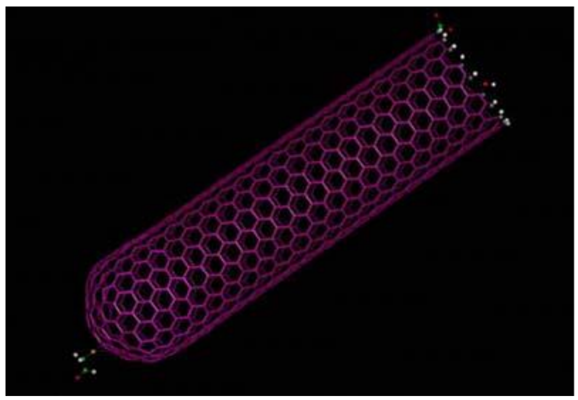

Fig. 34: A single walled carbon nanotube (courtesy of the smalley group, Rice University).

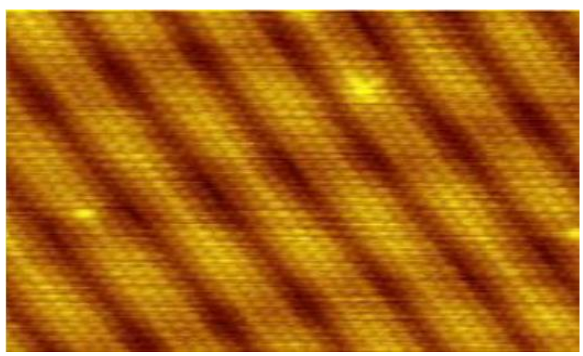

Fig. 35: Image of reconstruction on a clean gold (100) surface, as visualized using scanning tunneling microscopy. The positions of the individual atoms composing the surface are visible.

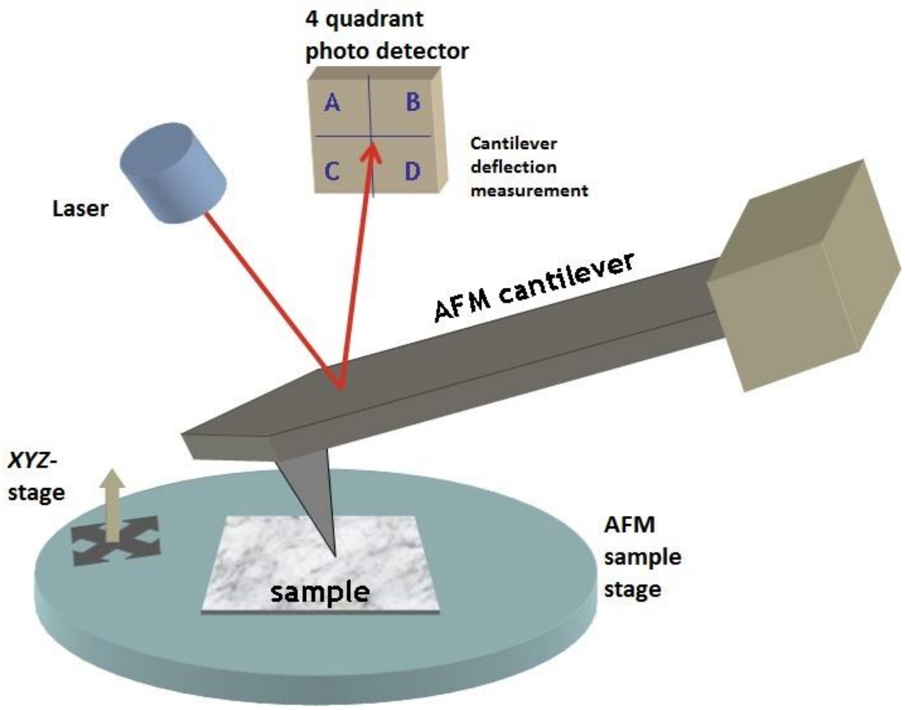

Fig. 37: Typical AFM setup. A microfabricated cantilever with a sharp tip is deflected by features on a sample surface, much like in a phonograph but on a much smaller scale. A laser beam reflects off the backside of the cantilever into a set of photoelectors, allowing the deflection to be measured and assembled into an image of the surface.

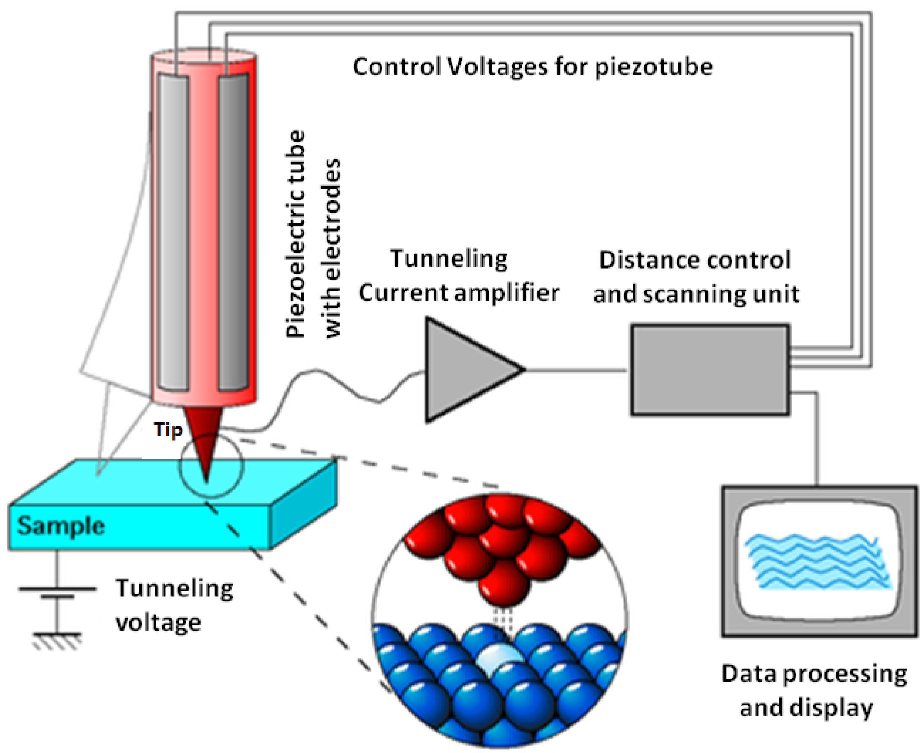

Fig. 38: Schematic view of an STM.

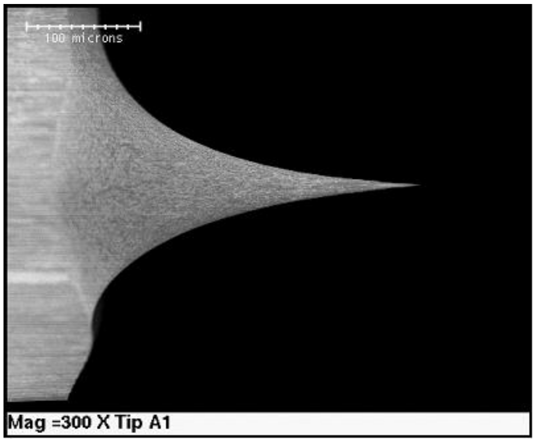

Fig. 39: An STM tip made of tungsten (courtesy of the Hersam Group, Northwestern University).

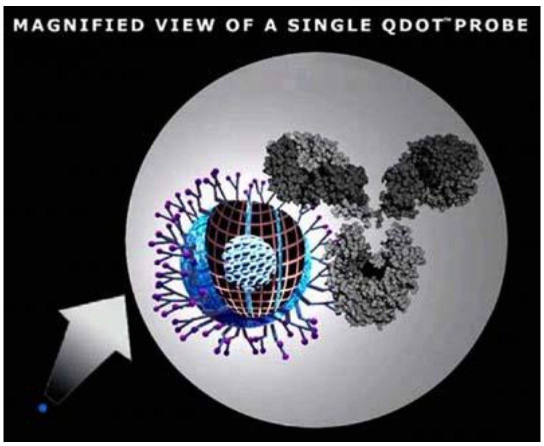

Fig. 40: Schematic of Qdot probe (courtesy of Quantum Dot Corporation).

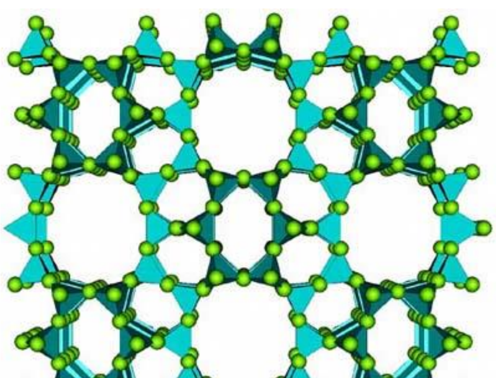

Fig. 41: A chemical model of a complex zeolite structure. Notice the differently sized holes that represent channels and galleries (courtesy of Geoffrey Price, University of Tulsa).

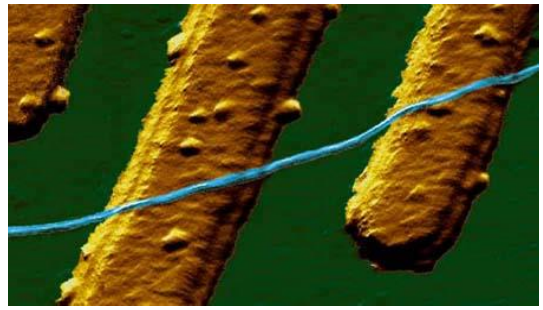

Fig. 42: Two electrodes made using E-beam lithography. The blue structure is a carbon nanotube (courtesy of the Dekker Group, Delft Institute of Technology).

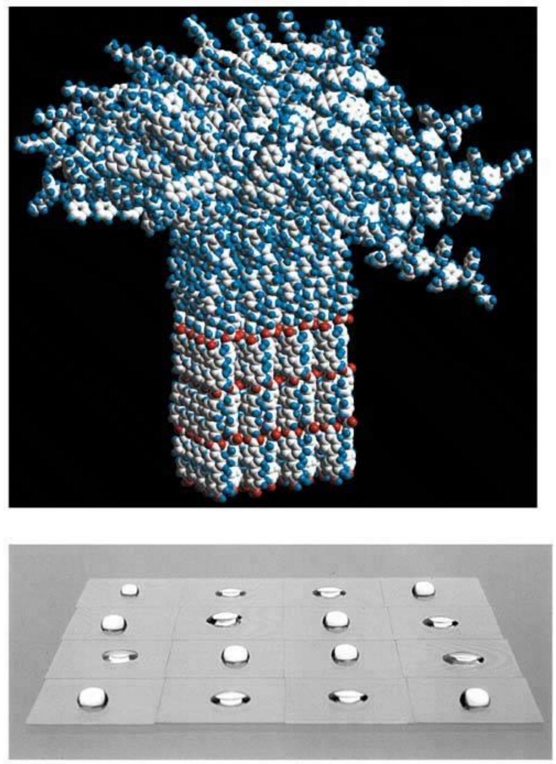

Fig. 43: Molecular model (top) of a self-assembled "mushroom" (more correctly a rodcoil polymer). The photograph (bottom) shows control of surface wetting by a layer of these mushrooms (*Courtesy of the Stupp Group, Northwestern University*).

Present Position of Nanotechnology

Allhoff, Lin and Moore [10] have discussed the current State of Technology. “They have discussed how is nanotechnology being research crosswise the world and what is the present direction of nanotechnology research? They have critical point out that understanding science of nanoscale interactions is tremendously significant to the progress of nanotechnology as these connections comprises one of the major fields of research in the area of nanotechnology. The laws of physics operational on objects at the nanoscale combine classical mechanics which govern the interactions of very tiny things. Most of the elementary laws of nature operating at this level are famous other than science at this scale is very tricky. Quantum Mechanics can clarify the interactions of very small things and works at nanoscale". [10].

"Nanotechnology is nano focusing on the formation, appreciative and the use of material at the nanoscale or nanomaterials. The material which used in history has clearly identifies the technology of the age, e.g. Stone Age, steel (iron) age, Bronze Age etc. In nanoscale materials, many atoms reside on the surface of the material and, therefore, the surface to volume ratio is quite large. It can radically alter the property of the material. Another valuable feature of nanotechnology is the modeling of nanoscale devices, materials and interactions. The larger the system being modeled, the more problematic the condition will be and as a result its results will be far from physical reality".

Modern modeling system which are used to predict the performance of nanoscale systems all rely upon the atom as their elementary unit (in quantum chemistry, the electrons is the fundamental unit).

Er. Rakesh Rathi has summarized all the recent developments in Nanotechnology, [13], e.g., New Biomedical Device for monitoring hip implant healing, Laser-based method for clearing grubby nanotubes, nano-robotic arms to operate within DNA sequence, use of butterfly wings as templates for photonic structures, nanoparticles to monitor tumour growth, Samsung's 50-nano memory chip, scanning photoionization micros copy, high efficiency solar cells, positioning carbon nanotube, nanoscale electronic materials, nanowires detectors, bistable nanoscrites, smart paper, chemical vapour deposition for smaller nano structures, new sensors based on reduction of the size of multi-layer nanoshells, atomically modified rice, nanoscale thermometers, nanoroboties, nanoparticle drug delivery method to replace eyed drops, nanotube coating for ice-free windscreens, spine control technique for sorting carbon nanotubes by length, smelting out nanoedges, improvement of full efficiency by alumina or aluminum oxide particles, textiles, thermal nanometer, super-hard nanocrytalline heat-resistant iron, nanoworms for targeting tumours, mass-production of turntable magnetic nanoparticles, agriculture and food processing, water purifiers, nano food packing etc. etc.

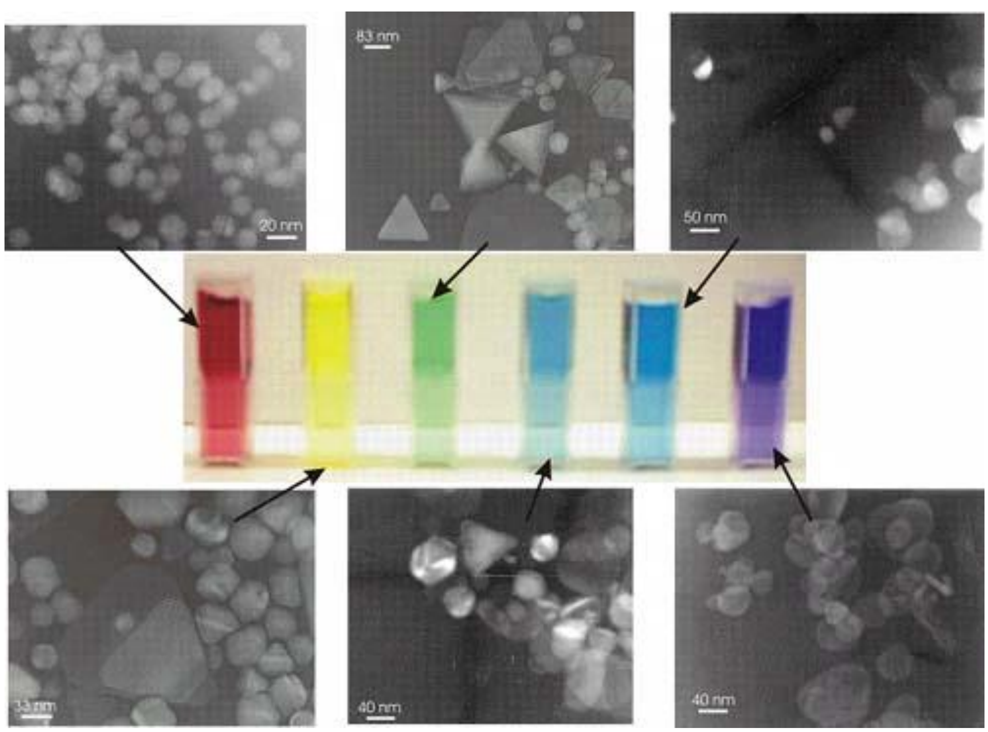

Fig. 44: Nanocrystals in suspension. Each jar contains either silver or gold, and the color difference is caused by particle sizes and shapes, as shown in the structures above and below (*Courtesy of Richard Van Duyne Group, Northwestern University*).

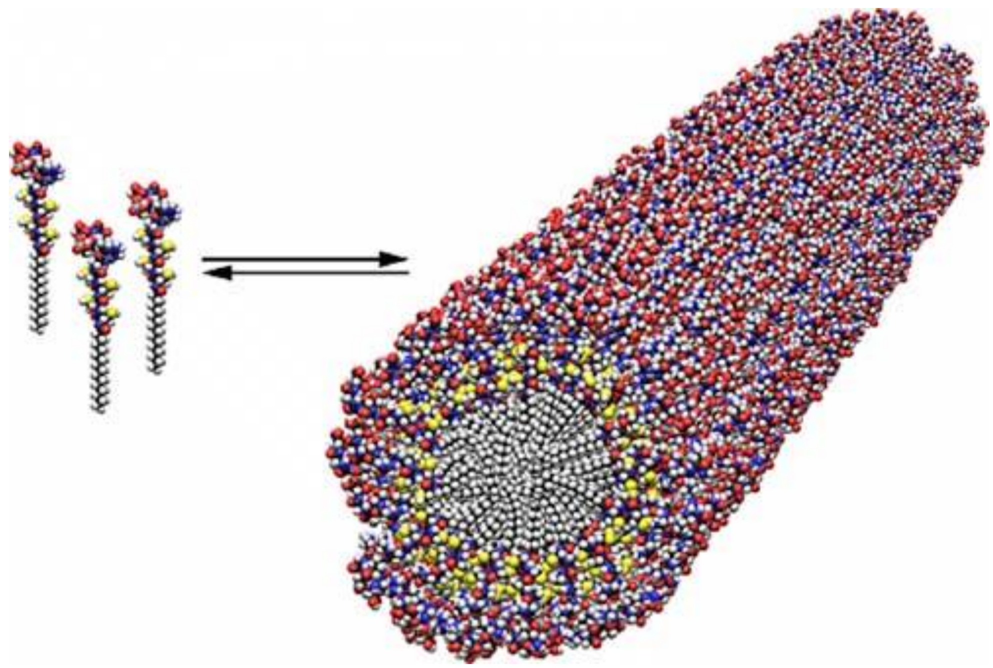

Fig. 45: Self-assembled molecular template for an artificial bone. The long rod self-assembles from the small molecule components and natural bone tissue forms on the outside edge (*Courtesy of Stupp Group, Northwestern University*).

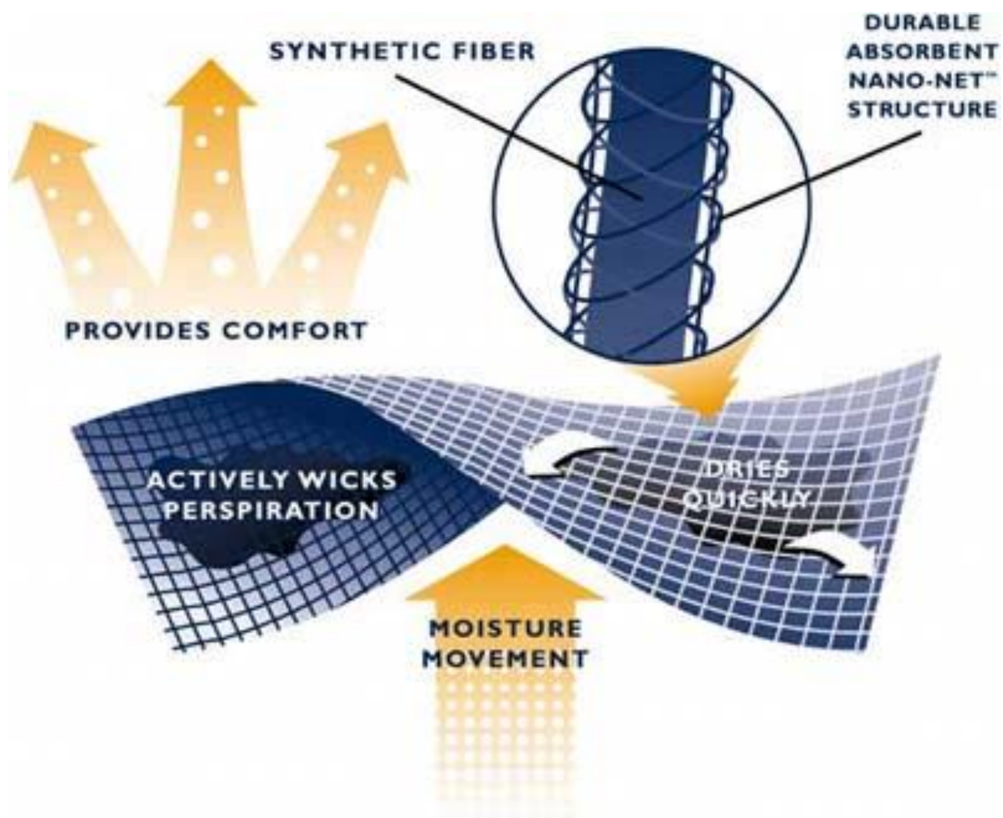

Fig. 46: Nano-Dry (Image courtesy of Nano-Tex, LLC).

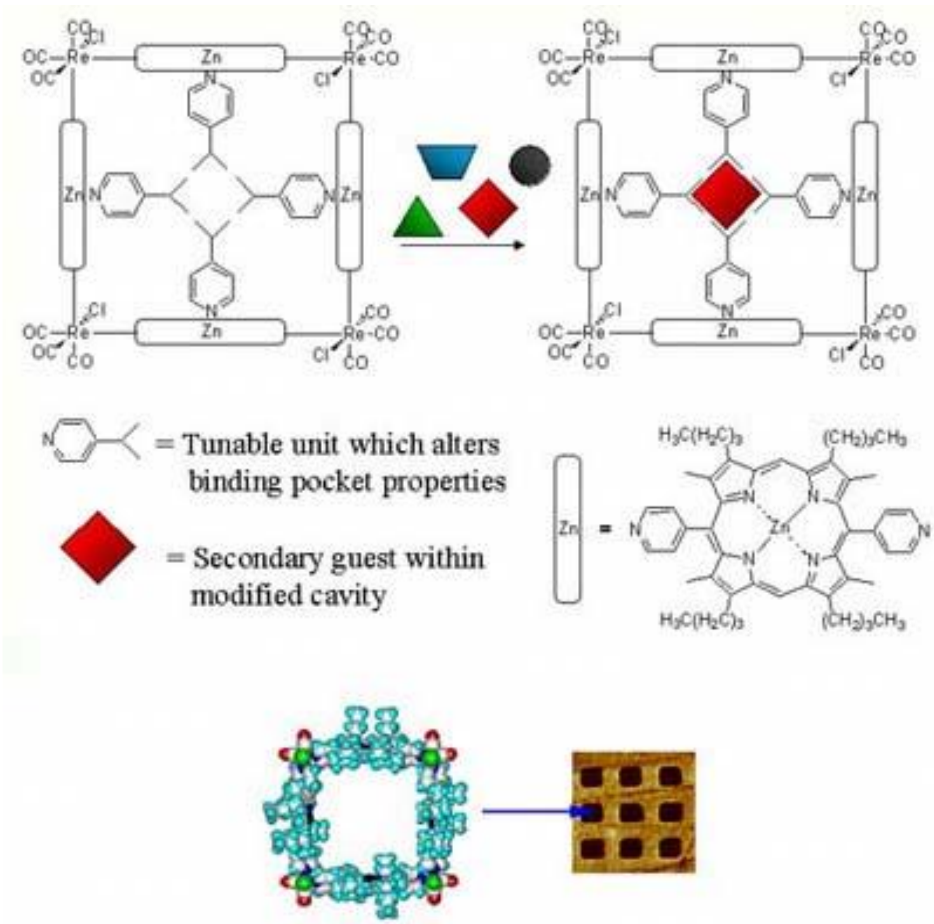

Fig. 47: Synthetic chemical nanoscience – metal-trapping molecular squares (courtesy of the Hupp Group, Northwestern University).

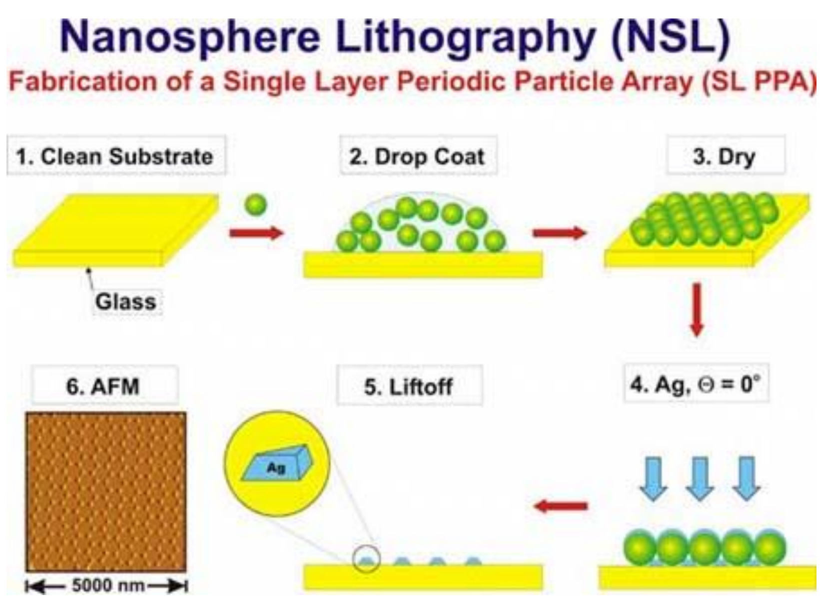

Fig. 48: Schematic of the nanosphere liftoff lithography process (courtesy of the Van Duyne Group, Northwestern University).

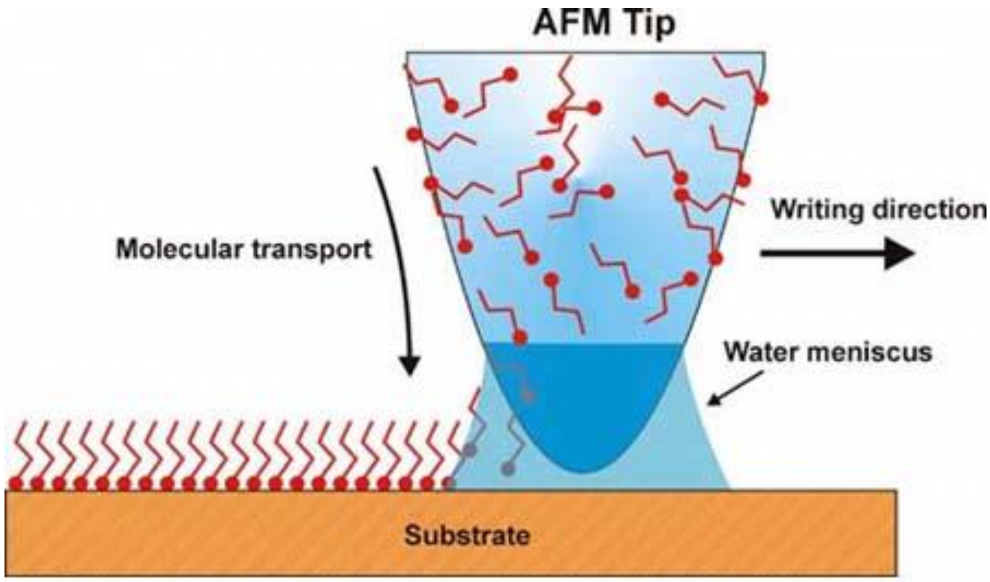

Fig. 49: Schematic of the dip pen lithography process-the wiggly lines are molecular “ink” (courtesy of the Mirkin Group, Northwestern University).

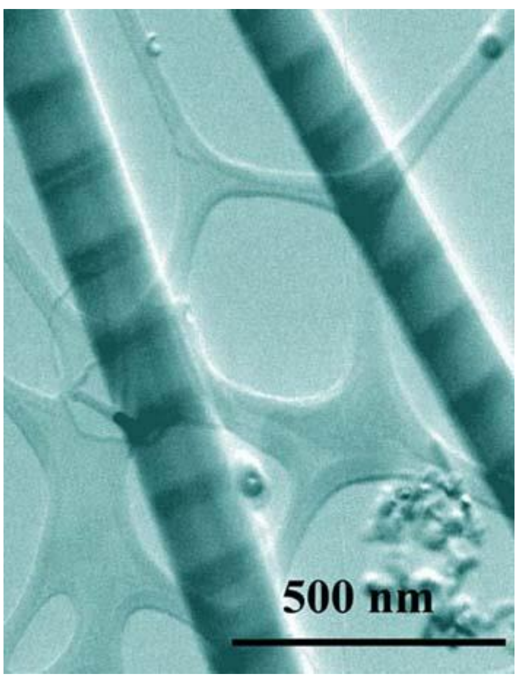

Fig. 50: Two parallel nanowires. The light color is silicon, and the darker color is silicon/germanium (courtesy of the Yang Group, University of California at Berkeley).

Future Prospects of Nanotechnology

“The future of nanotechnology has been subjected of many books and articles over a long period. Non-fiction books have included Drexler’s Engine of Creation, John Storrs Hall’s Nanofuture, Damien Broderick’s The Spike, Ray Kurzweil’s The Singularity is Near etc. We want to mind it some of the broader development on the way to which nanotechnology is working, e.g., nanotechnology computing development, nanoscale robots, nano-machine, molecular manufacturing. Here it would be appropriate to mention what Douglas Adams wrote about future, “Trying to predict is a mug’s game. And a Chinese Proverb says, “Only a fool would predict the future.” As Gerald Gallwas [113] says that predicting the future is a hazardous task. What you need is a tool chest of relevant experience and intuition, one that will enable us to move from today’s paradigm to a vision of tomorrow’s potential. These tools are needed because the rules of the physical world change when technology moves to the atomic level. Only the scientists are armed with a sound understanding of the fundamental principles are able to explore, discover and invent. Gerald Gallwas goes on to say, “Predicting the future is a hazardous task but you can try it by conducting this thought experiment. Consider the work before synthetic fibers, such as nylon, then jump back to natural fibers, hemp, silk and cotton. Describe their characteristics; envision the ubiquitous applications that these new materials would enable. Now consider the devices required for the new synthetic technology to become commercial reality. This is what we can call the forecast of the future of nanotechnology [113]. “Predicting the future has always been a practice from olden times John Storrs Hall says, "Every general futurist gets the future wrong to a significant extent". The difficulty with calculation, he says, is not that the futurist predicts changes that are too fantastical. The trouble is that futurists have a tendency to under expect technological advancement. Due to its breadth of application, nanotechnology represent a technological revolution that will affect many aspect of human life, altering the way things are probed and the manner people interact with technology"[10]. Prof. Fulekar says [114], "Nanotechnology research is tailor-made for industry, which provides improved nanomaterials and devices for wide applications in alternate energies, medicine and health care, ecological security and remediation, bio-detection, biotech, tissue engineering, information technology, bioinformatics, agriculture and food, space sciences etc. Research development and technology development would address exclusive economic, social and environmental uses. [114].

Potential Risks of Nanotechnology

The advancement of nanotechnology raises quite a few issues of principles, open policy, law and societal dependability and there is an urgent and important need to address them. Nanotechnology has already excited many with - its defence and weapon application. There is also the possibility of creation of dangerous viruses (biological weapons). There is also the possibility of elf-replicating of dangerous viruses, weapons etc. Thus, the nano-science andtechnology is not the sole property of the researchers and the engineers but of thinkers, ethicists, lawyers, theologians and politicians also. George W. Bush has aptly said [115], "As the discoveries of current science generate wonderful hope, they also lay vast ethical nine areas. Manasi Karkare [11] has discussed the potential risks of nanotechnology, viz., in halation, dermal contact and ingestion. She has dealt at length the risk to health from nanoparticles and nanomaterials. Buckyballs are known to cause extensive brain damage and liver damage. She has also quoted societal risks due to the possibility of military applications.

"Regulatory bodies as the US Environmental Protection Agency the Food and Drug Administration or the Health and Consumer Protection Directorate of the European Commission have in progress deals with the prospective risks posed by the nanoparticles. Unfortunately, the Material Safety Data Sheet, issue for certain a material does not differentiate between bulk and nanoscale size of the material in question [11]." It is pertinent to mention here that "nanotechnology is truly a portal opening on a new world (Rita Colwell) in Mark Ratner & Daniel Ratner" [14].

"Many sites on the Web have information about nanotechnology and nanoscience. Quite a few are sensational and untrustworthy. Some of the useful sites are given below, Miguel de Cervantes Saavedra [14]:

NanotechBook: www.nanotechbook.com. This is the official Website for the book. On the site you will find copious links to other good sites as well as references for the book and some additional information and online discussions about nanotechnology.

Small Times: www.smalltimes.com. This is a good news-compilation site that concentrates on microelectromechanical engineering, Microsystems, and nanaotechnologies. It is also home of the Small Times Stock Index.

Scientific American Nanotechnology: www.sciam.com/ nanotech. This site is an excellent resource for breaking scientific news about nano.

The National Nanotechnology Initiative: www.nano.gov. This overview of the federal government program for nanotechnology links to some good educational resources.

The Nanotechnology Bulletin: www.nanotechbulletin.com. This site contains interviews with movers and shakers in nanotechnology. If you want to hear what experts inside the industry are saying, this is a good resource.

The nanoBusiness Alliance: www.nanobusiness.com. This is a good source for those interested in the business and political side of the industry. It is also a good place to find out about events and conferences related to nanotechnology.

Nanotech Now: nanotech-now.com. This site is a portal that links to other good sites about nanotechnology.

Nanotech Planet: www.nanotechplanet.com. This is another good headline and portal site, although it is liable to mix nano with micro and other semi related news. It also has a nanotech stock portfolio and an associated convention.

To end this paper, we would like to emphasize that, "Nanoscientists illustrate on information from many discipline. Scientists are normally concerned with molecules, and significant molecules have distinguishing sizes that can be considered exactly on the nanoscale: they are bigger than atoms and smaller than microstructures. Physicists care about the property of matter, and as properties of matter at the nanoscale are quickly changing and frequently size-controlled, nanoscale physics is a very significant contributor. Engineers are apprehensive with the understanding and consumption of nanoscale materials. Materials scientists and electrical , chemical, and mechanical engineers all contract with the exclusive features of nanostructures and with how those special property can be utilize in the developed of completely novel materials that could give new capability in medicine, industry, recreation, and the environment.

The interdisciplinary nature of nanotechnology might explain why it takes so lengthy to expand. It is strange for an area to involve such assorted expertise. It also explains why most novel nano research amenities are supportive efforts between scientists and engineers from each part of the workforce." [14]. It is obvious that nanotechnology and nanoscience multidisciplinary fields. Whatever, good or bad, has been achieved in this field it owes to the scientists (Physicists, Chemists, Physical Metallurgists) and to the engineers (mechanical, materials).

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