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Nanotechnology : A Boon for Medical Science

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As the twenty first century unfolds nano-technology's impact on the health, wealth and security of the people and it is expected to be at least as significant as the combined influences in the century of antibiotics the integrated cricket and human made polymers. Nanotechnology engineering is a multi-disciplinary engineering field, which simultaneously draws from and benefits areas such as material science and engineering, chemistry, physics and biology. Indeed, it is all about generating new solutions based on atomic- and molecular-scale manipulations.

Nanotechnology most commonly refers to the fabrication, study and manipulation of structures having sizes in the range from one to one hundred nanometers (a nanometer is a billionth of a meter). This length scale bridges the important gap between atoms and molecules (which are less than one nanometer in size) and bulk materials; requiring fundamental chemistry and quantum physics. Clusters, fullerenes, nanotubes, macromolecules, nanorobots, and nanosystems, are the examples of Nano-technology system. [1]

Nanotechnology is an emerging interdisciplinary technology that has been booming in many areas during the recent decade, including material science, mechanics, electronics, optics, medicine, plastics, energy electronics and aerospace. Its profound societal impact has been considered as the huge momentum to usher in a second industrial revolution.

The "nano" in Nanotechnology comes from the Grek work "nanos" that means dwarf. Scientists use this prefix to indicate 10^{-9} or one-billionth. One nanometer is one-billionth meter that is about 100,00 times smaller than the diameter of a single human hair. Nano-technology endeavors are aimed at manipulating atoms, molecules and nano- size particles in a precise and controlled manner in order to build materials with a fundamentally new organization and novel properties. The embryo of Nanotechnology is "atomic assembly" which was first publicly articulated in 1959 by physicist Richard Feynman. Nanotechnology is called a “bottom up” technology by which bulk materials can be built precisely in tiny building blocks, different from the traditional manufacture; “top down” technology. Therefore, resultant materials have fewer defects and higher quality. [2]

The fundamentals of Nanotechnology lie in the fact that properties of substances dramatically change when their size is reduced to the nanometer range. When a bulk material is divided into small size particles with one or more dimension (length, width or thickness) in the nanometer range or even smaller, the individual particles exhibit unexpected properties, different from those of the bulk materials. It is known that atoms and molecules possess totally different behaviors than those of bulk materials; while the properties of the former are described by quantum mechanics, the properties of the latter are governed by classical mechanics.

The field is loosely divided into four subareas: micro and nanoinstruments, nanoelectronics, nano-biosystems, and nanoengineered materials:

The first addresses some of the most far-reaching yet practical applications of miniature instruments for measuring atoms or molecules in chemical, clinical, or biochemical analysis; in biotechnology for agent detection; and environmental analysis.

The second category, nanoelectronics concerns the development of systems and materials required for the electronics industry to go beyond current technological limits – producing even finer details than features in a high-performance microprocessor chip. Also in this category is a new generation of electronics based on plastics, which is expected to create new markets with applications ranging from smart cards to tube-like computers.

The third class, nano-biosystems can be described as molecular manipulation of biomaterials and the associated miniaturization of analytical devices such as DNA, peptide, protein, and cell chips.

The last subarea, nanoengineered materials looks at several classes of advanced materials including nanocrystalline materials and nanopowders used in electronics and photonics applications, as catalysts in automobiles, in the food and pharmaceutical industries, as membranes for fuel cells, and for industrial-scale polymers.

Application of Nanotechnology in Cancer Drug Delivery

Nanomaterials are at the cutting edge of the rapidly developing area of nanotechnology. The potential for nanoparticles in cancer drug delivery is infinite with novel new applications constantly being explored. Multifunctional nanoparticles play a very significant role in cancer drug delivery. [3] In the past, cancer patients were using various anticancer drugs but these drugs were less successful and had major side effects. Nanoparticles have attracted the attention of scientists because of their multifunctional character. The treatments of cancer using targeted drug delivery nanoparticles are the latest achievement in the medical field.

With more than 10 million new cases every year, cancer has become one of the most devastating diseases worldwide [4]. In 2000, it has been reported by The World

Health Organization (WHO), malignant tumors were responsible for 12 per cent of the nearly 56 million deaths worldwide from all causes. Over 22 million people in the world were treated for cancer in 2000, representing an increase of approximately 19 per cent in incidence (cases) and 18 per cent in mortality since 1990. In many countries, more than a quarter of deaths are attributable to cancer. This article focuses different types of nano particles and the application in treatment of cancer.

Nanoparticles and other nanostructures appear to hold great promise for the future of cancer treatment. In experimental studies, primarily in animal models, nanoparticles appear to be able to selectively deliver high concentrations of antitumour drugs to tumor cells. The high concentrations of toxic agents seem to persist for long periods within tumor cells and have more potent antitumour effects and less toxicity than their systematically administered counterparts. Nanoparticles are much more successful at delivering anticancer agents during drug delivery to cancer cells or tissues.

One of the main goals of nanomedicine is to create medically useful nanodevices that can function inside the body. Additionally, nanomedicine will have an impact on the key challenges in cancer therapy such as localized drug delivery and specific targeting. Among the recently developed nanomedicine and nanodevices, quantum dots, nanowires, nanotubes, nanocantilevers, nanopores, nanoshells and nanoparticles are potentially the most useful for treating different types of cancer.

Nanodevices

"Smart" dynamic nanoplatforms have the potential to change the way cancer is diagnosed, treated, and prevented.

Nanoscale devices (less than 100 nanometers) can enter cells and the organelles inside them can interact with DNA and proteins. Tools developed through nanotechnology may be able to detect disease in a very small amount of cells or tissue. They may also be able to enter and monitor cells within a living body. In order to successfully detect cancer at its earliest stages, scientists must be able to detect molecular changes even when they occur only in a small percentage of cells. This means the necessary tools must be extremely sensitive.

Nanopores

Another interesting nanodevice is the nanopore. Improved methods of reading the genetic code will help researchers detect errors in genes that may contribute to cancer. Scientists believe nanopores, tiny holes that allow DNA to pass through one strand at a time, will make DNA sequencing more efficient. As DNA passes through a nanopore, scientists can monitor the shape and electrical properties of each base, or letter, on the strand. Because these properties are unique for each of the four bases that make up the genetic code, scientists can use the passage of DNA through a nanopore to decipher the encoded information, including errors in the code known to be associated with cancer.

Nanotubes

Nanotubes are carbon rods about half the diameter of a molecule of DNA that cannot only can detect the presence of altered genes but they may help researchers pinpoint the exact location of those changes. Carbon nanotubes (CNTs) are remarkable solid state nanomaterials due to their unique electrical and mechanical properties. The electronic properties of nanotubes combined with biological molecules such as proteins could make miniature devices for biological sensing applications. [5,6]

Nanoshells

Nanoshells are layered colloids with a nonconducting nanoparticle [7] core covered by a thin metal shell, whose thickness can be changed to precisely tune the plasmon resonance.

Quantum Dots

Quantum dots are tiny crystals that glow when stimulated by ultraviolet light. The wavelength or color of the light depends on the size of the crystal. 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. The diversity of quantum dots will allow scientists to create many unique labels, which can identify numerous regions of DNA simultaneously. This will be important in the detection of cancer, which results from the accumulation of many different changes within a cell. Another advantage of quantum dots is that they can be used in the body, eliminating the need for biopsy.

Other Practical applications of Nanotechnology

Applications include ultra-fast and high memory capacity computers, highly advanced communication systems, advanced display technology, advanced biological imaging, stem-cell engineering, medical diagnostic tools, sensors for airborne pollutants, energy storage materials, photovoltaic cells fuel cells, polymer nanocomposites, super-tough nanocoatings, landmine detectors, and thousands more.

Conclusion

Nanotechnology is useful for developing ways to eradicate cancer cells without harming healthy, neighboring cells. Scientists hope to use nanotechnology to create therapeutic agents that target specific cells and deliver their toxin in a controlled, time-released manner. Nanotechnology is definitely a medical boon for diagnosis, treatment and prevention of cancer disease. It will radically change the way we diagnose, treat and prevent cancer to help meet the goal of eliminating suffering and death from cancer. Although most of the technologies described are promising and fit well with the current methods of treatment, there are still safety concerns associated with the introduction of nanoparticles in the human body. These will require further studies before some of the products can be approved. Nanoteachnology is also overcoming challenges of early detection and imaging therapies.

References

[1] Cover story, Nanomaterials, A Big Market potential, Chemical Week, October 16, 17, 2002,.

[2] Qian Lei, Juan P, Application of Nanotechnology for high performance textiles, Journal, 4, 1, 1-6, 2004.

[3] K. K. Jain, Editorial: Targeted Drug Delivery for Cancer, TCRT, 4, 4, 2005.

[4] B.W. Stewart, P. Kleihues, World Cancer Report, IARC Nonserial Publication, 2003.

[5] M. Bockrath, D.H. Cobden, P.L. McEuen, N.G. Chopra, A. Zettl, A. Thess, R.E. Smalley, Single-Electron Transport in Ropes of Carbon Nanotubes Science, 275, 1922-1925, 1997.

[6] R.S. Ruoff, D.C. Lorents, Mechanical and Thermal Properties of Carbon Nanotubes, Carbon, 33, 925-930, 1995.

[7] L. R. Hirsch, R. J. Stafford, J. A. Bankson, S. R. Sershen, B. Rivera, R. E. Price, J. D. Hazle, N. J. Halas, J. L. West, Nanoshell-mediated near-infrared thermal therapy of tumors under magnetic resonance guidance, PNAS, 100, 23, 13549–13554, 2003.