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Future of Nanotechnology

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ABSTRACT
Nanotechnology is the science that studies the use of matter on a nanometric scale. It is the promising means of manipulating individual atom and molecule of an object at the nanoscale. It is an emerging science which is expected to have strong future developments. Although it is hard to predict what will happen to nanotechnology in the next 100 years, we know that nanotechnology will be a powerful tool of science and technology in the future. This paper introduces recent trends in nanotechnology and its future scope. It also addresses known barriers to future progress in nanotechnology and its applications.

Keywords: nanotechnology; future of nanotechnology

INTRODUCTION
Life is becoming interesting due to the invention of new technologies every day. Human dreams often give rise to a new technology. Nanotechnology was born out of such dreams [1]. It is the ability to understand, control, and manipulate matter at the level of individual atoms and molecules.

It is the kind of engineering involves manipulating individual atoms. Nanotechnology is a multidisciplinary field that covers engineering, physics, chemistry, and biology. In roughly five decades, nanotechnology has become the foundation for remarkable industrial applications [2]. The 21st century can be regarded as the century of nanotechnology. In the future, nanotechnology could also enable objects to harvest energy from their environment. It has helped create batteries that can store more energy for electric cars and has enabled solar panels to convert more sunlight into electricity.

Small things behave differently and old rules do not apply. Many diseases causing bacteria and viruses are nanosize. Measurement at nanotechnology level is in nanometers (nm). Figure 1 shows the differences in scale that range from hair diameter down to one hydrogen atom [3]. Nanotechnology has begun to blossom in recent years due to the development of new instruments that allow researchers to observe and manipulate matter at the nanolevel.

OVERVIEW OF NANOTECHNOLOGY
Richard Feymann, the Nobel Prize-winning physicist, introduced the world to nanotechnology in 1959. The term "nanotechnology" was coined in 1974 by Norio Tanigutchi, a professor at Tokyo Science University. Nanotechnology involves the manipulation of atoms and molecules at the nanoscale so that materials have new unique properties. It is the science of small things—at the atomic level or nanoscale level [4]. Nanotechnology also includes domains like nanoscience, nanomaterials, nanomedicine, nanomeasurement, nanomanipulation, nanoelectronics, and nanorobotics.

Techniques are now available which make it possible to manipulate materials on the atomic or molecular scale to produce objects which are no more than a few nanometres in diameter. The processes used to make and manipulate such materials are known as *nanotechnology*, the materials or objects themselves are called *nanomaterials*, and the study and discovery of these materials is known as nanoscience.

Nanotechnology may be regarded as the controlled manipulation of nanomaterials with at least one dimension less than 100nm. Thus, nanomaterials are basically chemical substances or materials that are manufactured and used at a very small scale. Nanoscale materials can be engineered from minerals and nearly any chemical substance. Engineered nanomaterials have been deliberately manufactured by humans to have certain required properties. Nanomaterials may also be produced incidentally as a byproduct of mechanical or industrial processes [5]. They can be classified in 0D, 1D, 2D, and 3D nanomaterials, as shown in Figure 2 [6]. Fullerenes, graphene flakes, single wall carbon nanotube, and nanoparticles, etc. are regaded as nanomaterials. They are 100 times stronger than steel but six times lighter. Nanomaterials are widely used in consumer and industrial applications. They also have potential applications in the military sector.

Nanotechnology has the idea that the technology of the future will be built on atoms. It has impact on every area of science and technology. Nanotechnology involves imaging, measuring, modeling, and manipulating matter at the nano scale. At this level, the physical, chemical, and biological properties of materials fundamentally differ from the properties of individual atoms and molecules or bulk matter [7].

Nanotechnology covers a wide variety of disciplines like physics, chemistry, biology, biotechnology, information technology, engineering, and their potential applications.

Nanotechnology features two primary approaches, which are "bottom up" where materials or devices are self-assembled from molecular components, and "top down" where nanoscale objects are constructed by micro-scale and macro-scale devices.

RECENT ADVANCES

Nanotechnology should benefit every industrial sector. Nanotechnology has seen a rapid growth and is fundamental in the near future. It has caused a positive impact on life in the sectors of food, medicine, energy, agriculture, environmental, and electronics

- ***Food nanotechnology***

Food demand continually increases as the global population keeps growing. Nanotechnology is an efficient method in the food industry and the area of functional foods. Food nanotechnology is an emerging field, employed in food packaging, food quality, and food safety. The food industry is investigating researching foods that have a longer shelf life due to the nanoparticles.

- ***Nanomedicine***

This is a medicinal application of nanotechnology. Nanomedicine includes tissue engineering, biomaterials, biosensors, and bioimaging. It involves diagnosing, treating, and preventing disease using nanoscale structured materials and nonorobots. The long-term goal of nanomedicine research is to characterize the molecular-scale components known as nanomachinery [8]. Once nanomechanics are available, the ultimate dream of every physician throughout recorded history will become a reality. Programmable nanorobotic devices would allow physicians to perform precise interventions in the human body at the cellular and molecular levels. Nanomachines, nanorobots, and nanodevices can be used to develop a wide range of automically precise microscopic manufacturing tools. You can imagine swarms of nanobots swimming through your veins and repairing cells. Nanomedicine may offer a new path forward for effective cancer treatment. Nanomedicine is predicted to become more high-tech and more effective in managing individual healthcare on a microscopic level. Nanotechnology-based drug delivery systems are being tried for conditions like cancer, diabetes, fungal infections, viral infections and in gene therapy. It has been predicted that nanotechnology will soon be used in brain implants capable of restoring lost memory**.** Nanotechnology is likely to revolutionize medicine in the future. Figure 3 shows some modern medicine nanotechnology future systems [9].

- ***Nanodentistry***

Nanotechnology will change dentistry, healthcare, and human life more profoundly than many developments of the past. Nanotechnology has the potential to bring enormous changes into the field of dentistry. Nanotechnology has revolutionarized restorative dentistry by providing nanofillers. Nanodentistry may succeed in maintaining near-perfect oral health through the aid of nanorobotics, nanomaterials, and biotechnology [10].

- ***Energy generation and use***

Nanoscales and nanoporous membranes are being used to facilitate production of biomass fuel. Nanomaterials are used for energy production and storage. Energy transmission could potentially be made efficient by using engineered nanomaterials. In the renewable-energy sector, nanotechnology has the potential to increase process efficiencies and process yields, decrease costs and enable energy processes. Fuel cells are cited as the engines of the future with the strongest impact on the emission. Nanotechnology is transforming photovoltaic cells [11]. In the future, novel, nanomaterials will make airplanes and vehicles lighter and therefore help reduce fuel consumption. Many research labs are working on nanotechnology-enabled batteries to increase their efficiencies for electric vehicles, home, or grid storage systems [12].

- ***Nanoelectronics***

Reducing size of electronic products is the need of era and this can be achieved with the help of nanotechnology. Nanoelectronics show promise as a technology to continue the miniaturization of ICs. Flexibility is another major breakthrough in the world of electronics and flexible devices have started to make their way into the commercial realm. Flexible electronics is the future of mobile electronics with potential applications in wearable electronic devices, biomedical uses, compact portable devices, and robotic devices [13].

BENEFITS AND CHALLENGES

Nanotechnology impacts human life every day. The potential benefits of nanotechnology man and diverse; they are mind boggling and brain enhancing. Today, nanotechnology is being used in cosmetics, sunscreens, clothing, and several other consumer products. Nanotechnology is now enabling scientists to domesticate atoms. The emerging applications of nanotechnology in many industries create numerous jobs along the way.

However, there are known barriers to future progress in nanotechnology and its applications. Nanotechnology has tremendous potential, but social issues of public acceptance, ethics, regulation, and human safety must be addressed before nanotechnology can be seen as the possibility of providing high quality healthcare.

Critics expressed concerns that nanoparticles can have a negative impact on human health. Predicting the future of any major technology is hard.

CONCLUSION

Nanotechnology has generated excitement world-wide and is being regarded as the key technology of the 21st century. This excitement is partly due to the development of new instruments for observing and manipulating matter at the nano level. Nanotechnology is the future of advanced development. Although nanotechnology is maturing rapidly, it is still in a formative phase. Nanotechnology will affect almost everything. It is expected to give impetus for a wide range of fields of application in almost all sectors of technology and industry. It will present new opportunities to make the stuff of life (electronics, medicines, products, cars, homes, etc.) better and cheaper, using fewer raw materials. Dramatic breakthroughs will occur in diverse areas such as food, medicine, computing, energy, and robotics. How soon will these innovative ideas to complete the R&D phase and enter the market? No one knows [14]. However, we can confidently say that nanotechnology is here to stay and its uses and applications can be made ethically to benefit mankind. More information about the future of nanotechnology can be found in the books in [15-23] and the following related journals:

- *Nanotechnology*
- *Nanoscale.*
- *Journal of Nanoscience and Nanotechnology,*
- *Journal of Micro and Nano-Manufacturing*
- *Journal of Nanoengineering and Nanomanufacturing*

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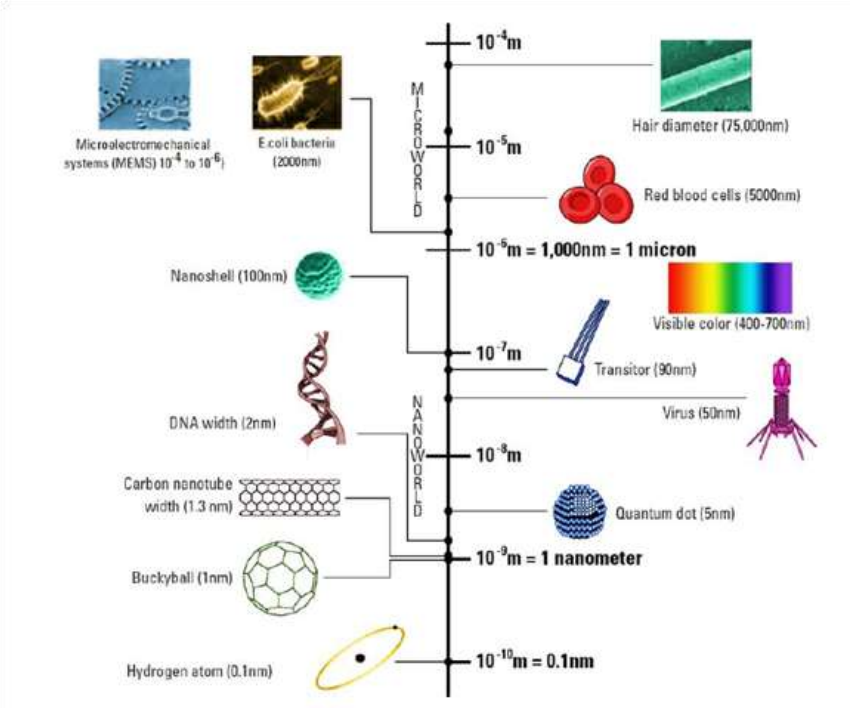

FIGURE 1: The size of things, from hair diameter (75.000 nm) to the hydrogen atom (0.1 nm) [3].

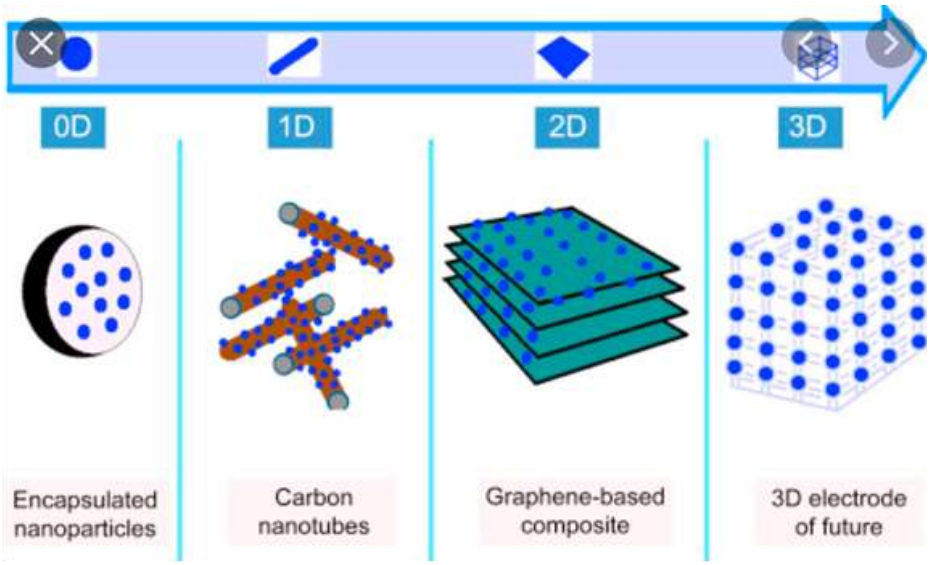

FIGURE 2: Classification of nanomaterials in classified in 0D, 1D, 2D, and 3D [6].

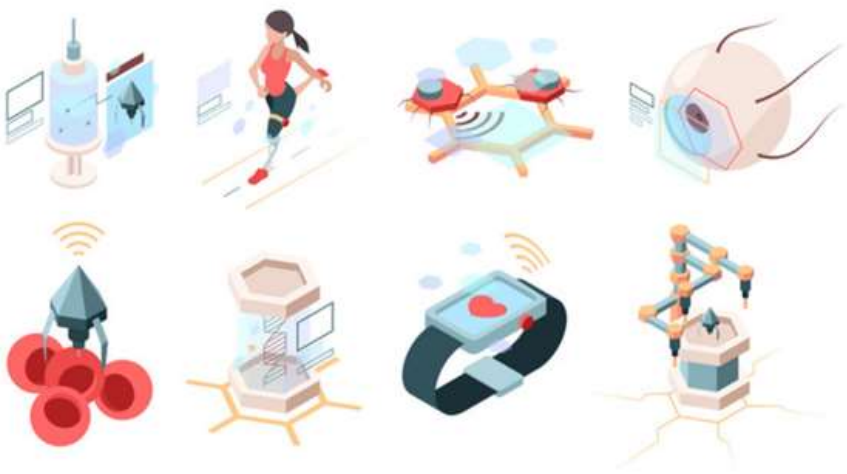

FIGURE 3: Medicine nanotechnology future systems [9].