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EMERGING FUNCTION OF NANOROBOTICS AND NANOROBOT'S APPLIANCE

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ABSTRACT: Nanorobotics is an emerging, advanced and multidisciplinary field that calls for scientific and technical expertise of medical, pharmaceutical, bio-medical, engineering as well as other applied and basic scientists. Nanorobots differ from macro-world robots, specifically in their nano sized constructs. Assembly and realization of nanorobotsdepend on the principles of molecular nanotechnology and mechanosynthetic chemistry. Practically, these systems are nano electro mechanical devices that are capable to carry out pre-programmed functions in a reliable and accurate manner with the help of energy provided by a preinstalled nanomotor or nanomachine. Due to their small size and wide functional properties, nanorobots have created exceptional prospects in medical, biomedical and pharmaceutical applications. Although, no technology is available to construct artificial nanorobots, it is now possible to create nanorobots by using biological means. The review presents a brief discussion on basic nanorobotics and its possible applications in medical, biomedical and pharmaceutical research. Advances in technology have increased our ability to manipulate the world around us on an ever-decreasing scale. Nanotechnologies are rapidly emerging within the realm of medicine, and this subfield has been termed nanomedicine. Use of nanoparticle technology has become familiar and increasingly commonplace, especially with pharmaceutical technology. An exciting and promising area of nanotechnological development is the building of nanorobots, which are devices with components manufactured on the nanoscale.

Keywords: Nanotechnology, nanomedicine, nanomachines, nanomotors, bionanorobots, nanomechanics, Surgery, nanorobotics.

1. INTRODUCTION

Progression in science and medicine has been marked by the ability of researchers to study and understand the world around us on a progressively smaller scale. With each order of magnitude of access to smaller dimensions, new therapeutic possibilities and frameworks of understandings were developed. These developments included the germ theory and microbiology. The next phase in the ever-decreasing size of operation is the development of nanotechnology, where researchers are able to work on the scale of nanometers. The scale of nanotechnology is defined by the National Nanotechnology Initiative (NNI), a United State government initiative to promote the development of nanotechnology research and development, as "science, research, and technology conducted on the nanoscale." The NNI defines this scale as approximately 1 to 100 nanometers. To give a practical idea of the nanoscale, a cell surface receptor is approximately 40 nanometers[1], a strand of DNA is about 2 nanometers in diameter, and a molecule of albumin is about 7 nanometers.

To date, some examples of what nanotechnology has enabled include the development of improved imaging techniques for higher sensitivity in detection of cancer and illness[2], improved targeting of drug treatments[3], decrease in the number of adverse effects of chemotherapy, and the enhanced effectiveness of other antineoplastic therapies such as cryotherapy[4] and ultrasound[5]. Outside of medicine, nanotechnology is also fueling developments in agriculture[6], energy[7], electronics[8], and many other fields.

The concept of nanotechnology is reported to have first been envisioned by the celebrated physicist Dr. Richard Feynman, during a lecture called "There's Plenty of Room at the Bottom," which was delivered to the American Physical Society in December of 1959. Dr. Feynman discussed the field and scale of nanotechnology in principle, and the possibilities it would unlock for biological research, information technology, manufacturing, electrical engineering, and other fields[9].

Nan biotechnology is a subfield of nanotechnology that uses the principles and techniques of nanotechnology and applies them towards research and advancement in the biological sciences and medicine. Nan biotechnology involves the development of technology such as pharmaceuticals and mechanical devices at the nanometer scale for the study of biological systems and treatment of pathology[10]. This article will focus on the advances of nanobiotechnology in the realm of device development, specifically on the construction of nanorobotics and their application in the medical field. Representative examples from the fields of microbiology, hematology, oncology, neurosurgery, and dentistry will be reviewed.

The need for targeted drug delivery systems is increasing as today's biomedical technologies request new, innovative systems to replace difficult procedures.

By developing a micro-scale delivery system we hope to replace the need for traditional methods and instruments. Biomedical micro-robots are one possible solution to this and various other medical challenges.

Nanomedicine offers the prospect of powerful new tools for the treatment of human diseases and the improvement of human biological systems by engineering nano/micro-scale robots that travel throughout the human body we can implement new technologies that re-define conventional processes [1].“Nanomedicine is the process of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using molecular tools and molecular knowledge of the human body.

Nanorobots would constitute any **"smart"** structure capable of actuation, sensing, signaling, information processing, intelligence, manipulation and swarm behavior at nano scale (10-9m).

Bio nanorobots – Nanorobots designed (and inspired) by harnessing properties of biological materials (peptides, DNAs), their designs and functionalities [2]. These are inspired not only by nature but machines too.
• Nanorobots could propose solutions at most of the nanomedicine problems.

Nanomedicine: Application of nanotechnology in medicine. Nanotechnology refers to the science and engineering activities at the level of atoms and molecules. A nanometer is a billionth of a meter, that is, about 1/80,000 of the diameter of a human hair, or 10 times the diameter of hydrogen atom. Nanorobots can offer a number of advantages over current methods such as;

(i) Use of nanorobot drug delivery systems with increased bioavailability;

(ii) Targeted therapy such as only malignant cells treated;

(iii)Fewer mistakes on account of computer control and automation;

(iv)Reach remote areas in human anatomy not operatable at the surgeon's operating table;

(v) As drug molecules are carried by nanorobots and released where needed the advantages of large interfacial area during mass transfer can be realized;

(vi)Non-invasive technique;

(vii) Computer controlled operation with nobs to fine tune the amount, frequency, time of release;

(viii) Better accuracy;

(ix)Drug inactive in areas where therapy not needed minimizing undesired side effects.

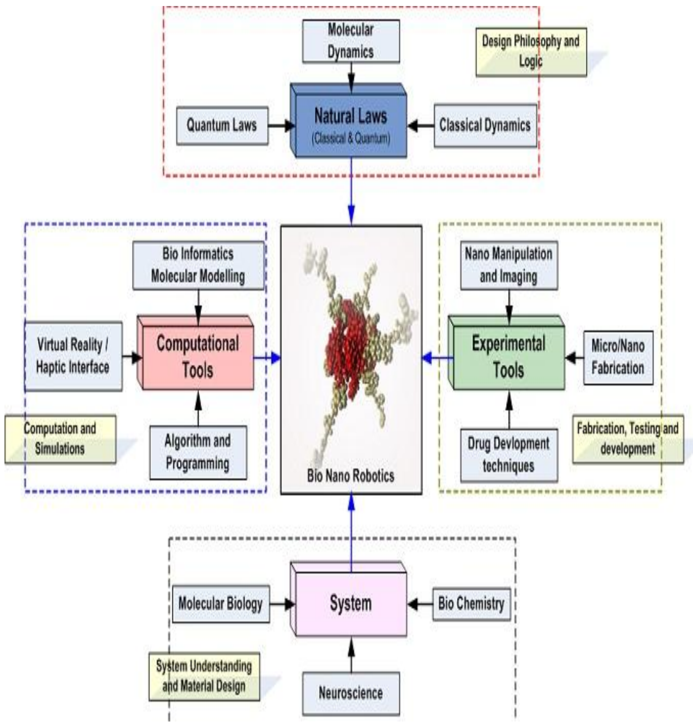

Figure 1 NANO ROBOTICS

2. LITERATURE REVIEW

Nanorobots are programmable assemblies of nanometer scale components constructed by manipulating macro/micro devices or by self assembly on pre-programmed templates or scaffolds [1].

Nanorobots are essentially nanoelectromechanical devices (NEMS). These nanorobotic devices are comparable to biological cells and organelles in size. The technology of design, fabrication, and programming of these nanorobotsis known as Nanorobotics [2, 3].

It is a multidisciplinary field requiring advanced level input from different areas of science and technology including, physics, chemistry, biology, medicine, pharmaceutical sciences, engineering, biotechnology and other biomedical sciences. Richard Feynman, Nobel laureate and a scientist predicted nanomachines to be devices of the future[4].

The concept of medical nanodevices traveling in the human body was first viewed in the movie Fantastic Voyage (Twentieth Century Fox, winner of the 1966 Oscar for best visual effects). Since then, nanomechanics have become the matter of scientific or technical curiosity and debate for researchers. It is predicted that nanorobotics would deliver unprecedented results in medicine and drug delivery applications [5].

These systems would be useful for drug targeting, controlled drug release, tumor diagnosis, cellular as well as genetic repair in the biological system. Following the publication trends, specifically in medical nanorobotics, it appears that there exist two schools of thought concerning the practical feasibility of nanorobots. Apart from the general view of the scientific community, which considers it theoretically acceptable but actually impractical, there exists a pool of scientists working in molecular nanotechnology and mechanosynthesis for nanorobotic applications. Eminent scientists including Feynman, Merkle, Drexler [6] and Freitas [7] have contributed significantly in the advancement of nanorobotic devices.

3. METHODOLOGIES

Molecular machines

Nanorobots need energy to carry out different manipulations such as propulsion, force, actuation, communication or any other activity in the biological system at nano-scale. This energy can be generated by natural (biological) or artificial (chemical) entities known as molecular motors, which when perform at nano-scale are known as Nanomachines. The natural molecular motors are present in a biological system and carry out important functions in the body at molecular or nano level. Most of these motors are composed of proteins or DNA. Scientists are studying these natural motors elaborately in order to use them as efficient and reliable motors for artificial nanorobots, e.g., Kinesin molecular motors , flagella motors , DNA Scissors and DNA Tweezers. Similarly, chemical molecular motors are also being used as nanomachinesin artificial nanorobotics. These machines are difficult to synthesize but are more robust than natural machines. Mostly, these machines are constructed from organic compounds such as Carbon, Nitrogen, and Hydrogen and can be controlled chemically, electrochemically or photochemically. Many chemical molecular machines are constructed using interlocked organic compounds known as Rotaxanes and Catananes.

Nanofabrication and assembly

Currently, scientists have succeeded to develop only biological nanorobotic systems, whereas, artificial nanorobots are still a concept that is being explored aggressively. The key challenge in the development of these systems is their fabrication and assembly at nano-scale. Various techniques are being developed for nanomanipulation including scanning probe microscopy (SPM) and Atomic Force Microscopy (AFM) as a couple of promising methods for small-scale development of nanodevices. These techniques use micro cantilevers suitable for miniaturized manipulation and assembly. Self-assembly of nanostructures is emerging as another useful method. It has been observed that nanoprobes or nanosensors would diversify the applications of nanorobots in the biomedical field. The key processes or components required for construction of nanorobots involve sensing, actuation, propulsion, control, communication, programming and coordination. Until now, only primitive, artificial nanorobotshave been developed and much advanced versions are expected in the near future with the development novel technologies.

Medical and pharmaceutical applications

An ideal nanorobotic system is visualized as a self-assembling, self-replicating and selfrepairing systems. Although, such an advanced artificial system may not be seen in the near future, it could be possible by using viral vectors or very small virus like particles (VSVLI) as carriers for drugs, diagnostic agents or other therapeutic biological material. Several other hypothetical nanorobotic systems have been proposed for the treatment and diagnosis of various diseases and disorder.

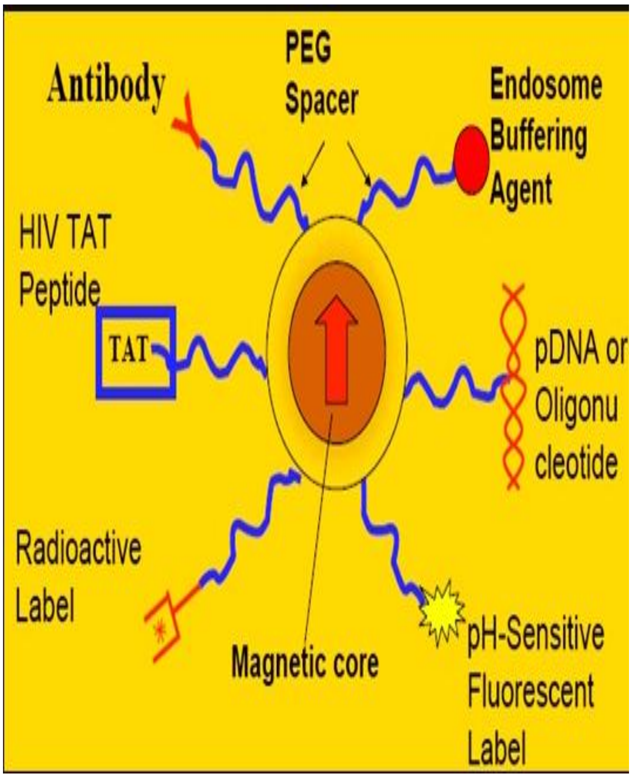

Figure 2 SMART NANO ROBOTICS

4. ALGORITHMS

1. Biochip:

The joint use of nanoelectronics, photolithography, and new biomaterials, can be considered as a possible way to enable the required manufacturing technology towards nanorobots for common medical applications, such as for surgical instrumentation, diagnosis and drug delivery. Indeed, this feasible approach towards manufacturing on nanotechnology is a practice currently in use from the electronics industry.

So, practical nanorobots should be integrated as nanoelectronics devices, which will allow tele-operation and advanced capabilities for medical instrumentation .

2. Nubots:

Nubot is an abbreviation for "nucleic acid robots." Nubots are synthetic robotics devices at the nanoscale. Representative nubots include the several DNA walkers reported by Ned Seeman's group at NYU, Niles Pierce's group at Caltech, John Reif's group at Duke University, Chengde Mao's group at Purdue, and Andrew Turberfield's group at the University of Oxford.

3. Positional nanoassembly:

Nanofactory Collaboration, founded by Robert Freitas and Ralph Merkle in 2000, is a focused ongoing effort involving 23 researchers from 10 organizations and 4 countries that is developing a practical research agenda specifically aimed at developing position ally-controlled diamond mechanosynthesis and a diamondoid nanofactory that would be capable of building diamondoid medical nanorobots.

4. Bacteria based:

This approach proposes the use biological microorganisms, like Escherichia coli bacteria. Hence, the model uses a flagellum for propulsion purposes. The use of electromagnetic fields are normally applied to control the motion of this kind of biological integrated device, although his limited applications.

5. Open Technology:

A document with a proposal on nanobiotech development using open technology approaches has been addressed to the United Nations General Assembly [7, 8]. According to the document sent to UN, in the same way Linux and Open Source has in recent years accelerated the development of computer systems, a similar approach should benefit the society at large and accelerate nanorobotics development.

The use of nanobiotechnology should be established as a human heritage for the coming generations, and developed as an open technology based on ethical practices for peaceful purposes.

6. The nanorobot prototype:

To create their new nanorobot, the team used cadnano, a DNA computing software, to help them design a folded, 3-D hexagonal DNA nanorobot that is able to carry molecular ‘cargo’ within its structure. The folded DNA device has two DNA-aptamer ‘locks’ – known as staples – that close around the cargo material to keep it secure until the destination cells are reached.

The nanorobot’s molecular locks are programmed to respond to specific key combinations of proteins on the cell surface, so the cargo can only be delivered when the intended cell’s receptors have the right combination. “We can finally integrate sensing and logical computing functions via complex, yet predictable, nanostructures

The first hybrids of structural DNA, antibodies, aptamers and metal atomic clusters – aimed at useful, very specific targeting of human cancers and T-cells,” said Douglas .

5. CONCLUSIONS

Nanorobotics is an upcoming field interconnecting various areas of science and technology. The advantages and applications of nanorobots in medicine and engineering technologies outweigh the challenges and hurdles it presents during the development process. It is clearly seen from the examples of biological molecular motors and bionanorobotics that it is difficult but possible to develop such systems. The day may not be far when nanorobotics would enter into the nanomedicine world as a boon for those suffering from various difficult to treat conditions such as cancer and AIDS. Nanorobots applied to medicine hold a wealth of promise from eradicating disease to reversing the aging process (wrinkles, loss of bone mass and age-related conditions are all treatable at the cellular level); nanorobots are also candidates for industrial applications. The scientific community is in the midst of a breakthrough in developing technology on a scale orders of magnitude smaller than ever before. As our technology advances, and as we explore on smaller and smaller scales, we are able to gain increased control of the world around us and ourselves. In the past, developing the ability to manipulate the world on a smaller scale brought transformative changes to the scientific community, and the world at large. Whether it was the age of microscopes ushering in the area of bacteriology, or the beginning of the atomic age with the study of particle physics, nanotechnology is poised to change many of the paradigms with which we think about disease diagnosis, treatment, prevention, and screening. Outside the bounds of medicine, nanotechnology will affect our lives in countless other ways through industries such as telecommunications and agriculture.

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