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The Versatility of Nanotechnology in the Field of Science - A Review

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ABSTRACT

A word Nanotechnology to understand and manipulate matter at the molecular and atomic levels promise a wave of significant new technologies over the next five decades. Dramatic breakthroughs will occur in diverse areas such as physics, chemistry, biology, medicine, communications, computing, energy, and robotics. These changes will generate large amounts of wealth and force wrenching changes in existing markets and institutions. This paper discusses the range of sciences currently covered by nanotechnology. It begins with a description of what nanotechnology is and how it relates to previous scientific advances. It then describes the most likely future development of different technologies in a variety of fields. However, rapid advances in a number of fields, collectively known as nanotechnology, This paper discusses the range of sciences currently covered by nanotechnology. It begins with a description of what nanotechnology is and how it relates to previous scientific advances. It then describes the most likely future development of different technologies in field of Science.

Keywords: Nanotechnology, DNA, molecules, transistor, CMOS, Artificial Intelligence

I. INTRODUCTION

A nanometer (nm) is one billionth of a meter. For comparison purposes, the width of an average hair is 100,000 nanometers. Human blood cells are 2,000 to 5,000 nm long, a strand of DNA has a diameter of 2.5 nm, and a line of ten hydrogen atoms is one nm. The last three statistics are especially enlightening. First, even within a blood cell there is a great deal of room at the nanoscale. The U.S. National Nanotechnology Initiative defines nanotechnology as: The science, engineering, and technology related to the understanding and control of matter at the length scale of approximately 1 to 100 nanometers. However, nanotechnology is not merely working with matter at the nanoscale, but also research and development of materials, devices, and systems that have novel properties and functions due to their nanoscale dimensions or components.

In a more general context nanotechnology can be seen as just the current stage of a long-term ability to understand and manipulate matter at ever smaller scales as time goes by. Over the last century, physicists and biologists have developed a much more detailed understanding of matter at finer and finer levels. At the same time, engineers have gradually acquired the ability to reliably manipulate material to increasingly finer degrees of precision.

The Structure of Nanotechnology

Nanotechnology is distinguished by its interdisciplinary nature. For one thing, investigations at the Nano level are occurring in a variety of

academic fields. More important, the most advanced research and product development increasingly requires knowledge of disciplines that, until now, operated largely independently.

Nanotechnology in the field of Science

(i) Physics

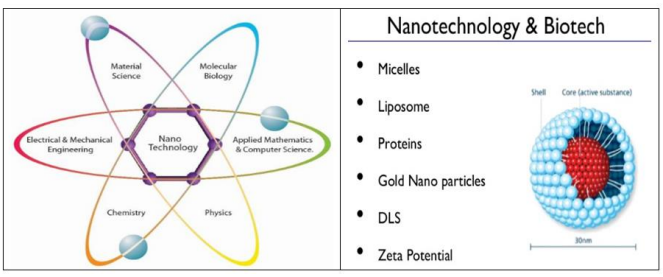
The construction of specific molecules is governed by the physical forces between the individual atoms composing them. Nanotechnology will involve the continued design of novel molecules for specific purposes. However, the laws of physics will continue to govern which atoms will interact with each other and in what way. In addition, researchers need to understand how quantum physics affects the behavior of matter below a certain scale.

(ii) Electrical and Electronics Engineering

To operate independently, Nano devices will need a steady supply of power. Moving power into and out of devices at that scale represents a unique challenge. Within the field of information technology, control of electric signals is also vital to transistor switches and memory storage. A great deal of research is also going into developing nanotechnologies that can generate and manage power more efficiently.

(iii) Chemistry

The interaction of different molecules is governed by chemical forces. Nanotechnology will involve the controlled interaction of different molecules, often in solution. Understanding how different materials interact with each other is a crucial part of designing new nanomaterials to achieve a given purpose.



(iv) Biology

A major focus of nanotechnology is the creation of small devices capable of processing information and performing tasks on the nanoscale. The process by which information encoded in DNA is used to build proteins. A better understanding of how biological systems work at the lowest level may allow future scientists to use similar processes to accomplish new purposes. It is also a vital part of all research into medical applications.

(v) Biotechnology (Genetics)

Nanotechnology promises an increased understanding and manipulation of the basic building blocks underlying all living matter. The basic theory of genetic inheritance has been known for some time. But biologists do not fully understand the details of how life goes from a single fertilized egg with a full set of chromosomes to a living animal. Questions exist on exactly how the information encoded in DNA is transcribed, the role of proteins, the internal workings of the cell and many other areas. Basically DNA consists of a long string of four molecules; adenine, thymine, guanine, and cytosine. Since these molecules are read off in units of three (called codons), there are 64 possible combinations. Each combination corresponds to one of 20 amino acids. The amino acids in turn form proteins that fold in unique three dimensional ways and perform many of the functions within individuals cells. On a basic level, research is allowing us to tease out the genetic basis for specific diseases and in the future may reliably allow us to correct harmful mutations. But what would a full understanding of the genetic process give us? Could we develop DNA that uses a fifth and sixth molecule? Could the existing process be reprogrammed to code for more than 20 amino acids? To what extent is it possible to create brand new proteins that perform unique functions? A better understanding of biological processes is obviously needed in order to deliver the health benefits that nanotechnology promises. But it is also important for many reasons outside of biology. Those used to traditional

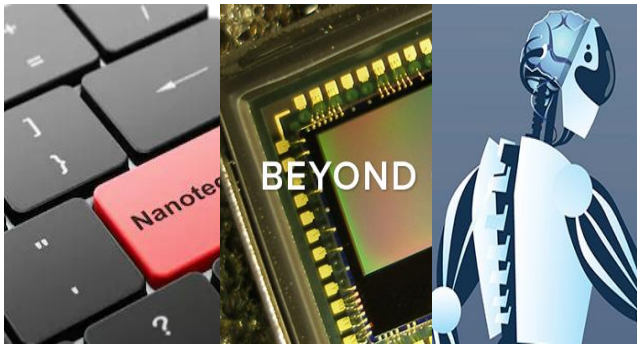
manufacturing techniques may at first have difficulty with the concept of building a product up from the molecular level. Biology offers a template for doing so. A single fertilized egg in the womb eventually becomes a human being; a system of incredible complexity from a simple set of instructions 2.5 nm in diameter. Scientists are hopeful that similar processes can be used to produce a range of other products.

(vi) Computer Science

The computer and communications industry has improved exponentially over the last several decades, has been accompanied by steady miniaturization. Continued decreases in transistor size face physical barriers including heat dissipation and electrons tunneling that require new technologies to get around. In addition, a major issue for the use of any Nano devices will be the need to exchange information with them. Finally, scientific advances will require the ability to manage increasingly large amounts of information collected from a large network of sensors.

(vii) Information Technology

Progress in information processing has depended on the continued application of Moore's law, which predicts a regular doubling of the number of transistors that can be placed on a computer chip. This produced exponential improvements in computing speed and price performance. Current computer technology is based on the Complementary Metal Oxide Semiconductor (CMOS). The present generation of computer chips already depends on features as small as 70 nanometers. Foreseeable advances in nanotechnology are likely to extend CMOS technology out to 2015. However, at transistor densities beyond that several problems start to arise. One is the dramatic escalation in the cost of a new fabrication plant to manufacture the chips. These costs must be amortized over the cost of the transistors, keeping them expensive. Second, it becomes increasingly difficult to dissipate the heat caused by the logic devices. Lastly, at such small distances, electrons increasingly tunnel between materials rather than going through the paths programmed for them. As a result of these constraints, any continuation of Moore's Law much beyond 2015 is likely to require the development of one or more new technologies. Future advances will also bring us closer to a world of free memory, ubiquitous data collection, massive serial processing of data using sophisticated software, and lightning-fast, always-on transmission. What happens when almost all information is theoretically available to everyone all the time?



(viii) Robotics Sciences

Continued advances in computer science combined with a much better understanding of how the human brain works should allow researchers to develop software capable of duplicating and even improving on many aspects of human intelligence. Although progress in Artificial Intelligence has lagged the expectations of many of its strongest proponents, specialized software continues to advance at a steady rate. Expert software now outperforms the best humans in a variety of tasks simply because it has instantaneous access to a vast store of information that it can quickly process. In addition, researchers continue to develop a much better understanding of how individual sections of the brain work to perform specific tasks. As processing power continues to get cheaper, more and more of it will be applied to individual problems.

II. Conclusion

Nanotechnology is highly interdisciplinary, involving physics, chemistry, biology, materials science, and the full range of the engineering disciplines. The word nanotechnology is widely used as shorthand to refer to both the science and the technology of this emerging field. Narrowly defined, nanoscience concerns a basic understanding of physical, chemical, and biological properties on atomic and near-atomic scales. Nanotechnology, narrowly defined, employs controlled manipulation of these properties to create materials and functional systems with unique capabilities.

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