

NANOROBOTICS: AN IMPRESSIVE TECHNOLOGICAL TREND

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ABSTRACT

The health care industry of today is focusing on developing minimally invasive techniques for diagnosis, as well as treatment of ailments. The most promising development in this field involves marriage of the latest nanomaterial science and robotics technology with biological knowledge : Nanorobotics. This paper will deal with the latest development in this field as well as the promising future it offers , mainly focusing on health care , though this is a nanoscopic fraction of the scope of this technology.

Keywords: Nanorobotics, Nanomaterial, Robotics Technology, Magnetic Resonance Imaging, MEMS

1. INTRODUCTION

The health care industry has seen many revolutions, from the invention of the first vaccine to much modern equipment like MRI (Magnetic Resonance Imaging). In the next decade, however, biologists and engineers hope to trigger the most significant revolution in the history of medicine. Having nanoscopic bots crawl (or swim) inside your body will no longer be science fiction. , we could think of nanobots as 'internal enhancement'. In comparison cyborgs possess external enhancements such as robotic prosthesis. We could even use nanobots inside our body to relay vitals to a wireless monitoring system, much like cyborgs in sci-fi movies. Nanomedicine uses nano-sized tools for the diagnosis, prevention and treatment of disease and to gain increased understanding of the complex underlying pathophysiology of disease. The ultimate goal is to improve the quality of life. The aim of nanomedicine may be broadly defined as the comprehensive monitoring, repairing and improvement of all human biological systems, working from the molecular level using engineered devices and nanostructures to achieve medical benefit. Most broadly, nanomedicine is the process of diagnosing, treating, and preventing disease and traumatic injury, relieving pain, and of preserving and improving human health, using molecular tools and molecular knowledge of the human body. Due to the advances in the field of nanotechnology, nano device manufacturing has been growing gradually. From such achievements in nanotechnology, and recent results in biotechnology and genetics, the first operating biological nanorobots are expected to appear in the coming 5 years, and more complex diamondoid based nanorobots will become available in about 10 years. In terms of time it means a very near better future with significant improvements in medicine. In future decades the principal focus in medicine will shift from medical science to medical engineering, where the design of medically active microscopic machines will be the consequent result of techniques provided from human molecular structural knowledge. A navigational network may be installed in the body, with station keeping navigational elements providing high positional accuracy to all passing nanorobots that interrogate them, wanting to know their location. This will enable the physician to keep track of the various devices in the body. These nanorobots will be able to distinguish between different cell types by checking their surface antigens.

HISTORY: According to Richard Feynman, it was his former graduate student and collaborator Albert Hibbs who originally suggested to him (circa 1959) the idea of a medical use for Feynman's theoretical micro-machines. Hibbs suggested that certain repair machines might one day be reduced in size to the point that it would, in theory, be possible to (as Feynman put it) "swallow the surgeon". The idea was incorporated into Feynman's 1959 essay "There's Plenty of Room at the Bottom". Since nano-robots would be microscopic in size, it would probably be necessary for very large numbers of them to work together to perform microscopic and macroscopic tasks.

COMPOSITION OF NANOROBOTS:

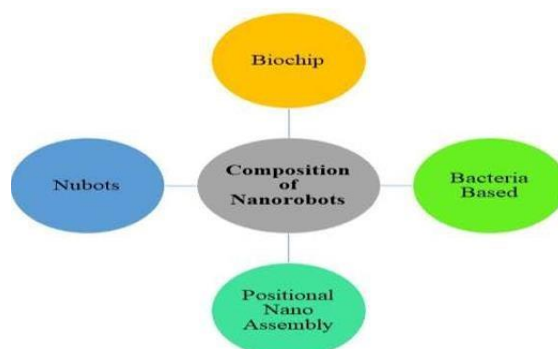


Figure 1: Composition of Nanorobots

A] Biochip

The Synthesis involves the joint use of the photolithography, nano electronics & the new biomaterials. For the manufacturing of the nano robots for the common medical applications such as for drug delivery ,surgical instrumentation & diagnosis, it can be used. The electronics industries currently use the biochips for manufacturing. The nano robots with the biochips can be integrated in the nano electronics devices which will allow the tele-operation & the advanced capabilities for the medical instrumentation.

B] Bacteria Based:

These approaches uses the biological microorganisms like the Escherichia coli bacteria. The model uses the flagellum for the propulsion purposes. To control the motion of this kind of the biological integrated device the use of the electromagnetic fields is normally applied.

C] Positional Nano Assembly:

The Robert Freitas & Ralph Merkle in 2000 are developing the practical research agenda which is specifically aimed at the developing positional-controlled the diamond mechanic synthesis & the diamonded Nano factory that would be capable of the building diamonded medical nano robots.

D] Nubots:

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

NANOROBOTS

A nanorobot has aspects measured in nanometres and it is an automated or electromechanical machine. It is a device synthetically developed which is capable of independently spreading out in the body of humans and communicating with the particular cell at the molecular level. Fig.1 is a schematic representation of a nanorobot that can be activated by the cell itself when it is needed.

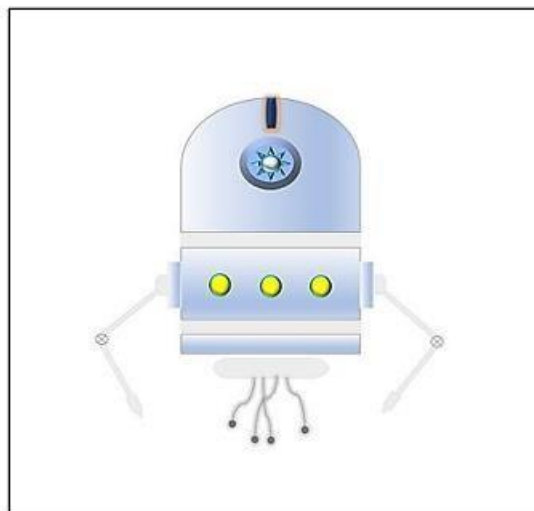


FIGURE 1. Hypothetical representation of nanobot.

Word micro/nanorobots are attributed to nano/micron dimension structures having the ability to change the power origin to kinetic energy. Micro/nanorobots can be categorized into 3 types.

The unification of artificial nanostructures and microbes capable of motion acts as the driving engine of nanorobots in biohybrid systems. Chemically motorized micro/nanorobots change chemical ammunition to movements by utilization of an asymmetric catalytic engine. Nanorobots which are physically motorized, change the energy source such as light, magnetic fields, etc. into locomotion by structural design. At the level of labs, the capability of nanorobots to complete distinct activities has been shown, describing utilization regarding targeted load delivery, bodily influence, and liquid infusion of micro-level objects.

Development of biomedical mediation such as fewer invasion surgical procedures, enhancement in curative measures, diagnostics of probable critical illnesses, and assistance to patients requiring a regular audit of bodily activities can be achieved by utilization of nanorobots. Implantable devices are utilized for the uninterrupted collection of patient data. Audit related to the patient is useful in the preparation of neurosurgery, diagnosis report in beginning to tackle cancer, and regulation of blood pressure concerning cardiology issues. Individuals suffering from hyperglycemia are monitored

in this way . The field of dentistry can be benefitted from nanotechnology in the area of higher sensitivity. Dentinal tubules are present in the teeth with more sensitivity, and the diameter of teeth with no increased sensitivity is twice less than teeth with high sensitivity. Dental nanorobots close up the dentinal tubules carefully and exactly. In About one hundred seconds dental nanorobots can accomplish the travel to the pulp chamber. That is why there is a rapid and durable revival . These Nano dimension robots have possibilities for developing healthcare-related cures and diagnostics. With these small-sized bots, different medical surgeries in the far regions of the body, where it is difficult to operate. Undoubtedly these nanorobots prove to be of great use, but still, these devices are required to be transitioned to be utilized at the clinical level . Figure 1 represents the hypothetical nanorobot.

Ideal Characteristics of Nanorobots

- Dimensions of nanorobots should be in the range of 0.5-3 microns.
- If the dimensions of nanorobots are greater than the mentioned range, then it will be led to occlusion.
- With the use of a passive diamond exterior, nanorobots avert themselves from possible charge by immunity .
- Nanorobots will interact with medical professionals by utilizing encoded communication to acoustic signals through 1-100 MHz frequency information-carrying waves.
- Possibly various duplicates might be formed by it to change the damaged units through selfreplication.

Advantages

- Nanorobot drug delivery system utilization with elevated bioavailability
- Specific Treatment, for instance, cure of cancer cells
- Even access to the far parts of the human body which are not easily operatable
- Nanorobots have a great area to interact thus, drug components transported via nanorobots can be benefitted while transferring mass from one location to other
- Method not requiring the introduction of instruments in the body
- Activities are regulated by computer through knobs to modulate quantity, repetitiveness; • Excelling correctness

Disadvantages

- Primary design expenses are more
- It has a sophisticated design
- The demagnetizing field can be built by electrical systems that may activate bioelectric-based molecular recognition systems
- Nanorobots are prone to be affected by electrical disruptions from different sources like demagnetizing fields from other devices present in vivo
- Terrorists can utilize nanorobots to give mental and physical pain to people as nanorobots can destroy the human body at the molecular level
- Secrecy can be an issue with nanorobots

Structure

A nanorobot consists of the following parts

- Microprocessor: Comprehensive working of nanorobots is commanded by this
- Magnetic switch: This is utilized to switch ON & OFF the nanorobot
- Manipulators: Regulates locomotion and velocity of nanorobots
- Payload: This part stores drugs needed, releases them at required locations
- Power source: To keep nanorobots workable, electromagnetic energy is supplied via nanocircuits
- Motor: This makes the nanorobots move in the blood vessels
- Sensors: These sensors recognize the particular chemicals from body cells, thus nanorobots are guided to targeted locations
- Micro Camera: The operator guides the nanorobot through the route with the help of a small sized camera

Types of Nanorobots Respirocytes :

Artificial erythrocytes, also known as red blood cells, are approximately 1 μ m in diameter. Respirocytes are spherical Nano-medical devices designed by Freitas RA that operate as artificial mechanical red blood cells. These devices are diamondoid 1000-atmosphere pressure vessels with active pumping powered by endogenous serum glucose. They can deliver 236 times more oxygen to the tissues per unit volume than natural red blood cells while simultaneously managing carbonic acidity. Red blood cells carry oxygen and carbon dioxide molecules throughout the body. Respirocytes exchange gases via molecular rotors and consist of three types of rotors. One rotor releases the stored oxygen, the second

rotor captures all the carbon dioxide molecules in the bloodstream and releases them to the lungs, and the third rotor takes in glucose from the bloodstream as a fuel source.

Microbivores :

These are spherical structures with squashed ends, assembled, mechanical phagocytes with a 3.5-micron diameter, which create an artificial immunity system when brought into blood circulation. It recognizes the disease-causing microbes and blood toxins and ravages them. By utilizing various kinds of chambers such as morcellation, digestion port, exhaustion chambers, and robotic grapples, the microbivores work

Clottocytes :

Also known as artificial mechanical platelets are approximately 2 μm in size. The natural blood clotting process takes 2-5 minutes to complete. In some patients, blood clots occur irregularly, which can be treated with corticosteroids. However, these drugs have side effects. To avoid side effects, choanocyte nanorobots can be used instead of drugs. They can complete hemostasis in just 1 second. The response time of choanocytes is 100-1000 times faster than the natural hemostatic system.

Respirocyte :

These act as artificial cells and transport oxygen and carbon dioxide in the human body. Respirocytes imitate red blood cells as well as kill the microbes. One and a half billion oxygen molecules can be stocked by these nanorobots accessible to tissues majorly. Alterations in surroundings are recognizable by respirocytes by sensors available on their surface and modulate the input and output of gases by nanocomputers

Vasculoids :

It reinstates and broadens the vascular system and is known as a vascular machine. Vasculoid is not just a synthetic vascular system, but also it is part of a class of space or volume adding nanomedical enhancement instruments whose function applies to the human vascular tree. Vasculoids can take part in every transfer involved in the vascular system such as gases, cytokines, cell particulars, glucose, hormones, etc 32. Table 2 lists the nanoproductions and their remarks

Dentifrobots

Nanorobot dentifrices wrap up subgingival surfaces in the mouth when given in mouthwash or dental cream and can assimilate captured food matter into nontoxic and non-odorous vapors. Dentifrobots when correctly set up can recognize and kill disease-causing bacteria that happen to be present in plaque or other parts. These small bots are mechanical machines and get decommissioned on ingestion

Applications

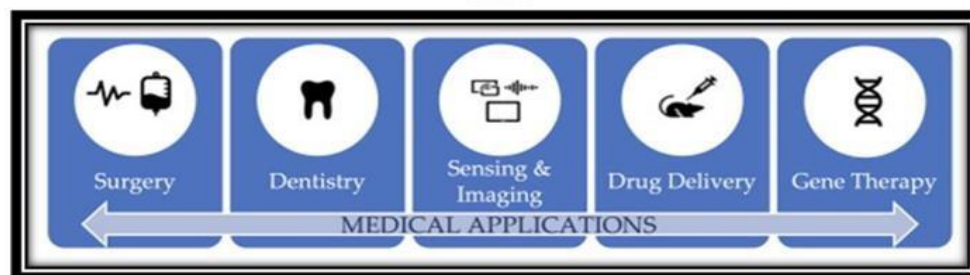


Figure 2: Medical Applications of Nanorobots.

Cancer Detection and Therapy :

As cancer survival rates improve with early detection, nanorobots designed with enhanced detection abilities will be able to increase the speed of a cancer diagnosis and therefore enhance the prognosis of the disease. Nanobots with embedded chemical sensors can be designed to detect tumor cells in the body. Proposed designs currently include the employment of integrated communication technology, where two-way signaling is produced. This means that nanobots will respond to acoustic signals and receive programming instructions via external sound waves along with transmitting data they have accumulated. A simple reporting interface could be produced through strategically positioned nanobots in the body which are able to log information supplied by active nanobots traveling through the blood stream. Instructions could be adapted in vivo to provide active targeting for monitoring or healing. Nanorobots with chemical sensors can also be utilized for therapy. Through specific programming to detect different levels of cancer biomarkers such as e-cadherins and betacatenin, therapy can be provided in both primary and metastatic phases of cancer. Nanobots have the advantage of producing targeted treatment. Current cancer treatments have severe side effects caused by the destruction of healthy cells. Targeted treatment can be formed by designing nanorobots with chemotactic sensors on their surface which correspond to specific antigens on the cancer cells.

Arteriosclerosis:

In this situation, the fat gets built in the lumen of blood vessels. This can be treated by nanorobots by removing the plaque in the lumen of arteries

Diabetes :

Nanorobots are thought of as the latest feasibility related to the medical sector to enhance diagnostics, medical care, and instrumentation. Multiple times a day individuals suffering from hyperglycemia should get their levels checked so that the range remains normal. These ways to check levels of glucose can be difficult and distressing. This issue can be resolved by utilizing nanorobots, these devices can regularly examine levels of glucose . This can lead to betterment in suffering individual's life quality and it can make sure that glucose levels remain normal.

Gene Therapy:

Medical nanorobots can treat genetic diseases effectively by comparing the molecular structures of DNA and proteins in cells to known reference structures. Any irregularities found in either structure can be corrected, or desired modifications can be made. In some cases, chromosomal replacement therapy is more efficient than cytoterepair. A repair vessel built by an assembler floats inside the nucleus of a human cell and performs genetic maintenance as shown in figure No.4. The nanomachine uses its lower pair of robot arms to stretch a supercoil of DNA and gently pulls the unwound strand through an opening in its prow for analysis. Meanwhile, the upper arms detach regulatory proteins from the chain and place them in an intake port [16]. With a diameter of only 50 nanometers, the repair vessel is smaller than most bacteria and viruses, yet capable of providing therapies and cures beyond the reach of presentday physicians. With trillions of these machines coursing through a patient's bloodstream, diseases such as cancer, viral infections, and arteriosclerosis could be eradicated.

Glucose level maintenance is crucial for healthy metabolism and diabetes treatment. HSGLT3 protein helps regulate extracellular glucose concentration, and it acts as a sensor to identify glucose . A nanorobot prototype model with embedded CMOS nanobioelectronics detects glucose levels, modulating hSGLT3 protein glucosensor activity . Significant data can be transferred via RF signals to the patient's mobile phone. If glucose levels reach critical levels, the nanorobot emits an alarm . The simulator workspace shows a venule blood vessel with nanorobots and red blood cells.

Kidney Stones:

Kidney stones can be intensely painful the larger the stone the more difficult it is to pass. A nanorobot could break up kidney stones using a small laser.

Drug Delivery System:

Nanorobots can be utilized for efficient drug delivery. Generally, drug molecules move through all body parts before arriving at the required site. With the help of nanobots, medicine can reach the location where it is needed. In this way, the adverse effects are decreased and the efficiency of the drug increases. With the regulation of electrical pulse, nanorobots regulate the period and quantity of the drug to be released.

Surgery:

Sophisticated surgeries can be eased by the introduction of robots and also broaden the abilities of surgeons. Procedures like these allow very low invasion surgeries with great accuracy and thus it is a dynamically evolving field. Small-sized robots can move through the narrower body parts and reach far remote sites and perform surgical procedures that are difficult to perform in contrast to large-sized robots. Latest developments in nanorobots demonstrate significant affirmation to removing restraints and utilizing small-sized bots for accurate surgical procedures 44. Nanorobots will be able to carry out medical procedures on the retina, membranes nearby to it, and operating microscope surgery of the human eye. Nanorobots do not require to be introduced into the eye rather can be added to other parts of the body, from there these could find their way to the eye for drug delivery. A model fragile surgical procedure is surgery related to the fetus. This surgery poses a great possibility of the death of the mother or baby. Because of nanorobots, this procedure can achieve 100% success as they would have better reach to the site of operation.

Dentistry:

Particular mobility mechanisms are used by nanorobots to enter into tissues of humans in a way effective concerning precise navigation, acquired energy, and alterations in surroundings. Without doing any injury, nanorobots can help in curing dental issues. The actions of nanorobots can be modulated by a nanocomputer that carries out computed directions as per local stimulation. Acoustic signals may be utilized by dentists to provide directions to nanorobots 38. Dentifrobots can cleanse matter which is organic and present on the biting edge of teeth by traveling through different surfaces of teeth and avert the gathering of tartar.

2. CONCLUSION

Nanorobotics, with all its challenges and opportunities, is poised to become an integral part of our future. Plenty of study and research is required to fill the void between information currently available for nanoparticle science and prospective nanorobot technology. The capability of nanorobots to handle medical problems is just in its beginning stages. In distinct medical fields filling in information voids will have serious beneficial effects. When considering the severe side effects of existing therapies, nanorobots are found to be more innovative and supportive in the treatment and diagnosis of lethal diseases.

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