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A Review on Application of Nanotechnology in Pharmaceuticals

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Review Article

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ABSTRACT

Nanotechnology is the engineering of functional systems at the sub-atomic level, covers a broad range of topics, and is focused on controlling and exploiting the structure of issues on a large scale below 100 nanometers. Nanotechnology is the future of advanced development. Nanotechnology use in various fields likes health and medicine, electronics, energy, and environment, is discussed in detail. Uses of nanoparticles in drug delivery, protein and peptide delivery, cancer are explained Uses of various nanosystems in cancer therapy such as carbon nanotube, dendrimers, nanocrystal, nanowire, nanoshells, etc. are given. Nano pharmaceuticals can be used to identify diseases at much earlier stages. In this paper, we have discussed the concept of Nanotechnology along with its history and different applications.

INTRODUCTION

Nanotechnology is the study of controlling matter on a particle and sub-atomic scale. Generally, nanotechnology deals with structures measured between 1-100 nanometers in at least one dimension and involves modifying or developing materials inside that size. Nanotechnology is a hypothetical and experimental field of applied science and technology. It makes the material lighter, stronger, faster, smaller, and more durable. The 'Nano 'word' derived from the Greek word 'Nanos', which means dwarf or extremely small. The prefix 'Nano' in the word of nanotechnology means a billionth (1 x 10-9). Nanotechnology is often referred to as general use technology because it has a significant impact on almost all industries and all areas of society. Nanoscience and nanotechnology are late progressive development in Science and Engineering that are evolving at high speed.

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Nanotechnology can be characterized as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization, on any occasion one measurement, is on the nanometer scale or one billionth of a meter [1]. Nanotechnology is sometimes proffered as a general-purpose technology because in its advanced version it will have a significant impact on almost all areas of society and all industries. History of Nanotechnology: The development in the field of nanotechnology started in 1958 and the different phases of development have been summed up in Table 1.

Table 1: Periodical Development in Nanotechnology.

Year	Development in Nanotechnology
1959	R. Feynman initiated thought process
1974	Taniguchi used the nanotechnology term for the first time.
1981	IBM Scanning Tunneling Microscope
1985	“Bucky Ball”
1986	The first book published on nanotechnology Engines of Creation by K. Eric Drexler, Atomic Force Microscope
1989	IBM logo was made with individual atoms
1991	S. Iijima discovered the Carbon Nanotube interestingly.
1999	1st nanomedicine book by R. Freitas “Nanomedicine” was published
2000	The first time National Nanotechnology Initiative was launched
2001	For developing the theory of nanometer-scale electronic devices and for synthesis and characterization of carbon nanotubes and nanowires, Feynman Prize in Nanotechnology was granted.
2002	Feynman Prize in Nanotechnology was awarded for using DNA to enable the self-assembly of new structures and for advancing our capacity to model molecular machine systems.
2003	Feynman Prize in Nanotechnology was awarded for demonstrating the molecular and electronic structures of new materials and for integrating single-molecule biological motors with nano-scale silicon devices.
2004	The first center for Nano mechanical systems was established, Feynman Prize in Nanotechnology was awarded for designing stable protein structures and for developing a novel enzyme with an altered function.
2005-2010	3D Nanosystems like robotics, 3D networking, and dynamic nano products that change their state during use were prepared.
2011	The era of molecular nanotechnology started

Norio Taniguchi was the man who first initially utilized the term 'nanotechnology' (Professor of Tokyo Science University) in 1974. He started his research on the free abrasive mechanisms of high exactness machining of hard and brittle materials. Kim Eric Dexler is the founder and father of nanotechnology. He is the man behind theorizing nanotechnology top to bottom and promoting the subject. He is an American engineer best known for promoting the capability of sub-atomic nanotechnology, from the 1970s and 1980s. In 1979, Eric Drexler encountered Feynman’s discussion on nuclear control and “Nano-factories.”

Nano scale and nanostructures

The nanoscale is where the properties of the most common things are determined just above the scale of a particle. Nanoscale objects have in any event one measurement (height, length, depth) that measures between 1 and 999 nanometers (1-999 nm) (Figure 1). The brief clarification of the pharmaceutical nanosystems is as follows: As shown in the diagram (Figure 2), pharmaceutical nanotechnology is separated into two basic types of nano congregations viz. nanomaterials and Nano devices These materials can be sub characterized into nanocrystalline and nano organized materials [2]. Nanostructure consists of nanoparticles, dendrimers, micelles, drug conjugates, metallic nanoparticles, etc.

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Figure 1: Nanoscale and Nanostructures.

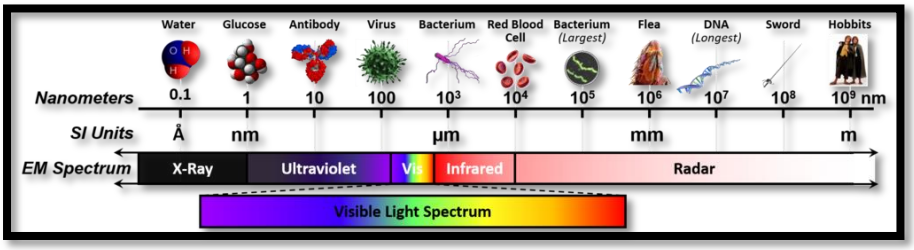
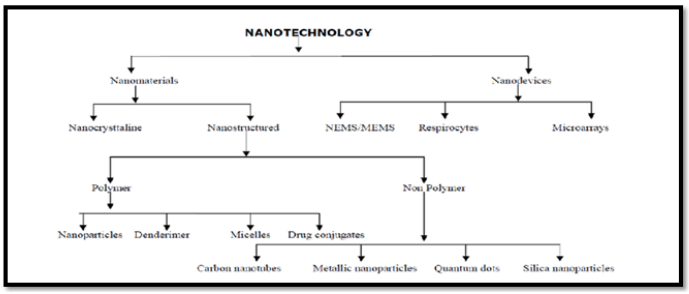


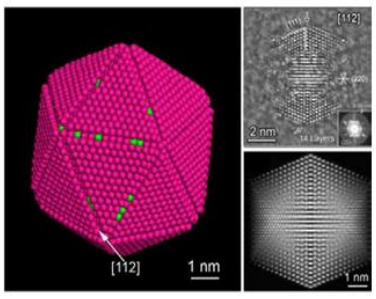
Figure 2: Various types of pharmaceutical nanosystems.



Nanoparticles

Particles whose sizes range of 1-100 nm is known as a nanoparticle, whether it is dispersed in gaseous, liquid or solid medium. This is several atoms or molecules bonded together and intermediate in size between individual atoms and aggregates large enough to be called mass material. Figure 3, shows the picture of Nanoparticles. Nanoscience and nanotechnology are later, a revolutionary development in Science and Engineering that are developing at a very fast pace. It is driven by the longing to fabricate materials with novel and improved properties that are probably to impact virtually all areas of the physical and chemical sciences, biological sciences, and health sciences. The dimensionality of different systems. As the nanoparticles are bigger than individual atoms and molecules but are smaller than bulk solid, those obey neither absolute quantum chemistry nor the laws of classical physics science and materials in the nanometer size regime show the behavior which is intermediate between that of a macroscopic solid and that of an atom or molecular system [3].

Figure 3: Nanoparticles



Properties of Nanoparticles

1. They can be built by gathering individual atoms or subdividing mass materials.
2. Physically, materials can be described by some critical length, a thermal diffusion length, or a scattering length.
3. The size of nanoparticles is less than the wavelength of light.
4. Critical characteristics are their very high surface-to-volume Ratio.
5. Vander wall forces or magnetic forces play a more important role than gravitational forces.

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Synthesis of Nanoparticles

There are two approaches for the synthesis of nanoparticles which are top-down (extreme miniaturization) and bottom-up (building blocks). The top-down approach involves the breaking of larger materials into fine particles, whereas the bottom-up approach tends to the formation of nanostructures from nano- or sub nanoscale objects. In the bottom-up approach, the size and shape of the nanostructure are maintained by adjusting the ratio of the concentration of chemical and selected capping material. Commonly used capping materials are polymers, micelles, dendrimers, and surfactants. The top-down approach includes various techniques for the manufacture of nano-scale materials are laser ablation, milling, nano-lithography, hydrothermal techniques, physical vapor deposition, and electroplating. In this approach, chemical methods are more effective for the mass production of metal nanoparticles compared to physical ones. The devices which are produced by the bottom-up approach can store an enormous amount of information. The bottom-up approach is used for the synthesis of nano-scale materials through sol-gel processing, liquid phase techniques based on inverse micelles, laser pyrolysis, chemical vapor deposition(CVD), and molecular self-assembly.

Applications of Nanotechnology:

1. The various fields that find potential applications of nanotechnology are as follows:
2. Health and Medicine
3. Electronics
4. Transportation
5. Transportation
6. Space exploration

Nanotechnology in health and medicine

Even today, various diseases like diabetes, cancer, Parkinson's disease, Alzheimer's disease, cardiovascular diseases, and multiple sclerosis as well as different kinds of serious inflammatory or infectious diseases (e.g., HIV) constitute a high number of serious and complex illnesses, which are representing a significant problem for the humankind. Nanomedicine and utilization of nanotechnology that works in the field of health and medicine. Nano-medication makes use of nanomaterials and nanoelectronic biosensors. In the future, nanomedicine will benefit molecular nanotechnology. The medical area of nanoscience application has many projected benefits and is potentially valuable for all human races. With the help of nanomedicine early identification and prevention, improved diagnosis, proper treatment, and follow-up of diseases are impossible. Certain nano-scale particles are used as tags and labels, biological can be performed quickly, the testing has become more sensitive and more adaptable. Gene sequencing has become more efficient with the invention of nano gadgets like gold nanoparticles, these gold particles when labeled with short segments of DNA can be used for the detection of genetic sequence in a sample.

Nanotechnology, energy, and environment

Protecting the environment and providing sufficient energy for the growing world. The advanced techniques of nanotechnology can help storage of energy, its conversion into other forms, eco-friendly manufacturing of materials, and better enhanced renewable energy sources. Nanotechnology can be used for less expensive energy production and renewal energies, in solar technology, nano-catalysis, fuel cells, and hydrogen technology. Carbon nanotube energy units are utilized for the capacity of hydrogen, subsequently discovers application in power vehicles.

Nanotechnology is used on photovoltaic, for making them cheap, lightweight, and more efficient, which can reduce the combustion of engine pollutants by nano permeable channels, and can clean the exhaust mechanically, with the help of catalytic converters made up of nanoscale noble metal particles and by catalytic coatings on cylinder walls and catalytic nanoparticles as an added substance for fuels [4].

Medical use of nano materials

Nanomedicine is a moderately new field of science and technology. By interacting with biological molecules at a nanoscale, nanotechnology broadens the field of research and application. Interactions of Nanodevices with bio-molecules can be perceived both in the extracellular medium and inside the human cells. Activity at the nanoscale allows exploitation of physical properties different from those observed at the microscale such as the volume/surface ratio. Two forms of nanomedicine have already been tested in mice and are awaiting human trials; the use of gold nano shells to help diagnose and cure cancer, and the use of liposomes as vaccine adjuvants and as vehicles for drug transport. Additionally, drug detoxification is also another application for nanomedicine that has

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been used successfully in rats. Medical technologies can make use of smaller devices that are less obtrusive and can be implanted inside the body, and their biochemical reaction times are greatly restricted. As compared to typical drug delivery nano devices are faster and more sensitive.

DRUG DELIVERY

In this procedure, the required drug dose is used and side effects are lowered significantly as the active agent is deposited in the morbid region only. This highly specific approach can reduce costs and pain to the patients. Thus, a variety of nanoparticles such as dendrimers, and Nano porous materials discover applications. Micelles obtained from blocks-polymers are used for drug encapsulation. They transport small drug molecules to the desired location. Similarly, nanoelectromechanical systems are used for the active release of drugs. Iron nanoparticles or gold shells are discovering important applications in cancer treatment. A focused medicine reduces drug consumption and treatment expenses, making the treatment of patients cost-effective. Nanomedicines used for drug delivery, are made up of nanoscale particles or molecules which can improve drug bioavailability. For maximizing bioavailability both at specific places in the body and over some time, molecular targeting is done by nano-engineered devices such as nano robots. The molecules are focused and delivering of drugs is done with cell precision. In vivo imaging is another area where Nano tools and devices are being developed for in vivo imaging. Using nanoparticle images such as in ultrasound and MRI, nanoparticles are used as contrast. The nano-engineered materials are being developed for successfully treating illnesses and diseases such as cancer. With the advancement of nanotechnology, self-assembled biocompatible nano gadgets can be made which will detect the cancerous cells and automatically evaluate the disease, will cure and prepare reports.

The applications of nanoparticles in drug delivery

Abraxane, is albumin-bound paclitaxel, a nanoparticle used for the treatment of breast cancer and non-small- cell lung cancer (NSCLC). Nanoparticles are used to deliver the drug with enhanced effectiveness for treatment for head and neck cancer, in a mice model study, which was carried out at Rice University and University of Texas MD Anderson Cancer Center. The detailed treatment uses Cremophor EL which allows the hydrophobic paclitaxel to be delivered intravenously. When the toxic Cremophor is replaced with carbon-nano particles its side effects diminished and drug targeting was much improved and needs a lower dose of the toxic paclitaxel.Nano molecule chain was used to deliver the drug doxorubicin to breast cancer cells in a mice study at Case Western Reserve University. The scientists arranged a 100 nm long nano molecule chain by chemically linking three magnetic, iron-oxide nanospheres, to one doxorubicin-loaded liposome. After infiltration of the nano chains inside the tumor magnetic nanoparticles were made to vibrate by generating, a radiofrequency field which resulted in the rupture of the liposome, thereby dispersing the drug in its free form throughout the tumor. Tumor growth was halted more effectively by nanotechnology than the standard treatment with doxorubicin and is less harmful to healthy cells as very few doses of doxorubicin were used [5].

Proteins and peptide delivery

Protein and peptides are macromolecules and are called biopharmaceuticals. These have been identified for the treatment of various diseases and disorders as they exert multiple biological actions in the human body. Nanomaterials like nanoparticles and dendrimers are called nano biopharmaceuticals, are used for targeted and/or controlled delivery.

Applications: Nanoparticles were found useful in delivering the myelin antigens, which prompt safe tolerance in a mouse model with relapsing multiple sclerosis. In this strategy, biodegradable polystyrene microparticles coated with the myelin sheath peptides will reset the mouse's immune system and thus prevent the recurrence of disease and decrease the symptoms as the protective myelin sheath forms coating on the nerve fibers of the central nervous system. This method of treatment can potentially be used in the treatment of various other autoimmune diseases.

Cancer: Due to the small size of nanoparticles can be of great use in oncology, particularly in imaging. Nanoparticles, for example, quantum dots, with quantum confinement properties, such as size-tunable light emission, can be used in conjunction with magnetic resonance imaging, to produce exceptional pictures of tumor destinations. As compared to natural colors, nanoparticles are much brighter and need one light source for

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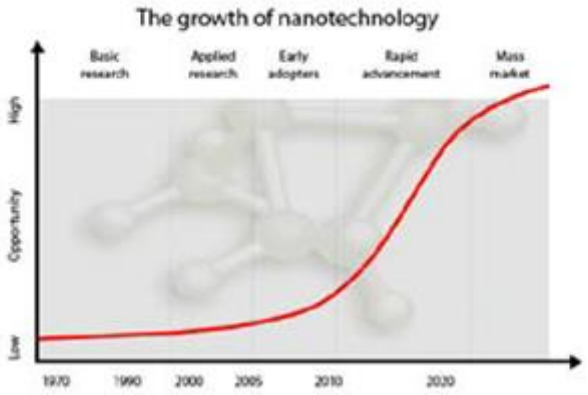
excitation. Thus, the use of fluorescent quantum dots could produce a higher contrast picture and at a lower cost than organic dyes used as differentiation media. But quantum dots are usually made of quite toxic elements. Nanoparticles have a special property of high surface area to volume ratio, which allows various functional groups to get attached to a nanoparticle and thus bind to certain tumor cells. Besides, the10 to 100 nm small size of nanoparticles, allows them to preferentially accumulate at tumor sites as tumors lack an effective lymphatic drainage system. Multifunctional nanoparticles can be manufactured that would detect, image, and then treat a tumor in future cancer treatment [21]. Kanzius RF therapy attaches microscopic nanoparticles to cancer cells and then "cooks" tumors inside the body with radio waves that heat only the nanoparticles and the adjoining (cancerous) cells. The applications of various nanosystems in cancer therapy [22] are summarized as:

- Carbon nanotubes, 0.5–3 nm in breadth and 20–1000 nm length, are used for the location of DNA mutation and detection of disease protein biomarkers.
- Dendrimers, less than 10 nm in size are helpful for controlled release drug delivery, and as picture contrast agents.
- Nanocrystals, of 2-9.5 nm size cause improved formulation for ineffectively dissolvable drugs, labeling of breast cancer marker HeR2 surface of cancer cells.
- Nanoparticles are of 10-1000 nm size and are used in MRI and ultrasound picture contrast agents and for focused drug delivery, as permeation enhancers, and as reporters of apoptosis, angiogenesis.
- Nanoshells find uses in tumor-specific imaging, deep tissue thermal ablation.
- Nanowires are valuable for disease protein biomarker detection, DNA mutation detection, and gene articulation detection.
- Quantum dots, 2-9.5 nm in size, can help in optical detection of genes and proteins in animal models and cell assays, tumor and lymph node visualization [23].

Future perspective

Nanotechnology is slowly creeping into popular culture. There is a possibility that the future of nanotechnology is very bright. Technology could end world hunger [24]. Figure. 4, shows the growth curve of Nano Technology.

Figure 4: shows the growth curve of nano technology.



RISKS

- There are impacts of the different nanoparticles on the human body and negative consequences on human health.
- Nanoparticles are immovably embedded in the matrix, which can release and are unsafe.
- Concentrations of nanoparticles at the workplace and in the environment are harmful.
- Its waste is very dangerous can cause the diseases like cancer etc.

CONCLUSION

In this review, we present a detailed overview of Nanotechnology, and build a database of Nanotechnology. Our study concludes that Nano carriers have had tremendous growth in recent years. Nanomaterials have expanded

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surface area and nanoscale impacts, hence used as a promising tool for the advancement of drug and quality delivery, biomedical imaging, and diagnostic biosensors. Nanomaterials have unique physicochemical and biological properties as compared to their bigger counterparts. A wide range of opportunities are the available portions of the nanoparticles that get synthesized are cost-effective.

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