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ROLE OF NANOTECHNOLOGY IN MEDICAL SCIENCES: A REVIEW

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ABSTRACT

The interface between nanosystems and biosystems is emerging as one of the broadest and most dynamic areas of science and technology, bringing together biology, chemistry, physics and many areas of engineering, biotechnology and medicine. Any damage at molecular or cellular level is the major culprit for disease & ill health. Nanotechnology, "the manufacturing technology of the 21st century," helps us to build a broad range of complex molecular machines by manipulating matter on an atomic and molecular scale. Nanotechnology is the creation of useful materials, devices and system through the manipulation of matter on an atomic, molecular, and supra-molecular level in the length scale of 1-100 nanometer size. At the nano scale, the physical, chemical, and biological properties of materials differ in fundamental and valuable ways from the properties of individual atoms and molecules or bulk matter .It enables the alignment of atoms in the most effective way in a very limited place. Extraordinary devices can be created by using this technique. Molecules could be aligned in such a way as to produce desired result in the areas of strength, ductility, reactivity, conductivity and capacity. This idea facilitates creating devices and structures that would occupy an unimaginably small space and have novel properties and functions because of their small size. The application of nanotechnology in the medical sector is referred as Nanomedicine. Nanoparticles have potential applications in the field of medical sciences including new diagnostic tools, imaging agents and methods, targeted drug delivery, pharmaceuticals, bio implants and tissue engineering. Drugs with high toxic potential like cancer chemotherapeutic drugs can be given with better safety profile with the utility of nanotechnology. The aim of the nanotechnology in the medical sciences is to develop new materials and methods to detect and treat diseases in a targeted, precise, effective and lasting way, with the ultimate goal of making medical practice safer and less intrusive.

KEY WORDS: Nanotechnology, Nanoparticles, Quantum dots, Nanomedicine, Targeted drug delivery system, Nanoshells, Smart drugs.

INTRODUCTION

Nanotechnology is the term derived from the Greek word "nano" meaning "dwarf" (short man). Nanomedicine involves utilization of nanotechnology for the benefit of human health and well being [1]. A nanometer is a billionth of a meter. It is difficult to imagine anything so small, but think of something only 1/80,000 the width of a human hair. Ten hydrogen atoms could be laid side-by side in a single nanometer. A red blood cell is approximately 7000 nm wide. Many molecules including some proteins range between 1 nm and larger. Nanotechnology is the creation of useful materials, devices, and systems through the manipulation of matter on this minute scale. The emerging field of nanotechnology involves scientists from many different disciplines, including physicists, chemists, engineers, and biologists. Although the word nanotechnology is relatively new, the "natural version" of nanotechnology was already in pole position with procreation of life itself thousands of millions of years ago. All natural materials and systems establish their foundation at the nanoscale. Basically, the biological building blocks of life are nano-entities that possess unique properties determined by the size, folding and patterns at nanoscale [1]. The genetic material deoxyribonucleic acid (DNA) is composed of four nucleotide bases in sizes ranging in the

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sub-nanometre scale, and the diameter of the double helix structure of DNA is in the nanometre range. The same is true for proteins and cell membranes which consist of lipids and proteins. The nanometer scale of nanomedicines is considered to be ideal to interact with cells that have dimensions (microns) that allow them to efficiently interact with nanoparticles (10–200 nm). Many drugs can be made significantly more effective if delivered using appropriate drug-delivery vehicles that allow them to efficiently reach their target in a form that both enables the drugs to be taken up by cells and minimizes off-target effects. More efficient and accurate delivery to their targets is expected to reduce the side effects of nanomedicines compared to conventional delivery [2]. Understanding of biological processes on the nanoscale level is a strong driving force behind development of nanotechnology [10]. In essence, Nanomedicine is the medical use of nano-sized particles, nanofiber and nanodevices to deliver drugs, heat, light or other substances to specific cells in the human body and for the detection and treatment of diseases or injuries within the targeted cells, thereby minimizing the damage to healthy cells in the body [3].

Surface to Volume Ratio of Nanomaterials

Different materials interact differently with their environment when they are sized on the nanoscale. Bulk materials interact with their environment in a certain way because the vast majority of their atoms are inside the volume of the material rather than on the surface, this makes the surface to-volume ratio very small .Atoms respond to their environment differently when they are surrounded by other atoms than when they are on a surface and do not have atoms surrounding them. And the relative amount of atoms on the surface can greatly influence the properties of the material as a whole. With nanoscale materials, many of the atoms reside on the surface of the material and therefore the surface-to-volume ratio is much larger [1-4]. Fig 1. Shows Interrelationships of radius, surface area, and volume of a quantum dot. Fig 1. also Shows that the volume decreases more rapidly than surface area for a given decrease in radius. Hence, surface area to volume ratio increases dramatically for a lower radius compared to the ratio for a higher radius.

Nano Devices and Their Activity with Biological Molecules

From the biological point of view, nanodevices match the typical size of naturally occurring functional units or components of living organisms and, for this reason, enable more effective interaction with biological systems [5]. Most animal cells are 10,000 to 20,000 nanometers in diameter. This means that nanoscale devices (less than 100 nanometers) can enter cells and the organelles inside them to interact with DNA and proteins. Nanodevices developed through nanotechnology are able to detect disease in a very small amount of cells or tissue. They can enter and monitor cells within a living body. Fig 2. Shows a nano device inside an animal cell. Because of their small size and larger surface area relative to their volume, nanoscale devices can readily interact with bio molecules such as enzymes and receptors on both, the surface of the cell and inside the cell. By gaining access to various areas of the body, nanoparticles have the potential to detect diseases at the micro level and deliver treatment. It is now possible to provide therapy at a molecular level with the help of nanotechnology. At the nanoscale the characteristics of matter can be significantly changed, particularly under 10-20 nm, because of properties such as the dominance of quantum effects, confinement effects, molecular recognition and an increase in relative surface area [6]. Downsized material structures of the same chemical elements change their mechanical, optical, magnetic and electronic properties, as well as their chemical reactivity, leading to surprising and unpredictable effects. In short, nanodevices exist in a unique kingdom, where the properties of matter are governed by a complex combination of classical physics and quantum mechanics. In order to interact with biological target, a biological or molecular coating or layer acting as a bioinorganic interface should be attached to the nanoparticle. Examples of biological coatings may include antibodies, biopolymers like collagen [7], or monolayers of small molecules that make the nanoparticles biocompatible [8]. In addition, as optical detection techniques are wide spread in biological research, nanoparticles should either fluoresce or change their optical properties. Nano-particle usually forms the core of nano-biomaterial. It can be used as a convenient surface for molecular assembly, and may be composed of inorganic or polymeric materials. It can also be in the form of nanovesicle surrounded by a membrane or a layer. The shape is more often spherical but cylindrical, plate-like and other shapes are possible. The core particle is often protected by several monolayers of inert material, for example silica. The same layer might act as a biocompatible material. However, more often an additional layer of linker molecules is required to proceed with further functionalisation. This linear linker molecule has reactive groups at both ends. One group is aimed at attaching the linker to the nanoparticle surface and the other is used to bind various moieties like biocompatibles (dextran), antibodies, fluorophores etc., depending on the function required by the application [9].

Synthesis of Nanoparticles

Nanoparticles can be prepared either by the "top down" technique starting with large particles and making things smaller by grinding or pulverizing. This approach has traditionally been used in making parts for computers and electronics [1]. The other technique is "bottom up" technique. This helps making things larger by building atom by atom or molecule by molecule and may prove useful in

manufacturing devices used in medicine. The control of the process is critical for the production of nanostructures. The development of enhanced microscopy techniques such as scanning tunneling microscopy (STM) and atomic force microscopy (AFM), has facilitated the use of the bottom up process. Most of the time nanoparticles are fixed with or on the surface of material. Nanoparticles can be made from a vast range of materials, such as metals (gold/silver), metal oxides (e.g. titanium dioxide -TiO_2, Silicon dioxide SiO_2), Inorganic materials (carbon nanotubes, quantum dots), polymeric materials and lipids. The other new sets of tools is available in nanotechnology are nanocrystals (Quantum dots), cantilevers, dendrimers, nanoshells and nanowires. These particles range from few to several hundreds of nanometers in diameter. Products made from each of these tools can be used for diagnosis (as biomarkers) and therapy [4]. Fig. 3 represents engineered nanoparticles in medical sciences. Several nanoparticle systems have been used to aid in the formulation, encapsulation and release of active compounds extracted or derived from natural resources.

Nanotechnology In Healthcare Management

- Liposomes
- Quantum dots (Nanocrystals)
- Nanoshells
- Cantilevers- A Nanoelectromechanical Sensor (NEMS)
- Dendrimers
- Nanowires

Liposomes

Liposomes were discovered in early 1960's by Bangham and collegue [11]. When dry phospholipids, or a mixture of such phospholipids and cholesterol, are immersed in water under laboratory conditions, they spontaneously form closed structure with internal aqueous environment bounded by phospholipid bilayer membranes known as liposome. Liposomes are small vesicle (a fluid filled sac) of spherical shape. They are biodegradable, biocompatible and non-immunogenic in nature, which makes them ideal drug carrier systems in therapeutics [12]. Fig. 6 shows a specimen of liposome. Liposomes are made of concentric spheres, one sphere inside of another and each forming half of a bilayered wall. A bilayer is composed of two sheets of phospholipid. Liposomes are useful for encapsulating other molecules such as pharmaceutical drugs. Liposomes are drug carrier loaded with great variety of molecules such as small drug molecules, proteins, nucleotides and even plasmids. Liposomes are lipid based nanoparticles used extensively in pharmaceutical and cosmetic industries because of their capacity for breaking down inside cells, once their delivery function has been met. Liposomes were first engineered nanoparticles used for drug delivery. Cancer chemotherapeutic drugs and other toxic drugs like amphotericin and hamycin, when used as liposomal drugs produce much better efficacy and safety as compared to conventional preparations. These liposomes can be loaded with drugs either in the aqueous compartment or in the lipid membrane. Liposomes transport hydrophilic drugs (water soluble) inside the core (aqueous compartment) and hydrophobic drugs (water insoluble but soluble in lipid) between the bilayer.

Quantum dots-Nanocrystals

Quantum dots (QD) are tiny (~2-10 nanometers or ~10-50 atoms in diameter) light emitting semiconductor/nanocrystals with vast applications in medical sciences [13]. Fig.7 shows quantum dots. They are so small that they can enter in the cell. They obey quantum mechanical principle of quantum confinement [14]. These can be used to detect cancer in the body. Quantum dots when used in conjunction with magnetic resonance imaging, can produce exceptional images of tumor sites [15]. Quantum dots glow when they are stimulated by ultraviolet light. The wavelength, or color, of the light depends on the size of the crystal. Fig. 8 shows this effect. Latex beads(polymeric particles suspended in a latex) filled with these crystals can be designed to bind to specific DNA sequences. By combining different sized quantum dots within a single bead, scientists can create probes that release distinct colors and intensities of light. When the crystals are stimulated by UV light, each bead emits light that serves as a sort of spectral bar code, identifying a particular region of DNA. Fig.9 shows nanosized quantum dot entering into a cell . Another advantage of quantum dots is that they can be used in the body, eliminating the need for biopsy. Quantum dots are 20 times brighter & 100 times more stable than traditional dyes.

Nanoshells

Nanoshells-tiny spheres of glass coated with gold are the first engineered nanomaterial to enter into human trials. Metal nanoshells are excellent optical absorbers. Particularly gold, because of the strong optical absorption from the metal's response to light. Similar to quantum dots, nanoshell diameter/size and thickness play a vital role in optical tuning of certain wavelength. To achieve more effective and better diagnostic and therapeutic goals, nanoshells can be conjugated to antibodies, oligonucleotides, fluorophores, targeting ligands, polymers, therapeutic agents, and radioisotope. Nanoshells (especially gold nanoshells) show promise application in biomedical imaging, target therapy, gene delivery, tissue welding, drug delivery systems, therapeutic applications in general and cancer imaging and treatment in particular [16].For treatment, a cancer patient receives a dose of nanoshells intravenously, and over the course of a day about 1% accumulate in a tumor site. Most of the rest wash out being so small in size. A physician then shines an infrared light over the tumor. The absorption of light by the nanoshells creates an intense heat burning away the tumor, while healthy cells nearby remain unharmed. This killing effect of heat is also know as Hyperthermia [17]. Advantage: zero

toxic effects (unlike chemotherapy) no ionizing radiation (like radiotherapy). Nanoshells loaded with insulin can be injected under the skin, where they can stay for months. To release the drug, patients use a pen-sized IR laser over the skin at the injection site. Fig. 10 & 11 show gold nanoparticles with glass core and under IR light.

Cantilevers- A Nanoelectromechanical Sensors (NEMS) [1-18]

The advances in micro- and nanofabrication technologies enable the preparation of increasingly smaller mechanical transducers capable of detecting the forces, motion, mechanical properties and masses that emerge in biomolecular interactions and fundamental biological processes. Thus, biosensors based on nanomechanical systems (NMS) have gained considerable relevance in the last decade. Due to the biological adsorption or interactions between the analyte (substance of interest, e.g. a particular chemical component, virus or micro-organism) and surface of cantilever some mechanical phenomena occur which shows a biological response. Nanoscale cantilevers work on this principle. The surface of cantilever is coated with bioreceptor/biorecognition element. Nanoscale cantilevers - microscopic, flexible beams resembling a row of diving boards - are built using semiconductor lithographic techniques. A biosensor consists of two components, a bioreceptor and a transducer. The bioreceptor is a biomolecule that recognizes the target analyte thereby generating a comprehensive surface stress which causes a downwards bending of the cantilever whereas the transducer converts the recognition event into a measurable signal. They are also known as Nanoelectromechanical Systems (NEMS). Fig.12 shows nanocantilever and its function. The physical properties of the cantilevers change as a result of the binding event. Researchers can read this change in real time and provide not only information about the presence and the absence but also the concentration of different molecular expressions. Nanoscale cantilevers, constructed as part of a larger diagnostic device, can provide rapid and sensitive detection of cancer-related molecules.

Dendrimers

The word dendrimer originates from the Greek dendron, meaning 'tree' and meros meaning 'part'. A dendrimer consists of molecular chains that branch out from a common center (like a tree), and there is no entanglement between each dendrimer molecules. Biodendrimers comprised of repeating units known to be biocompatible or biodegradable in vivo to natural metabolites. Dendrimers are defined by three components; a central core, an interior dendritic structure (the branches), and an exterior surface with functional surface groups. The interior of the dendrimer offer cavities (nanosized 'container') that can readily accept small molecules or particles, which make them ideally suitable for encapsulation, isolation from external media or active catalytic sites. The surface of the dendrimer can be modified with a wide variety of function, allowing to finely tuning the chemical, physical and topological properties of the molecule. The ends of the dendrimer molecule can be attached with other molecules for transport. These molecules give the dendrimers various functional applications [19]. They are used in medical sciences for targeted drug delivery and contrast agent in MRI. Fig.13 shows a specimen of dendrimers. The cavities present in dendrimers can be used as binding sites for smaller molecules - effectively the dendrite becomes a nanosized 'container' for various molecules [1].

Nanowires

A nanowire is a wire of diameter of the order of nm. Typically their width ranges from forty to fifty nanometers, but their length is not so limited. Since they can be lengthened by simply attaching more wires end to end or just by growing them longer, they can be as long as desired. The nanowires have unique metallic[20], semiconducting [21], and insulating [22] properties. The extremely high surface-to-volume ratio of 1D (1 dimension) biosensor like nanowires and nanotubes makes them ideal building blocks for biosensor development. They have strong biocompatibility and size similarity with the host (biomolecules), with emphasis on novel electron transport properties [23]. Nanowires can detect even slight disturbances from the surrounding environment (due to their high surface area to volume ratio). The constituent atoms reside on the surface of the nanostructures, which can generate electrical signals even with slight disturbances [24-27] in the system. Nanowires are far smaller than the smallest capillary in the body, that means nanowires could, in principle, be threaded through the circulatory system to any point in the body without blocking the normal flow of blood or interfering with the exchange of gases and nutrients through the blood-vessel walls. Bunch of nanowires being guided through the circulatory system to the brain. Once there, the nanowires would spread out branching into tinier and tinier blood vessels. Each nanowire would then be used to record the electrical activity of a single nerve cell, or small groups of nerve cells (better than PET or fMRI) giving the ability to pinpoint damage from injury and stroke, localize the cause of seizures, and other brain abnormalities. PET-Scan stands for Positron emission tomography. It is an imaging technique that helps to reveal how the tissues and organs are functioning in the body. It uses a radioactive drug/tracer to show this activity. The tracer may be injected, swallowed or inhaled depending on which organ or tissue is being studied by PET scan. The tracer collects in areas of the body that have higher levels of chemical activity, which often correspond to areas of disease. On a PET scan, these areas show up as bright spots. fMRI refers to as functional magnetic resonance imaging. It is a technique which is used to measure brain activity. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity – when a brain

area is more active it consumes more oxygen and to meet this increased demand blood flow increases to the active area. fMRI can be used to produce activation maps showing which parts of the brain are involved in a particular mental process. It's long been known that people with Parkinson's disease (a progressive disorder of the nervous system that affects the movement. It develops gradually, sometimes starting with a barely noticeable tremor in just one hand) can experience significant improvement from direct stimulation of the affected area of the brain with electrical pulses. Indeed, that is now a common treatment for patients who do not respond to medication. But the stimulation is currently carried out by inserting wires through the skull and into the brain, a process that causes scarring of brain tissue. The hope is, by stimulating the brain with nanowires threaded through pre-existing blood vessels, doctors could give patients the benefits of the treatment without the damaging side effects. The small size of nanoparticles can be very useful in oncology, particularly in imaging [28]. Fig.14 shows nanowire sensor place in brain using body's main arteries.

Research & Development in Medical Field

Research & Development (R&D) of newer drug delivery systems based on nanotechnology methods is being tried for conditions like cancer, diabetes, fungal infections, viral infections and in gene therapy. The main advantages of this modality of treatment are targeting of the drug and enhanced safety profile. Nanotechnology has also found its use in diagnostic medicine as contrast agents, fluorescent dyes and magnetic nanoparticles. Table. 1 shows a list of nanoparticles and their use in life sciences.

A list of some of the applications of nanomaterials to biology or medicine is given below:

- Fluorescent biological labels [29-30]
- Drug and gene delivery [31-32]
- Bio detection of pathogens [33]
- Detection of proteins [34]
- Probing of DNA structure [35]
- Tissue engineering [36-37]
- Tumour destruction via heating (hyperthermia)[38]
- Separation and purification of biological molecules and cells [39]
- MRI contrast enhancement [40]
- Phagokinetic studies [41]

Benefits of Using Nanomaterials

- Smaller devices are less invasive.
- They can be implanted inside body.
- Biochemical reaction time is much shorter.
- Devices are faster & more sensitive than typical drug delivery.

Characterization of Nanomaterials

Characterization, when used in materials science, refers to the broad and general process by which a material's structure and properties are probed and measured. It is a fundamental process in the field of materials science, without which no scientific understanding of engineering materials could be ascertained.

Following microscopes are of great importance for the imaging and manipulation of individual atoms or molecules in nanotechnology.

- Gerd Binnig invented Scanning Tunnelling Microscopy (STM)
- Henrich Rohrer invented Atomic Force Microscopy (AFM).
- Transmission Electron Microscope (TEM)

A. Targeted Drug Delivery System

In recent years significant efforts have been made to use nanotechnology for the purpose of drug and vaccine delivery. The nanoparticles offer a suitable means to deliver small molecular weight drugs as well as macromolecules such as proteins, peptides or genes in the body using various routes of administration. The nano-sized materials provide a mechanism for local or site specific targeted delivery of macromolecules to the tissue/organ of interest, *in-vivo*. The newer developments in material science and nanoengineering are currently being leveraged to formulate therapeutic agents in biocompatible nanocomposites such as nanoparticles, nanocapsules, micellar systems and conjugates. This can be achieved by molecular targeting by nanoengineered devices [42-43]. It is all about targeting the molecules and delivering drugs with cell precision. Drug delivery systems, lipid- or polymer-based nanoparticles [44], can be designed to improve the pharmacological and therapeutic properties of drugs [45]. The basic point to use drug delivery is based upon three facts, (a)Efficient encapsulation of the drugs, (b) Successful delivery of said drugs to the targeted region of the body and (c) Successful release of that drug there. Polymer-based nanoparticles are submicron-sized polymeric colloidal particles in which a therapeutic agent of interest can be embedded or encapsulated within their polymeric matrix or adsorbed or conjugated onto the surface [46]. These nanoparticles serve as an excellent vehicle for delivery of a number of biomolecules, drugs, genes and vaccines to the site of interest *in-vivo*. During the 1980's and 1990's several drug delivery systems were developed to improve the efficiency of drugs and minimize toxic side effects [47]. There is a size limit for the particles to be able to cross the intestinal mucosal barrier of the gastrointestinal (GI) tract after the drug has been delivered orally. Most often, macroparticles could not cross mucosal barrier due to their bigger sizes resulting in failed delivery of drugs. Nanoparticles on the other hand have an advantage over microparticles due their nano-sizes. Now, a wide variety of biomolecules, vaccines and drugs can be delivered into the body using nanoparticulate carriers and a number of routes of delivery. NPs (nanoparticles) can be used to safely and reliably deliver hydrophilic drugs (having a strong affinity for water and readily dissolve in water), hydrophobic drugs (not to

dissolve in water), proteins, vaccines, and other biological macromolecules in the body. They can be specifically designed for targeted drug delivery to the brain, arterial walls, lungs, tumor cells, liver, and spleen. They can also be designed for long-term systemic circulation within the body. In addition, nanoparticles tagged with imaging agents offer additional opportunities to exploit optical imaging or MRI in cancer diagnosis and guided hyperthermia therapy [48]. Fig.4 shows Multifunctional nanoparticles. It can combine a specific targeting agent (usually with an antibody or peptide) with nanoparticles for imaging (such as quantum dots or magnetic nanoparticles), a cell-penetrating agent (e.g., the polyArg peptide TAT), a stimulus-selective element for drug release, a stabilizing polymer to ensure biocompatibility polyethylene glycol (most frequently), and the therapeutic compound. Development of novel strategies for controlled released of drugs will provide nanoparticles with the capability to deliver two or more therapeutic agents.

Benefits of Nano Carriers In Drug Delivery Systems [15]

- Exhibit higher intracellular uptake
- Can penetrate the submucosal layers while the microcarriers are predominantly localized on the epithelial lining.
- Can be administered into systemic circulation without the problems of particle aggregation or blockage of fine blood capillaries.
- The development of targeted delivery is firmly built on extensive experience in pharmaco-chemistry, pharmacology, toxicology, and nowadays is being pursued as a multi-and interdisciplinary effort.

B. Cancer Therapy[15]

The small size of nanoparticles can be very useful in oncology, particularly in imaging. Quantum dots when used in conjunction with magnetic resonance imaging, can produce exceptional images of tumor sites [49]. These nanoparticles are much brighter than organic dyes and only need one light source for excitation which shows that the use of fluorescent quantum dots could produce a higher contrast image and at a lower cost than today's organic dyes used as contrast media. But the drawback is quantum dots are usually made up of quite toxic elements. Another nanoproperty, high surface area to volume ratio, allows many functional groups to be attached to a nanoparticle, which can seek out and bind to certain tumor cells. Additionally, the small size of nanoparticles (10 to 100 nanometers), allows them to preferentially accumulate at tumor sites (because tumors lack an effective lymphatic drainage system). Another use is with Sensor test chips containing thousands of nanowires, able to detect proteins and other biomarkers ("biomarker" refers to any of the body's molecules that can be measured to assess your health. Molecules can be obtained from your blood, body fluids, or tissue.) left behind by cancer cells, could enable the detection and diagnosis of cancer in the early stages from a few drops of a patient's blood [50]. The nanoshells can be targeted to bond to cancerous cells by conjugating antibodies or peptides to the nanoshell surface. By irradiating the area of the tumor with an infrared laser, which passes through flesh without heating it, the gold is heated sufficiently to cause death to the cancer cells [51].

C. Enhanced Visibility of Nanoparticles

Tracking movement can help determine how well drugs are being distributed or how substances are metabolized. It is difficult to track a small group of cells throughout the body, so scientists used to dye the cells. The way out of this problem is use of quantum dots, which is a tiny particle or nanoparticles of semiconductor materials (e.g. selenides or sulfide) of metals in all three spatial dimension. They are more superior to traditional organic dyes. Quantum dots are 20 times brighter & 100 times more stable than traditional dyes [49].

D. Tissue engineering

Tissue engineering has been defined as “the application of principles and methods of engineering and life sciences towards fundamental understanding of structure-function relationships in normal and pathological mammalian tissues and the development of biological substitutes to restore, maintain or improve tissue function” [52]. The products that arise from these techniques may provide an alternative to available therapies to replace damaged, injured or missing body tissues. Tissue-engineered products (TEPs) typically are a combination of three components, i.e. isolated cells, an extracellular Matrix(all living things are made of cells but most of the cells in multicellular organisms are surrounded by a complex mixture of nonliving material that makes up the extracellular matrix -ECM). and signal molecules, such as growth factors. Nanotechnology provides new possibilities for the extracellular matrix, often referred to as the scaffold. The extracellular matrix serves three primary roles. First, it facilitates the localisation and delivery of cells in the body. Second, it defines and maintains a three-dimensional space for the formation of new tissues with an appropriate structure. Third, it guides the development of new tissues with appropriate function. The interaction of the cells and the extracellular matrix is of great importance for the intended function of the final product. The excellent physical properties such as high surface area, high porosity, interconnective pores of the nanofibre matrices and appropriate mechanical properties, well-controlled bio-degradation rates and biocompatibility, make (synthetic) biodegradable polymeric nanofibre matrices ideal candidates for developing scaffolds for TEPs, as reviewed by [53].

Table 1. Nanoparticles and Their Applications in Life Sciences

Particle class	Materials	Application
Natural materials or derivatives	Gelatine Liposomes Starch	Drug/Gene delivery
Dendrimers	Branched polymers	Drug delivery
Fullerenes	Carbon based carriers	Photodynamics Drug delivery
Polymer carriers	Polyethyleinemine Block copolymers	Drug/gene delivery
Ferrofluids	SPIONS USPIONS	Imaging (MRI)
Quantum dots	Cd/Zn-selenides	Imaging In vitro diagnostics
Various	Silica-nanoparticles Mixtures of above	Gene delivery

Fig. 1. Interrelationships Of Radius, Surface Area, And Volume Of a Quantum Dot

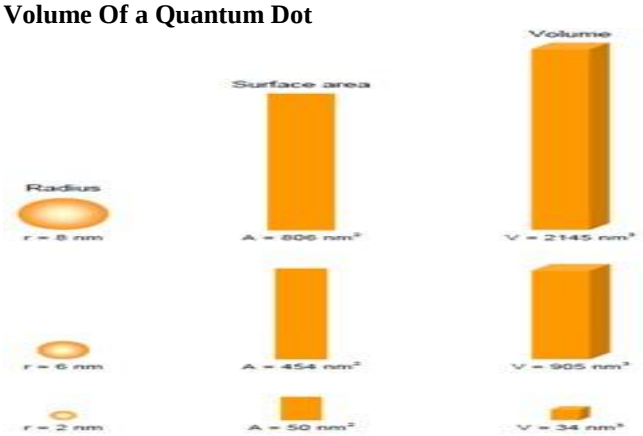


Fig. 2. Magnified Image Of Nano Device Inside Cell

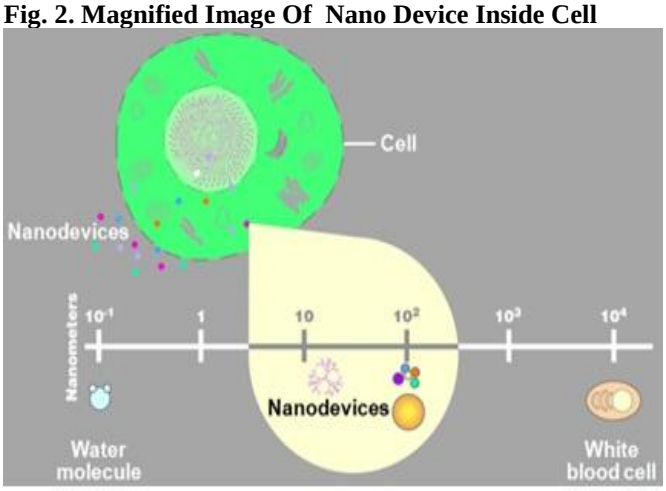


Fig. 3. Nanotechnology Tools And Their Dimension

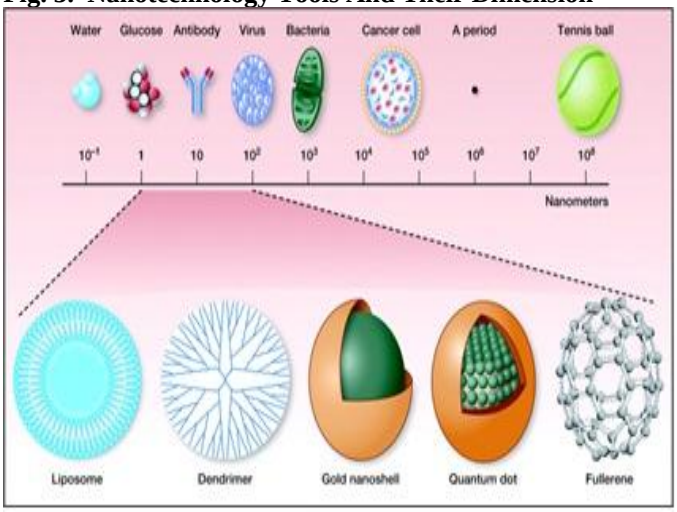


Fig. 4. Multifunctional Nanoparticles

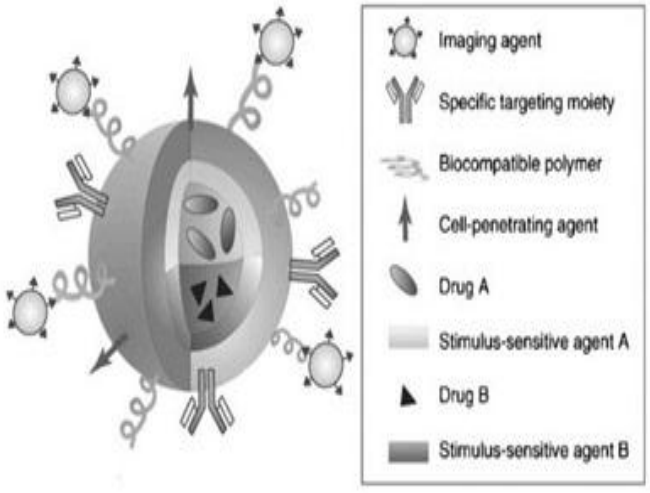
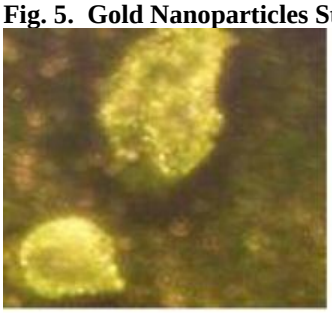


Fig. 5. Gold Nanoparticles Stick to Cancer Cells



Gold nanoparticles stick to cancer cells and make them shine

Fig. 6. A Specimen Of Liposomes As Two Sheets Of Phospholipid

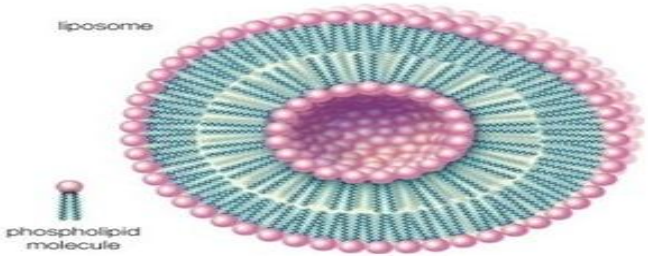


Fig. 7. Quantum Dots Under Ultraviolet Light

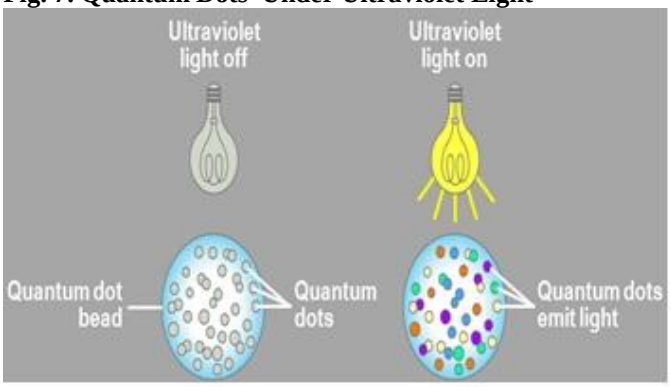


Fig. 8. Effect of Size in Quantum Dots

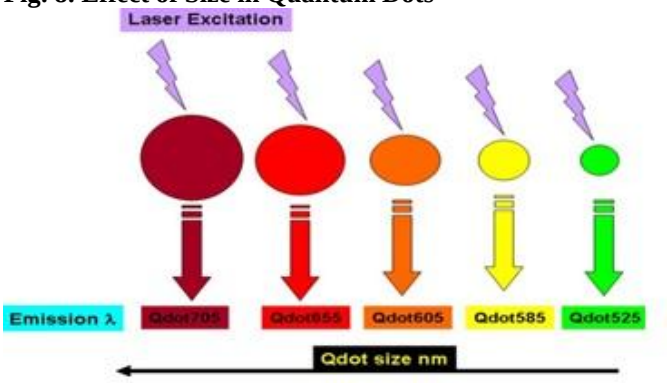


Fig. 9. Nanosized Quantum dot Entering Into a Cell

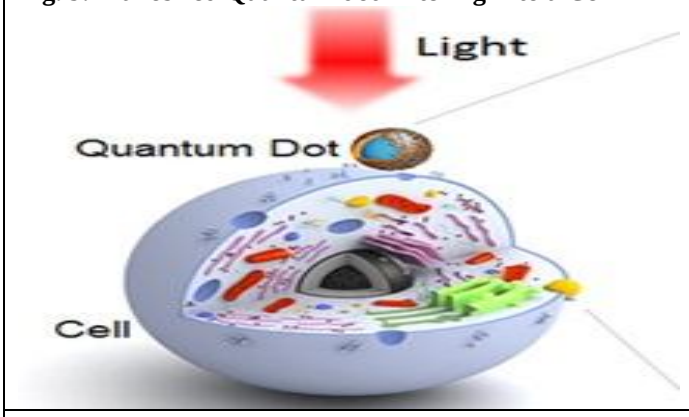


Fig. 10. Gold Nanoshells with Glass Core

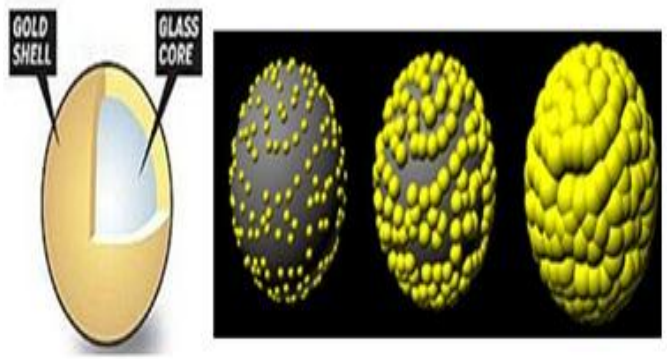


Fig. 11. Nanoshells Under Infrared Light

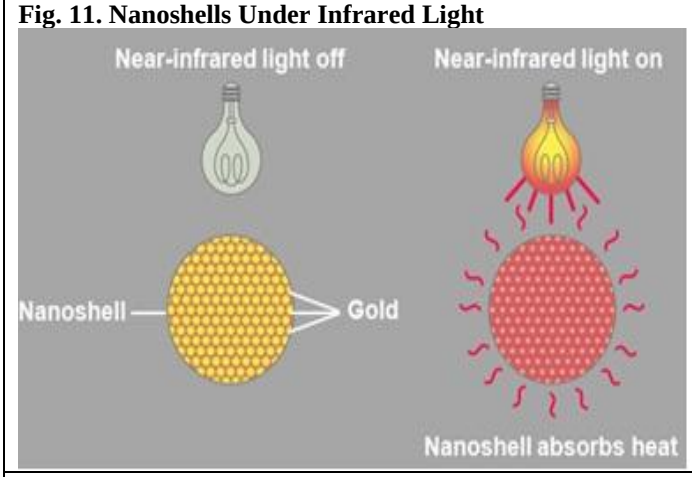


Fig. 12. Nanocantilever/ A Biosensor For The Early Detection Of Cancers

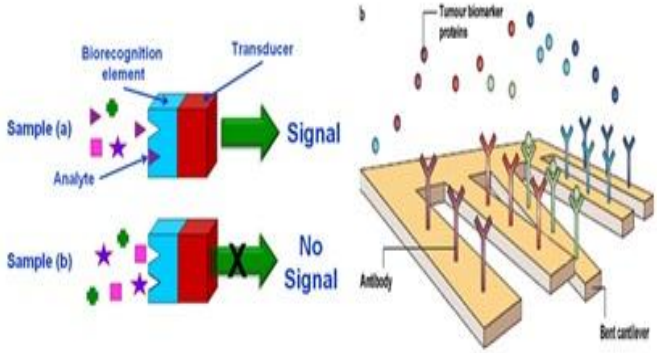
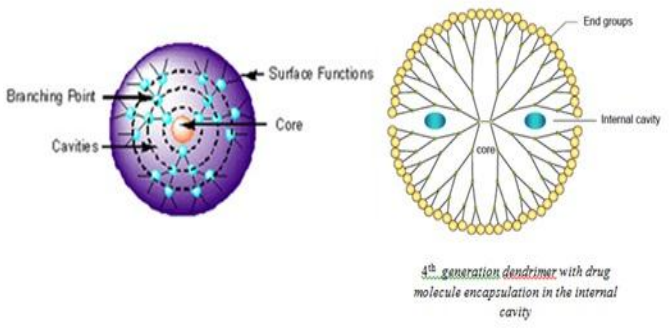
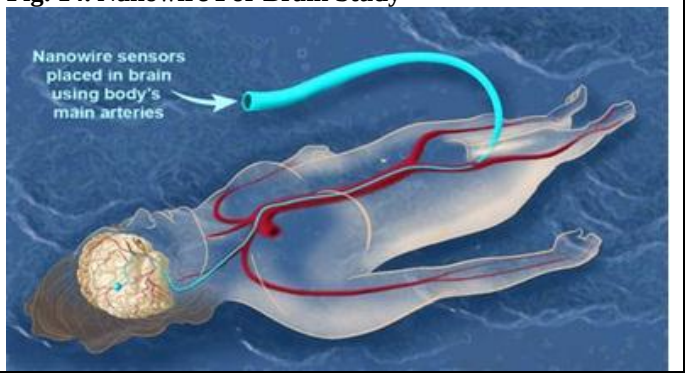


Fig. 13. Dendrimers



4th generation dendrimer with drug molecule encapsulation in the internal cavity

Fig. 14. Nanowire For Brain Study



CONCLUSION

Nanotechnology influences almost every facet of life. When one goes down to the bottom of the material, one can discover unlimited possibilities and potential of the basic building block of the material (particle) which is different to that observed for the same material at bulk. The change in behaviour of material at nanoscale is dominated in the first place by quantum mechanics and is additionally attributable to material confinement in small space, and the increase in surface area per volume. At the nanoscale, physics, chemistry, biology, material science, and engineering converge toward the same principles and tools. As a result, progress in nanoscience has very far-reaching impact. Nanoparticles have potential applications in the field of medical sciences including new diagnostic tools, imaging agents & methods, targeted drug delivery, pharmaceuticals, bio implants and tissue engineering. Drugs with high toxic potential like cancer chemotherapeutic drugs can be given with better safety profile with the utility of nanotechnology. A single molecule of drug can be assisted to reach the desired site in order to reduce the side effects of the dose and its quantity. Quantum dots with MRI can produce excellent pictures of a tumor. Gold nanoshells can be used to detect, find, accumulate, and potentially destroy the tumor by heating the Nanoparticles. In the future, we can visualize a world with medical nanodevices, implanted or even injected into the body. A global perspective and collaboration might be needed in the field of research & development to give such benefits to mankind.

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