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A REVIEW ON NANOTECHNOLOGY – SHAPING THE FUTURE

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Abstract:

A basic definition of Nanotechnology is the study manipulation and manufacture of extremely minute machines or devices. The future of technology at times becomes easier to predict. Computers will compute faster, materials will become stronger and medicine will cure more diseases .the technology that works at the nanometer scale of molecules and atoms will be a large part of this future, enabling great improvements in all the fields of human presence. A supercomputer no bigger than a human cell. A spacecraft no longer or more expensive than the family car. These are just a few promises of nanotechnology. Within a decade, nanotechnology is expected to be the basis of $1 trillion worth of products in the United States alone and will create anywhere from 8, 00,000 to 2 million new jobs.Nanotechnology is expected to have a revolutionary impact on medicine. A variety of medical processes occur at nanometer length scales. Among the approaches for exploiting developments in nanotechnology in medicine, nanoparticles offer some unique advantages as sensing, delivery, and image enhancement agents. Several varieties of nanoparticles are available including, polymeric nanoparticles, metal nanoparticles, liposomes, micelles, quantum dots, and dendrimers.

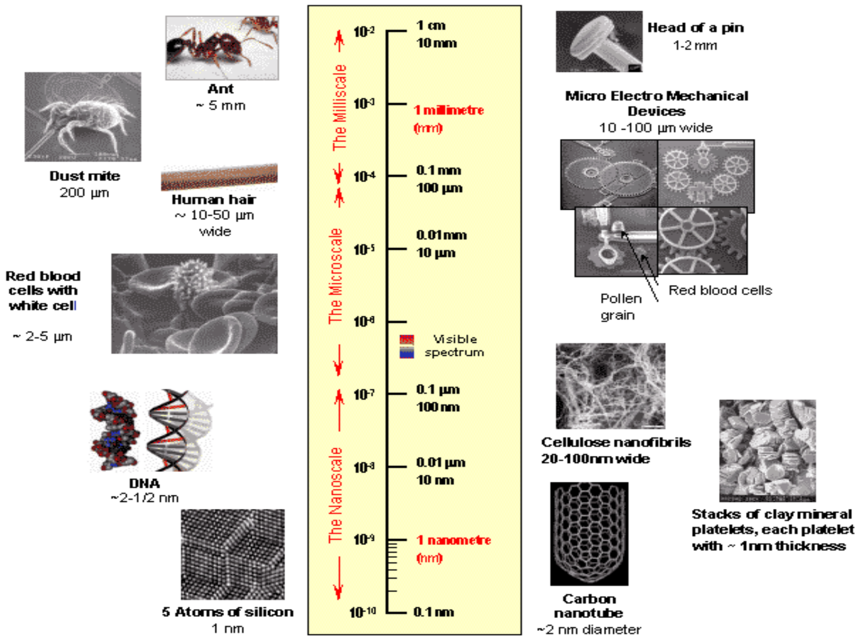
1. Introduction:

Nanoscience is the study of effects while nanotechnology is more about fabrication. Nanotechnology is about is building machines at the molelcular level. Machines so small they can travel through your blood stream. Since the days of D.W. Griffith, Hollywood movies have always entertained our need to be scared out of our seats with all things creepy-crawly, like an invasion of ants or spiders. Nanorobots traveling on highways just behind our eyeballs? Now that's scary. It is precisely such fear that will hinder nanotechnological development, and for good reason. The thought of nanorobots on a search and destroy mission to see out mutated bacteria and viruses in the body is enough to make most sci-fi stories up until now look like Disney cartoons. What's to prevent one of these nanorobots from going "mad?" If that's not enough, imagine these nanorobots as weapons of mass destruction. Many scientists and other socially concerned individuals are, in fact, imagining such scenarios.Nanotechnology is the manufacturing of electronic circuits and mechanical devices at the molecular level. At the molecular level, scientists can create materials and structures atom by atom, with fundamentally new functions and characteristics. But for as small as nanotechnology might be in design, its scope dramatically affects every other field, from the biosciences to medicine, from physics to DNA manipulation. Nanotechnology promises many new benefits in medicine. The National Cancer Institute is funding a project that uses nanotechnology to develop a targeted delivery system for anti-cancer drugs. The National Heart, Lung, and Blood Institute is funding researchers at Biomod Surfaces in Salisbury, MA, using nanofiber technology to create blood vessel replacements for vascular disease and heart bypass surgeries. The National Institute on Alcohol Abuse and Alcoholism and Howard University, Washington D.C., are creating injectable nanoparticles that control delivery and availability of naltrexone, a medication for treatment of alcoholism and other addictive disorders.

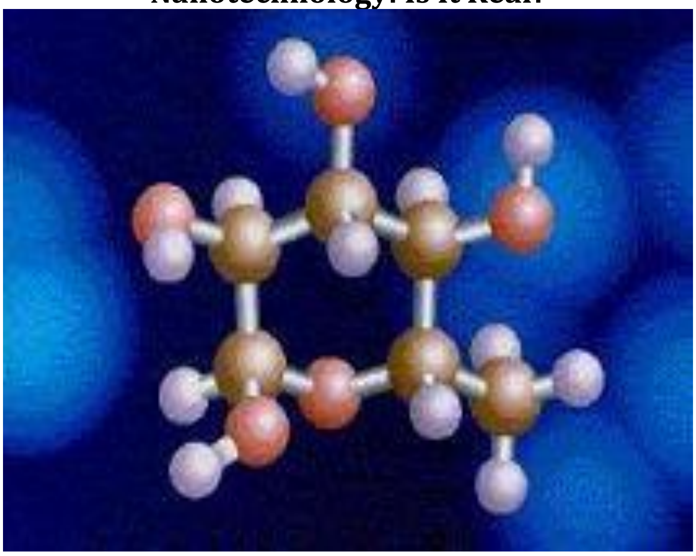
What is Nanotechnology? :

Nanotechnology—How Big or Small?

If a definition of technology is "the application of science and scientific knowledge for industrial or commercial objectives," then in its most simplistic form, nanotechnology might be specifically defined as "the application of science and scientific knowledge, at the nanoscale, for industrial or commercial objectives." In order to understand the size of material/matter involved at the nanoscale level, one needs to trace down the units of measurement, commencing with an ant (at the milliscale) and ending at the very bottom, at the nanoscale. The nanoscale is far from the smallest unit of measurement—it is however the smallest scale at which matter can be manipulated. Figure 1 illustrates where the nanoscale fits in with relation to other scales.



Nanotechnology: Is It Real?



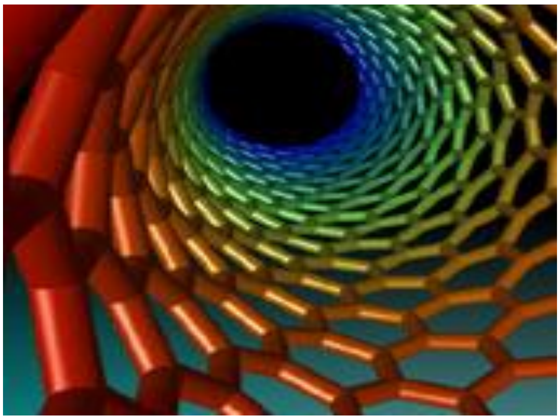
For the uninitiated, Nanotechnology might seem somewhat cartoonish, simply because of the funny word "nano." But, rest assured, nanotechnology is very real…and it's definitely not a cartoon. Understanding nanotechnology and nanoscience means learning how to think small…very small. This paradigm is a 180-degree turnaround from a world that up until now was built on thinking big. In the battle of the telescope versus the microscope, the stars always win out over the atoms. Afterall, we can see the stars with our own eyes. It takes tremendous imagination to see what something might look like at the molecular level. Well, nanotechnology takes place at the atomic, molecular or macromolecular levels, in the length scale of approximately 1-100 nanometer range. A nanometer is one-billionth of a meter. Forget your average lab microscope. Molecules consist of one or more atoms. So, how big is an atom? To get us there, our imaginations can start with one cubic inch of air, which consists of an estimated 500 billion molecules.

Applications:

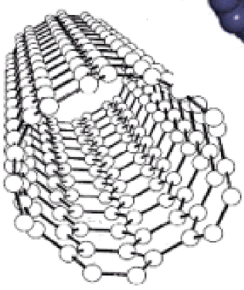
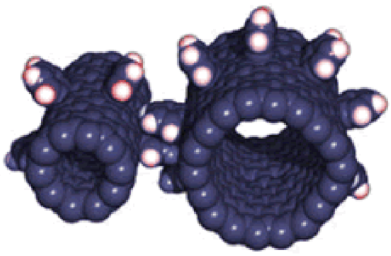
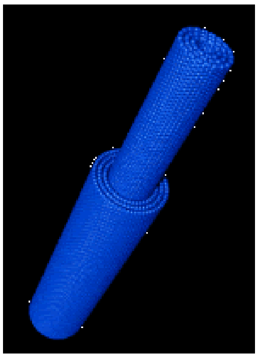
Robotics:

Robotic surgical systems are being developed to provide surgeons with unprecedented control over precision instruments. This is particularly useful for minimally invasive surgery. Instead of manipulating surgical instruments, surgeons use their thumbs and fingers to move joystick handles on a control console to maneuver two robot arms containing miniature instruments that are inserted into ports in the patient. The surgeon's movements transform large motions on the remote controls into micro-movements on the robot arms to greatly improve mechanical precision and safety. A third robot arm holds a miniature camera, which is inserted through a small opening into the patient. The camera projects highly magnified 3-D images on a console to give a broad view of the interior surgical site. The surgeon controlling the robot is seated at an ergonomically designed console with less physical stress than traditional operating room conditions.

Carbon Nanotubes




The combination of remarkable mechanical properties and unique electronic properties of carbon nanotubes (CNTs) offers significant potential for revolutionary applications in electronics devices, computing and data storage technology, sensors, detectors, nanoelectromechanical systems (NEMS), as tip in scanning probe microscopy (SPM) for imaging and nanolithography and a number of other applications. Thus the CNT synthesis, characterization and applications touch upon all disciplines of science and engineering. This tutorial will provide an overview of the following topics: CNT properties, growth techniques particularly CVD and plasma CVD, patterned growth, vertical alignment, applications in nanoelectronics, sensors, field emission, microscopy and others.

Development of Silicon Carbide Nanotubes (SiCNT) for Sensors and Electronics:

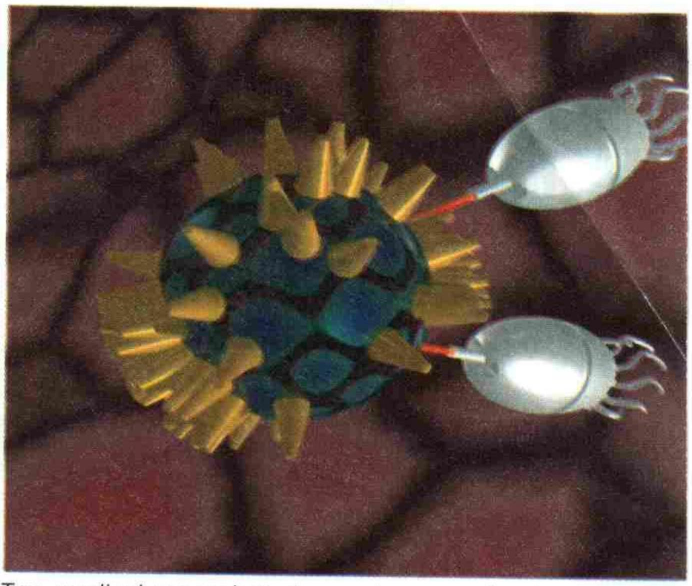
The objective of this task is to evaluate multiple approaches to synthesize and characterize the highest performing SiCNTs for high temperature & high radiation conditions. Also to develop sophisticated modeling and simulation technologies that will facilitate the research and development of various chemical techniques for SiC-based nanotube (SiCNT) fabrication and to further expedite the design and prototyping of more complicated assemblies and devices made from SiCNTs. Multiple synthetic approaches are planned which parallel the direct CNT formation as well as an indirect approach involving derivatization of a CNT to a SiCNT. One indirect approach that may be envisioned to produce a SiCNT, which can be thought of as a chemical derivative of a CNT, starts with a CNT that is modified by chemically attaching different Silicon-containing functional groups to the CNT (functionalizing). This derivatized-CNT is then pyrolyzed in an appropriate environment to yield a SiCNT. A more direct approach would employ Chemical Vapor Deposition (CVD) using reduced partial-pressures of reactants and trace amounts of catalysts to directly obtain SiCNTs. This more direct fabrication attempt would rely on high temperature (2000°C) CVD using a catalytic (trace metal) substrate. Compared with theoretical SiCNT modeling results. The electrical properties include investigations into potential semiconductor properties that could be extended to higher (than CNT) temperatures. Once fabricated, the SiCNTs electrical and mechanical properties would be characterized and Electrical activity of SiCNTs could also be studied as a function of adsorbates, which could ultimately lead to applications such as nano-gas-sensors for harsh environments. Mechanical properties to be studied include tensile and compressive stress for structural components (e.g. actuators) and also their effect on SiCNT electrical properties. Knowledge gained from these fabrication results and empirical investigations can be incorporated into the models of the simulation environment to improve fidelity.

Nanomedicine:

The Promise of Nanomedicine:

The ultimate promise of nanomedicine is the eradication of disease. To accomplish this goal requires the convergence of nanotechnology and biotechnology. In turn, nanomedicine is the convergence of many disciplines: biology, chemistry, and physics, engineering and material science.

***The eradication of disease involves three sub-goals*:**



Two medical nanorobots in a pulmonary alveola killing a virus using nanolasers (Artist: Antonio Siber)

1. Using nano-robots, nano-machines or other methods at the molecular level to search and destroy disease causing cells
2. Same as above for the purposes of repairing damaged cells
3. Using pumps or similar technology at the molecular scale as a means of drug delivery

Nanotechnology involves the creation and use of materials and devices at the level of molecules and atoms. As life itself creates and uses molecular materials and devices, nanoscience will provide great insights in life science concepts, such as how molecular materials self-assemble, self-regulate, and self-destroy. Nanomedicine eventually will infiltrate virtually every field of medicine, if not every realm of human endeavor. Nanomedicine may be defined as the monitoring, repair, construction and control of human biological systems at the molecular level, using engineered nanodevices and nanostructures. A sample list of areas covered by and converged with nanomedicine include: Biotechnology, Genomics, Genetic Engineering, Cell Biology, Stem Cells, Cloning, Prosthetics, Cybernetics, Neural Medicine, Dentistry, Cryonics, Veterinary Medicine, Biosensors, Biological Warfare, Cellular Reprogramming, Diagnostics, Drug Delivery, Gene Therapy, Human Enhancement, Imaging Techniques, Skin Care, Anti-Aging.

Nanomedical Issues:

Mobile nanorobotic janitors (green) patrol the lungs, collecting inhaled debris and transporting it to recycling stations (blue-gray) (Artist: Tim Fonseca)

Other nanomedical issues include sensory feedback, control architectures, cellular repair and destruction, replication, safety, biocompatibility, environmental interaction, genetic analysis, diagnosis and treatment. Treatment covers the full range of illness and disease, from cardiovascular to trauma, amputations to burns, brain, spinal and other neural injuries/diseases, nutrition, sex and reproduction, cosmetics and aging.

Devices:

Nanodevices will supplement current micro devices, which includes micro-electromechanical systems (MEMS), microfluidics, and microarrays. Examples of medical applications include biosensors and detectors to detect trace quantities of bacteria, airborne pathogens, biological hazards, and disease signatures, microfluidic applications for DNA testing and implantable fluid injection systems and MEMS devices which contain miniature moving parts for pacemakers and surgical devices. MEMS stands for Micro Electronic Mechanical Systems, a technology used to integrate various electro-mechanical functions onto integrated circuits. A typical MEMS device combines a sensor and logic to perform a monitoring function. A typical example is the sensing device used to deploy airbags in cars and switching devices used in optical telecommunications cables. MEMS developers will be able to exploit nanotechnologies in fabricating new integrated circuits (NEMS—Nano Electrical Mechanical Systems).

Other Applications:

New imaging technologies will provide high quality images not currently possible with current devices. This allows greater surgical precision and targeted treatment. Chasing cancerous cells or removing tumors can result in severely damaged normal tissue or the loss of abilities like hearing and speech as in the case of brain tumors. Nanotechnology can offer new solutions for the early detection of cancer and other diseases. Nanoprobes can be used with magnetic resonance imaging (MRI). Nanoparticles with a magnetic core are attached to a cancer antibody that attracts cancer cells. The nanoparticles are also linked with a dye, easily seen on an MRI. The nanoprobes latch onto cancer cells and once detected by MRI, can then emit laser or low dosage killing agents that attack only the diseased cells. Miniature devices are also implantable for imaging not possible currently. A pill, for instance, can contain a miniature video system. When the pill is swallowed, it moves through the digestive system and takes pictures every few seconds. The entire digestive system can be assessed for tumors, bleeding, and diseases in areas not accessible with colonoscopies andendoscopies.

Conclusion:

We can nevertheless to say our coming age will be a nanotechnology. Adding programmed positional control existing methods gives us greater control over the material world and improved our standards of living.

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