



Future Impact of Nanotechnology on Medicine and Public Health

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Abstract: *Nanotechnology is a multidisciplinary field which covers a vast and diverse array of devices derived from engineering, physics, chemistry, biology and many other fields. The burgeoning new field of nanotechnology, opened up by rapid advances in science and technology that creates myriad new opportunities for advancing medical science and disease treatment in human health care. Applications of nanotechnology to medicine and physiology imply materials and devices designed to interact with the body at subcellular (i.e., molecular) scales with a high degree of specificity. This can be potentially translated into targeted cellular and tissue-specific clinical applications designed to achieve maximal therapeutic efficacy with minimal side effects.*

Keywords: *Nanotechnology.*

I. INTRODUCTION

Nanotechnology is the science of the extremely tiny. It is so small that even the most powerful conventional microscopes cannot see it. To put things in perspective, if the world were scaled down so that people averaged 100 nanometers tall, the Moon would be about 8 inches (20.5 cm) across—about the size of a basketball or a soccer ball. The Earth would be roughly 30 inches (76 cm) in diameter, or just small enough to squeak through a doorway.

Microscopic robotic surgeries, artificial skeletons and muscles, noninvasive imaging devices; the promises of nanotechnology are seemingly endless. Medicine based on nanotechnology is expensive; perhaps even more so than many of the other current and extremely expensive technologies available today [1]. This cost could have dramatic effects on the already large gap between the health problems that are widespread in wealthy countries compared to those that are prevalent in poorer countries. Even if we were able to completely understand the medical benefits of nanotechnology, we would still need to closely examine possible social effects.

II. APPROACHES AND BENEFITS

There are two basic approaches used to design nanomolecules: top-down and bottom-up. In the top-down approach, scientists start with macroscopic material and then modify the material using ultra-precise instruments. Alternatively in the bottom-up approach, researchers try to design and synthesize molecules that will self-assemble given a change in the surrounding environment, such as a change in pH, the concentration of the solute, or the electric charge [2]

Once made, these nanomolecules have a wide range of potential applications within the medical field. For example, researchers could make drugs with far fewer side effects by developing nanomaterials that affect desired biological targets with incredible accuracy. Cancer medications using nanomolecules would be better able to selectively kill tumor cells rather than indiscriminately killing both cancerous and healthy cells. For example, a buckyball, a very small sphere of carbon atoms with a cage-like structure, provides a useful example. The cage-like structure allows other molecules, such as a drug, to be encased inside. Independently, these encased molecules are potentially dangerous if they come into contact with certain molecules or tissues, but buckyballs ensure that the drug is safely delivered where it needs to go [3]

III. NANOTECHNOLOGY AND MEDICINE

Nanotechnology involves manipulating properties and structures at the nanoscale, often involving dimensions that are just tiny fractions of the width of a human hair. Nanotechnology is already being used in products in its passive form, such as cosmetics and sunscreens, and it is expected that in the coming decades, new phases of products, such as better batteries and improved electronics equipment, will be developed and have far-reaching implications [4]

One area of nanotechnology application that holds the promise of providing great benefits for society in the future is in the realm of medicine. Nanotechnology is already being used as the basis for new, more effective drug delivery systems and is in early stage development as scaffolding in nerve regeneration research. Moreover, the National Cancer Institute has created the Alliance for Nanotechnology in Cancer in the hope that investments in this branch of nanomedicine could lead to breakthroughs in terms of detecting, diagnosing, and treating various forms of cancer.

Nanotechnology medical developments over the coming years will have a wide variety of uses and could potentially save a great number of lives. Nanotechnology is already moving from being used in passive structures to active structures, through more targeted drug therapies or “smart drugs.” These new drug therapies have already been shown to cause fewer side effects and be more effective than traditional therapies. In the future, nanotechnology will also aid in the formation of molecular systems that may be strikingly similar to living systems. These molecular structures could be the

basis for the regeneration or replacement of body parts that are currently lost to infection, accident, or disease. These predictions for the future have great significance not only in encouraging nanotechnology research and development but also in determining a means of oversight. The number of products approaching the FDA approval and review process is likely to grow as time moves forward and as new nanotechnology medical applications are developed.[4]

IV. MEDICAL DEVICES BASED ON NANOTECHNOLOGY

Nanotechnology tools are used in process development and product development. Process development refers to both synthesis of drugs, drug intermediates, and to the development of analytical tools for diagnostics. One of the most important tool is miniaturization and automation in organic synthesis and biological screening on a nanoscale. In addition to the miniaturization of synthetic methods, nanomaterials are being developed as efficient catalysts and supports for solid-phase organic synthesis. Magnetic nanoparticle supported chiral Ruthenium complexes are known to catalyze heterogeneous asymmetric hydrogenation of aromatic ketones with remarkably high activity and enantioselectivity. Magnesium oxide nanoparticles are utilized for residue-free catalytic process for production of Nabumetone, an anti-inflammatory agent, in high yield and high selectivity.

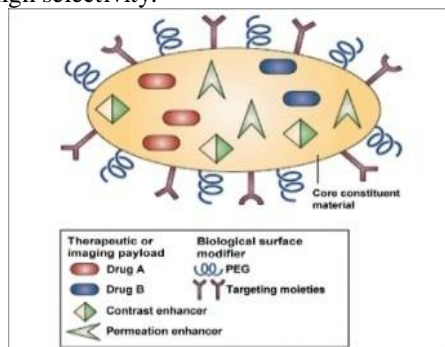


Fig1: Diagram of Nanoscale

One of the most obvious and important nanotechnology tool for product development is the opportunity to convert existing drugs having poor water solubility and dissolution rate into readily water soluble dispersions by converting them into nanosize drugs. Simply by reducing the particle size of drugs to the nanometer range, the exposed surface area of the drug is increased and hence its ability to be absorbed. Once the drug is in nano form, it can be converted into different dosage forms such as oral, inhalation, nasal, and injectable. [5][6]. One of the major applications of nanotechnology in relation to medicine is drug delivery. The problems with the new chemical entities such as insolubility, degradation, bioavailability, toxicologic effects, targeted drug delivery, and controlled drug release are solved by nanotechnology. For example, encapsulated drugs can be protected from degradation. Specific nanosized receptors present on the surface of the cell can recognize the drug and elicit appropriate response by delivering and releasing the therapy exactly wherever needed. Because of their small size and large surface area relative to their volume, nanoscale devices can readily interact with biomolecules. Nanoscale devices include: nanoparticles, nanotubes, cantilevers, semiconductor nanocrystals, and liposomes.

V. NANOTUBES

Nanotubes are smaller than nanopores . Nanotubes help to identify Dioxiribonucleic acid (DNA) changes associated with cancer cells. They are about half the diameter of a molecule of DNA. It helps to exactly pin point location of the changes. Mutated regions associated with cancer are first tagged with bulky molecules. The physical shape of the DNA can be traced with the help of the nano tube tip. A computer translates the information into topographical map. The bulky molecules identify the regions on the map where mutations are present. Since the location of mutations can influence the effects they have on a cell, these techniques are important in predicting disease. [7],[8],[9]

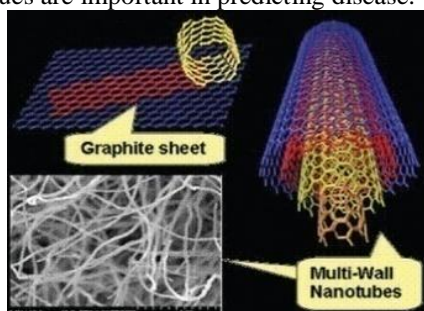


Fig2: Nanotubes

VI. QUANTUM DOTES

These are tiny crystals that glow when these are stimulated by ultraviolet light. The latex beads filled with these crystals when stimulated by light, emit the color that lights up the sequence of interest. By combining different sized quantum dotes within a single bead, probes can be created that release a distinct spectrum of various colors and intensities of

lights, serving as sort of spectral bar code. Latex beads filled with crystals can be designed to bind to specific DNA sequences. When the crystals are stimulated by light, the colors they emit serve as dyes and light up the sequences of interest. [\[7\].](#)[\[10\].](#)[\[11\].](#)[\[12\]](#)

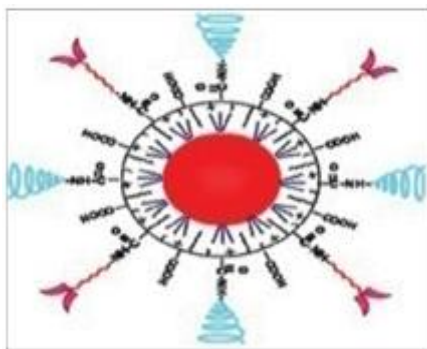


Fig3: Quantum

VII. NANOSHELLS

Nanoshells (NS) are gold coated miniscule beads. The wavelength of light which the beads absorb is related to the thickness of the coatings. Thus, by manipulating the thickness of the layers making up the NS, the beads can be designed that absorb specific wavelength of light. The most useful NS are those that absorb near infrared light that can easily penetrate several centimeters in human tissues. Absorption of light by NS creates an intense heat that is lethal to cells. Metal NS which are intense near-infrared absorbers are effective both *in-vivo* and *in-vitro* on human breast carcinoma cells [13]

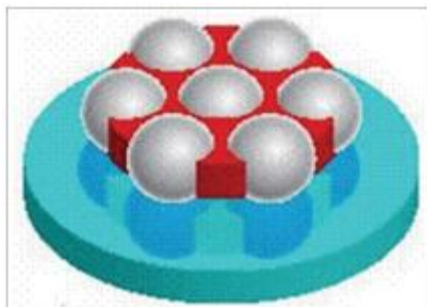


Fig4: Nanoshells Liposomes

Liposomes are self-assembling, spherical, closed colloidal structures composed of lipid bilayers that surround a central aqueous space. Liposomal formulations have shown an ability to improve the pharmacokinetics and pharmacodynamics of associated drugs. Liposome based formulations of several anticancer agents have been approved for the treatment of metastatic breast cancer and Kaposi's sarcoma. [\[14\].](#)[\[15\].](#)[\[16\]](#)

Cantilevers

Tiny bars anchored at one end can be engineered to bind to molecules associated with cancer [\[Figure 5\]](#). These molecules may bind to altered DNA proteins that are present in certain types of cancer monitoring the bending of cantilevers; it would be possible to tell whether the cancer molecules are present and hence detect early molecular events in the development of cancer cells. [\[17\].](#)[\[18\]](#)

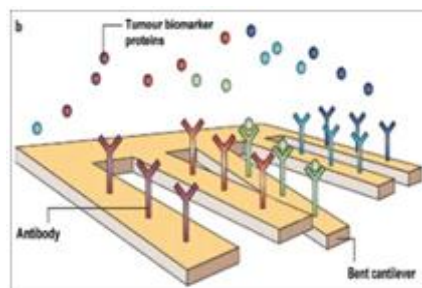


Fig5: Cantilevers

Dendrimers

Dendrimers are new class of macromolecules which have a symmetric core and form the 3-D spherical structure [\[Figure 6\]](#). These have branching shape which gives them vast amounts of surface area to which therapeutic agents or other biologically active molecules can be attached. A single dendrimer can carry a molecule that recognizes cancer cells, a therapeutic agent to kill those cells, and a molecule that recognizes the signals of cell death. It is said that dendrimers can be manipulated to release their contents only in the presence of certain trigger molecules associated with cancer. [\[19\].](#)[\[20\].](#)[\[21\]](#)

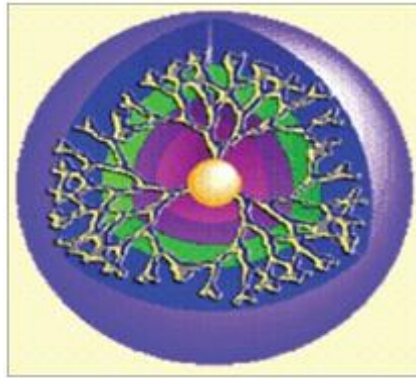


Fig6: Dendrimers

VIII. 4 WAYS NANOTECHNOLOGY WILL REVOLUTIONIZE MEDICINE

A. Nanomedicine

For some medicine, like chemotherapy, treatment is like trying to hit a small target with a fire hose. The likelihood to hit the bullseye is high, but in the process the rest of the board will take damage. The same is true when seeking out cancer cells. Chemotherapy is effective but does a number on the human body, causing a plethora of unwanted side effects. Nanomedicine aims to turn the fire hose into a precise dart. The National Nanotechnology Initiative reports that drugs that aim toxins directly at tumors without affecting other areas of the body are already in clinical trials. The same technology can also be used for early Alzheimer's detection. This new wave of technology isn't just for treatment. Researches at the Roswell Park Cancer Institute are studying a method where nanoparticles provide specific imaging for doctors during surgeries. Combined with a specific dye, the particles react to tumors to help visualize the cancerous tissue and arm doctors with better information. The new innovation will help make surgeries faster and more efficient.

B. 3D Printing

Also known as additive manufacturing, 3D printing uses a variety of materials to build 3D objects from scratch using CAD files to design almost anything the mind can imagine. Right now the technology is used to experimentally build anything from car engines to firearms, but 3D printing could also serve as a valuable tool in the medical industry. Manufacturing, waste and transportation all increase the final price on medical bills, making health care costs out of reach for many consumers. Take prosthetic limbs, for example. Building artificial limbs for amputee victims is a long and expensive process. With advanced 3D printing, a prosthetic limb could go from design to finished product for a fraction of the price (and all under one roof), cutting down on waste and time in the process. Chris Barnatt, professor of computing and future studies at Nottingham University, said that [3D printing](#) is no longer just a prototype but ready for real-world application.[22]

C. Nanowires

The annual checkup with a general practitioner is a hassle and often skipped, leaving many Americans at risk to conditions like high blood pressure. The Georgia Institute of Technology wants to take the checkup out of the equation. Popular Mechanics reports they've designed an implantable nanowire that records vital stats and can alert the patient or doctor if fluctuations in blood pressure become alarming. The alerts could be especially useful when patients are traveling abroad. Providers like [HCCMIS](#) could partner with friendly nations to forward alerts to doctors nearby. Currently, the most convenient method to measure blood pressure is a strap around the arm, but with the nanowire, a small watch could record the data and even send life-saving alerts to a doctor in case of cardiac arrest.

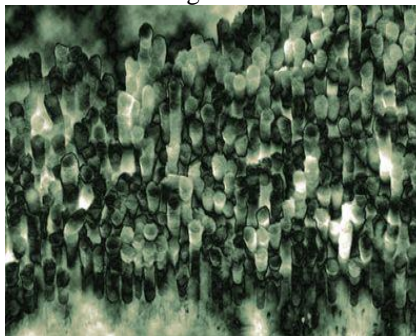


Fig7: Nanowires

Scrubs and lab coats from Vestagen Technical Textiles are made with nanosized silicon particles that repel microscopic materials. The silicone creates a tension on the surface of the clothes that help reject up to 99.9 percent of dangerous bacteria found in blood and vomit, which could be hazardous to doctors and nurses. The innovative clothing materials don't just keep medical professionals safe, but help prevent the spread of disease to other patients, too.

D. Medical-Supplies

Infection control is another area of health care nanotechnology could serve well. Scrubs and lab coats from Vestagen Technical Textiles are made with nanosized silicon particles that repel microscopic materials. The silicone creates a tension on the surface of the clothes that help reject up to 99.9 percent of dangerous bacteria found in blood and vomit, which could be hazardous to doctors and nurses. The innovative clothing materials don't just keep medical professionals safe, but help prevent the spread of disease to other patients, too [22]

IX. CONCLUSION

Within 10–20 years it should become possible to construct machines on the micrometer scale made up of parts on the nanometer scale. Subassemblies of such devices may include such as useful robotic components as 100 nm manipulator arms, 10 nm sorting rotors for molecule by molecule reagent purification, and smooth super hard surfaces made of automatically flawless diamond. Nanotechnology has the potential to offer invaluable advances such as use of nanocoatings to slow the release of asthma medication in the lungs, allowing people with asthma to experience longer periods of relief from symptoms after using inhalants. Thus, what nanotechnology tries to do is essentially make drug particles in such a way, that they don't dissolve that fast, done this with. Currently, most legal and illegal drug overdoses have no specific way to be effectively neutralized, using nanoparticles as absorbents of toxic drugs, is another area of medical nanoscience that is rapidly gaining momentum. Goal is design nanostructures that effectively bind molecular entities, which currently don't have effective treatments. We are putting nanosponges into the blood stream and they are soaking up toxic drug molecules to reduce the free amount in the blood, in turn, causes a resolution of the toxicity that was there before you put the nanosponges into the blood.

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