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REVIEW ON: NANOROBOTICS ADVANCES IN PHARMACEUTICAL SCIENCE

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ABSTRACT

Medical, pharmaceutical, engineering, and other applied scientific areas might benefit from scientific research and technological assistance in the rapidly developing, cutting-edge, and multidisciplinary subject of nanorobotics. This paper's goal is to examine the potential uses and difficulties of nanorobotics at the micro and nanoscale. The discipline of Biopharmaceutical and biomedical sciences refers to robotics as nano robotics. These tiny nanorobots offer special benefits like cheap cost, adaptability, and distribution, enhanced flexibility, usefulness, and robustness, and access to previously unheard-of small locations. The technology of building machines or robots that are nearly microscopic—that is nanometers—is known as nanorobots. The purpose of these medications is to increase the bioavailability of drugs. At the moment, target drug delivery is the most sophisticated use of nanorobots in the medical field. Future medical treatment could be completely transformed by nanorobots.

KEYWORDS: Nanorobotics; biomedical; drug delivery; treat disease.

INTRODUCTION

A nanorobot, sometimes referred to as a nanomachine, is a tiny mechanical or electromechanical apparatus intended to carry out particular activities at the nanoscale level.[1] The study, design, production, synthesis, manipulation, and use of materials, systems, and devices at the nanoscale scale—one meter is equivalent to one billion nanometers—is known as nanotechnology.[2] By combining combining nanotechnology with autonomous and tele operated robotics, the area of nano robotics offers ground-breaking solutions which are not possible with traditional robotics. A nanorobot, sometimes referred to as a nanomachine, is a tiny mechanical or electromechanical apparatus made to carry out particular activities at the nanoscale.[3] Nanoparticles, in place of nanorobotics, are minuscule particles with special characteristics that are employed in the delivery of drugs and other applications. Creating Robots at the molecular scale for applications like focused medical procedures is known as nanorobotics. The former works with passive materials, whereas the later introduces active, controlled machinery at the nanoscale. Due to their little stature, these tiny robots present special chances for molecular and cellular operations. Medical robots' shrinking trend has been gaining significant traction, and the possible effects of this movement on the biomedical fields are extensive. The investigation of small-scale medical robots, which spans from few millimeters to a few nanometers in all dimensions, has accelerated beyond the meadow of macroscale medical robotics. Several biological and healthcare uses, including biosensing and single-cell manipulation, targeted medication delivery, minimally invasive surgery, medical diagnosis, tumor therapy, detoxification, and more, have been studied for these micro and nanoscale robots.[4]

The film Fantastic Voyage (Twentieth Century Fox, winner of the 1966 Oscar for best visual effects) introduced the idea of medical nanodevices moving throughout the human body. Since then, scientists and technologists have been interested in and debating nanomechanics. Nanorobotics is expected to produce previously unheard-of outcomes in drug delivery and medicine.[5]

Drug targeting, controlled drug release, tumor diagnostics, and cellular and genetic repair in biological systems might all benefit from these systems. There seem to be two schools of thought on the viability of nanorobots in practice, based on publishing trends, particularly in medical nanorobotics. 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 mechano synthesis for nanorobotic applications. Prominent researchers like Feynman, Merkle, Drexler.[6] and Freitas.[7] have made substantial contributions to the development of nanorobotic devices. Which predominantly either measure or function very much within a size parameter of 1- 100nm*. In order to give these dimensions some tangible significance, a micronized aspirin molecule is discovered to be less than 1 nm in size, while a red blood cell (RBC) is nearly 5 mcm (5µm, nm). Its, however, pertinent to state at this point in time that the present scenario in the domain of the biological applications are at a very early stage of scientific evolution which essentially comprise such areas as.

- Drug Delivery
- Bioanalysis
- Therapeutics
- Biosensors
- Medical Devices (Tissue Engineering).

However, the two most common areas of research effort, especially in the so-called private sector, are fundamentally included in nanobiotechnology.

- Drug discovery
- Diagnostics

Crucial Examples: These basically consist of: The scanning probe microscope, which operates just on a nanoscale scale, is a crucial instrument that is frequently employed in "cellular studies."

Nanoparticles: Based on their ability to change color with varying particle size, they can offer newer labeling technologies in the investigation of cells or molecules.

Contrast Agent X-Ray Imaging: It is being used as an application possibly empowered with.

- Better image resolution
- Tissue targeting
- Retention profile in blood stream.

Overview of Micro–Nano Robots

Since the 21st century, micro-nano technology has steadily progressed toward maturity and stability as a result of the deduction and application of science and technology in the understanding and production of novel materials and gadgets. In terms of global rivalry and exchange, nanotechnology is still in its infancy.[8] Figure 1A compares the scales of micro- and nano-robots. Hair has a diameter of roughly 100 μm. Currently smaller than a hair's diameter, micro-nano robots are progressively evolving to the nanoscale. Robots below the millimeter level, or those with three-directional dimensions (length, width, and height) smaller than 1 mm, are the primary subject of this article.

In the early 1970s, American intelligence services carried out and classified the first studies and conceptual designs of microrobots.[9] The primary determinants of micro-nano robot movement modes are the application scenarios and research goals. Gravity, inertial force, and other influences will be negligible at the submicrometer scale, where the main force shifts. On the contrary, surface tension and viscous resistance will be key factors in the shift because of the high surface area to volume ratio. The viscous force outweighs the inertial force in the microfluidic environment, and the micro-nano robot's Reynolds number is less than 1. Consequently, rather than the lift force, the viscous force may be the primary force driving the micro-nano robot's motion. Changes in Noncontact control is necessary for fluid. Figure 1B illustrates how the well-established control techniques of optical, magnetic, acoustic, and electric fields may direct micro-nano robots to resist viscous forces.[10,11] Micro-nano robots are mostly used in the biomedical field.[8,12,13] and as Figure 1C illustrates, medication delivery has emerged as the most widely used application among them.[14] Cell surface receptors attaching to adhesion molecules, the application of promotive forces, the dilatation of vascular walls, and the physical deformation of migrating cells are all components of the mechanism of cell migration across vascular endothelium. The robot may literally "free ride" through blood arteries by adhering to migratory inflammatory cells; it does not require a complicated migration mechanism of its own. Numerous new technologies for creating specialized approaches to maximize medicine delivery are made possible by micro-nano technology.

However, the majority of nanodrugs lack features like real operational control and are just passively targeted.[15,16] Nanorobots may be produced from magnetic resonance imaging (MRI) guided nanocapsules.[17] The most recent developments in nanorobots.[8,18] have already been covered, as have micro-nano robots that are powered by magnetic fields.[19] The probable purpose of robotics in infectious disease management, particularly for the COVID-19 epidemic of the past two years could also be found in recent review.[20] Also, the latest progress on the application of micro–nano robots in cancer treatment has been discussed in a recent review.[21] Micro–nano robots not only shine in the medical field, but also have immeasurable application value in other popular fields, as shown in Figure 1C. Large numbers of pollution control and antipollution nanorobots will be deployed into the contaminated environment for environmental protection. These robots will use sensors to break down the source of pollution and establish cleaning protocols to effectively handle the problem of gas and water pollution.[22]

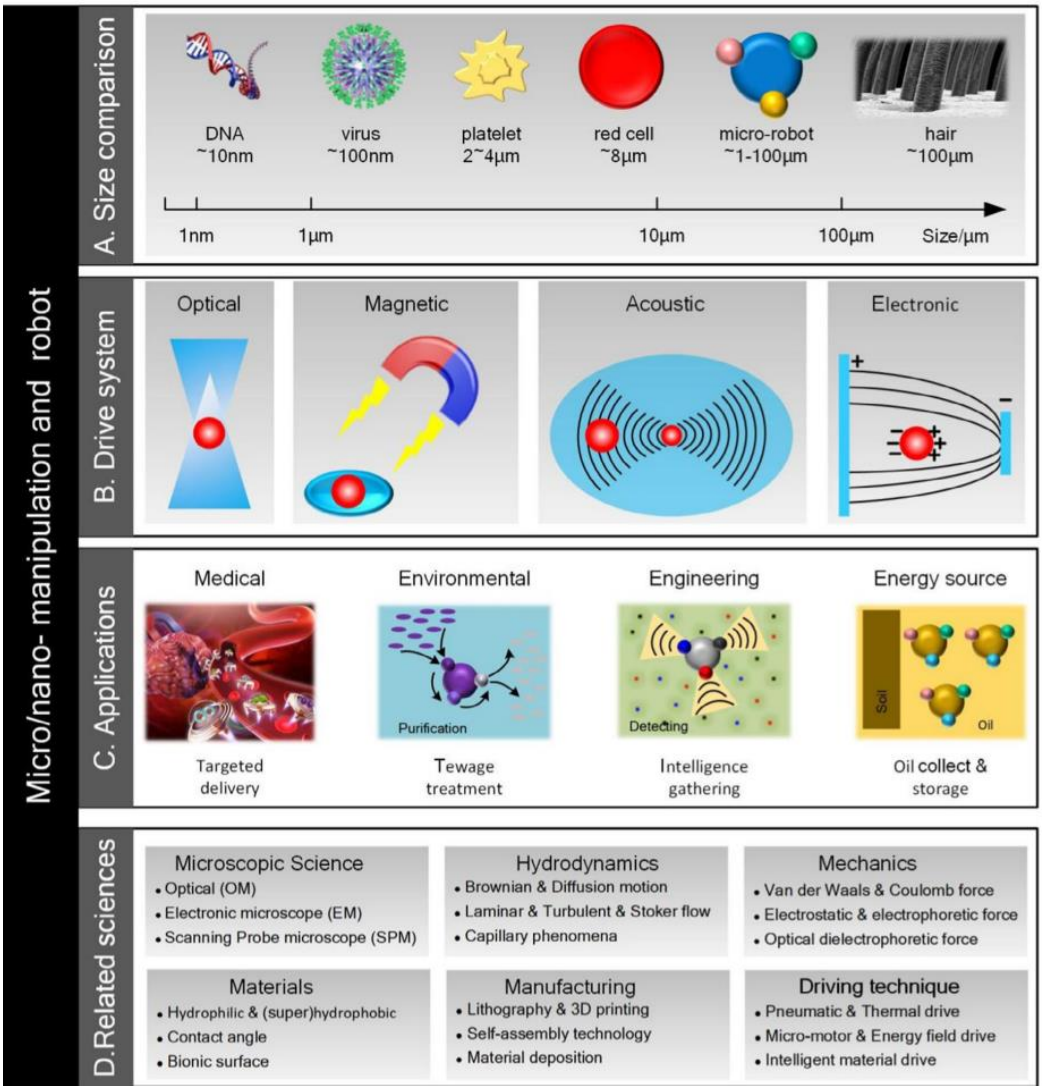


Figure 1. An overview of micro-nano robots and manipulations. A) Micro-nano robot size comparison, roughly equivalent to hair diameter. B) Four typical noncontact activations for micronano robots and manipulations. C) Four primary uses for micro-nano robots and manipulations D) Related sciences for robots and micro-nano manipulations.

In the realm of engineering.[23] bionics technology has given micro-nano robots the potential to be little creatures like insects and birds or multispecies, which can be used as an invincible attack weapon in addition to being a tool for reconnaissance and information gathering.[24] Micro-nano robots integrate molecular, chemical, and mechanical systems in the energy sector. According to some academics, oil exploration, extraction, and storage may be effectively accomplished by petroleum nanorobots.[25] As seen in Figure 1D, the creation of micromanipulation and micro-nano robots requires the fusion of numerous fields. The science of micro-nano fluid mechanics, which covers Brownian motion, diffusion motion, laminar and turbulent flow, stoke flow, and capillary phenomena, is inextricably linked to the construction, observation, and monitoring of micro-nano robots; in micro–nano scale, it is necessary to consider intermolecular forces, including Vander Waals force, Coulomb force, electrostatic and electrophoretic force, optical dielectrophoretic force. Materials science technologies are needed to help produce micro-nano robots. Hydrophilicity, contact angle, and other characteristics are frequently taken into account while designing materials. The range of micro-nano robots has also increased with the advent of biomimetic surface technology.[26] Related precision processing and manufacturing technologies, such as photolithography, 3D printing, self-assembly, and microfluidics, have been pushed by the processing, manufacturing, and assembly needs of micro-nano robots, as seen in Figure 1D. Optical lithography is currently the most important lithographic technology.[27] and its mainstream status will remain unshakable in the next few years. As photolithography technology has developed, devices' feature sizes have decreased steadily, and chip performance and integration have increased steadily as well. 3D printing technology is a processing method of constructing 3D entities through a layer-by layer printing method.[28] and has been widely used in the production and molding of artificial organs, blood vessels, and cells.[29] Because of the small The droplet wrapping and material molding technologies using microfluidics have high efficiency, controllable structure, controllable material, and size are the core technologies that have also been used in the manufacturing of micro–nano robots.[30] A common method for creating nanostructured material systems is self-assembly technology. The constructed nanostructured materials feature quantum coupling and synergistic effects created by the combination of nanostructure units, in addition to inheriting the properties of their structural units (such as nanoparticles, nanowires, etc.). Furthermore, the system's ability to take external field modulation characteristics (such as optical, electrical, or magnetic) is one of the newly derived qualities. These characteristics are the basis for design and manufacture of nanodevices, sensors or other devices.[31,32]

Medical application of nano robots

Nano robots are expected to enable new treatments for patients sufering from diferent diseases and will lead to a significant breakthrough in medical history. Recent advancements in the field of bimolecular computing represent a potential first step toward the construction of more complicated nanoprocessors in the future. Research aimed at developing the biosensors and nanokinetic devices needed to facilitate the movement and operation of medical nanorobotics has also advanced.[33] The employment of nano robots could increase treatment effectiveness via early diagnosis of potentially serious diseases, help patients who require continuous monitoring of bodily functions, and advance biomedical intervention through less invasive operations.[34] For instance, the nano robots might be used to adhere to white blood cells or transmigrating inflammatory cells to help inflamed areas recover more quickly. Nanorobots are going to be used in Chemotherapy uses precise chemical dosage administration to fight cancer, and anti-HIV medications could be delivered by nano robots using a similar method. As auxiliary devices for damaged organs, nanorobots could be utilized to process particular chemical reactions in the human body. Nano robots may be used to monitor diabetes and regulate blood sugar levels for patients.[35]

Kidney stones could be found and broken using nanorobots. The ability to identify atherosclerotic lesions in stenosed blood arteries, especially in the coronary circulation, and treat them physically, chemically, or pharmacologically is another significant potential characteristic of medical nano robots. Bio-nanorobots, or organic nano-robots, are molecular machines that are based on DNA and ATP.[36] In this instance, the concept involves creating devices using adenosine triphosphate and ribonucleic acid, as well as using modified microbes to accomplish biomolecular computation, sensing, and actuation for nanorobots. The inorganic nano robot is another strategy for creating molecular machines. Tailored nano electronics is the foundation for the creation of inorganic nano robots. As opposed to bionanorobots, A significantly higher level of integrated nanoscale component complexity could be attained by inorganic nanorobots. These projects demonstrate how to make it possible to manufacture inorganic nanorobots. One strategy that might aid in the development of new materials for inorganic nano robots is the application of novel diamondoid stiff materials. The NanoBuild Hardware Integrated System (Nanobhis) is the method used in our work.[36,37] In order to create nano robots, it combines a number of well-established processes with novel approaches from nanotechnology.[39] It incorporates integrated nano electronics analyses into industrial design and 3D simulation. New techniques in fabrication, processing, sensing, and manipulation could make creating nanorobots more difficult. Tools for real-time 3D prototyping are essential for nanotechnology. It might directly affect the way the new manufacturing procedures are implemented. The performance of novel nanodevices can be predicted through simulation. Additionally, it can assist in the design of nanomechatronics as well as the testing of automation and control schemes.

Nanorobots for the treatment of cancer

can be effectively treated using the most up-to-date medical technology and therapeutic instruments. Nonetheless, a critical determinant of a cancer patient's survival is the timing of the diagnosis; ideally, a malignancy should be identified at least prior to the onset of metastases.[40]

The creation of effective targeted medication delivery to lessen chemotherapy side effects is another crucial component of a successful patient treatment. Nano robots can assist with such crucial components of cancer treatment because of their ability to navigate as blood-borne gadgets. Early tumor cell detection within the patient's body can be accomplished with nanorobots equipped with chemical biosensors.[41] Integrated nanosensors can be applied to this task to measure the E-cadherin signal's intensity. Thus, a nanobioelectronics-based hardware architecture is presented for the use of nanorobots in cancer treatment. Real-time 3D simulation is used to get analyses and findings for the suggested model.

Gene therapy using nanorobots in medicine

Nano robots can readily treat genetic problems by comparing the molecular structures of the cell's proteins and DNA to desired or known reference structures. Any mistakes can then be corrected, and any necessary adjustments can be made. In some cases, chromosomal replacement therapy works better than CY for repair. An constructed repair vessel that floats inside a human cell's nucleus performs some genetic maintenance. After stretching a super coil of DNA between its lower set of robot arms, the nano machine delicately pulls the unwound strand through a hole in its prow for inspection. Meanwhile, the higher arms detach the regulatory proteins from the chain and insert them into an intake port.[42, 43] The Protein and DNA molecular compositions are compared to information stored in the database of a larger nanocomputer located outside the nucleus and connected to the cell-repair spacecraft via a communications link. The repair vessel would have a diameter of only 50 nanometers, making it smaller than the majority of bacteria and viruses but able to perform treatments and cures that are much beyond the scope of current medical professionals. The proteins are reattached to the DNA chain, which re-coils into its original shape once any anomalies in either structure are corrected. When billions of these devices were pumping through a patient's circulation, the term "internal medicine" would take on new meaning. Targeting disease at the molecular level could eliminate viral infections, cancer, and arteriosclerosis.

Brain aneurysm with a nanorobot

The prognosis of brain aneurysms utilizing a nano robot and medical device prototyping by computational nanotechnology. Inside-body transduction, the manufacturing technique, and equipment prototyping are its three primary components. Computational nanotechnology is a crucial tool for the quick and efficient creation of nanorobots, aiding in the exploration of important facets of medical instruments and device prototype. Industry has previously used a similar strategy to construct medical gadgets, racing vehicles, aircraft, submarines, and integrated circuits.[44] The development and study of medical nanorobots can now benefit from the same.[45–46] He The nano robot's manufacturing technology ought to be included into a biochip device. Thus, photonics, nanobioelectronics, and novel materials are introduced. providing an explanation of the architecture of the nano robot. Additionally, inside-body transductions include the use of cell morphology, microbiology, and proteomics as factors for inside-body interaction and nano robot morphology. The activation of the nano robots is based on proteomic overexpression, and changes in chemical gradients and telemetric instruments are used for medical prognosis.[47] These three ideas make up the essential components needed to progress the creation and application of medical nano robots, as the study explains. Nano robots must monitor vessel endothelial damage prior to a subarachnoid hemorrhage in order to predict the prognosis of brain aneurysms. The nano robots are guided by these variations in chemical concentration to detect brain aneurysms in their early stages of development (Figure 2). Because they are too little, the biomolecules detected consistently: rather, the robot detects them by chemical nanobiosensor contact.[48] In order to represent the study of nano robots' sensing and interaction within the damaged blood vessel, the primary morphologic features associated with brain aneurysms are used.[49,50] Intracranial NOS concentrations are low, and some positive interactions between N-oxide and semi-carbazone (pNOS) may even result in false positives. Along with the Luid low, cells and nano robots keep coming into one end of the workspace. The setup for sensing and control activation can be adjusted for different values, such as modifying the detection thresholds, and the nano robots must detect protein overexpression. They low with the Luid as it exits the workspace since we treat any nano robots that do not react while in the workspace as though they did not detect any signal. The electrochemical sensor of the nano robot produces a faint signal below 50 nA if it detects NOS in little amounts or inside a normal gradient.[51,52] In this If the NOS concentration is within the anticipated range of intracranial NOS, the nano robot disregards it. Every time the cell phone receives at least 100 nano robots with higher proteomic signal transduction, the model considers this to be strong evidence of an intracranial aneurysm. This is a feasible threshold for medical diagnosis in order to prevent noise distortions and get a higher resolution. When engaged, the sensors on the nano robots also show their respective positions at the precise moment when they identified a high concentration of NOS protein, giving valuable information on the location and size of the vessel bulb.

Dental nanorobots

A new field known as "nano dentistry" is emerging as a result of increased interest in the potential uses of nanotechnology in dentistry. Oral analgesia is produced by nanorobots, which also desensitize teeth and manipulate tissue to straighten and realign crooked teeth and increase dental durability. Additionally, the use of nanorobots for therapeutic, restorative, and preventive procedures is described.[53,54] For significant tooth repair, nano dental techniques use a variety of tissue engineering approaches. Complete dentition replacement therapy is achieved primarily through the use of nano robots in the production and insertion of a biologically autologous entire replacement tooth that consists of both cellular and mineral components. Sapphire is a nanostructured composite material made possible by nano dentistry that improves the beauty and durability of teeth. Covalently bound artificial material, like sapphire, replaces the upper layers of enamel.[55] Compared to ceramic, this material has 100–200 times the hardness and failure strength. Sapphire is somewhat prone to acid corrosion, just like enamel.[56] The best conventional whitening sealant, or cosmetic substitute, is sapphire. Nano composites are a new restorative nanomaterial that increases the durability of teeth. This is produced by creating nano composites, which are made up of discrete nanoparticles that have been agglomerated and uniformly distributed in resins or coatings.[57,58] The nanoiller consists of an alumino silicate powder with a 1:4 alumina to silica ratio and a typical particle size of roughly 80 nm. In addition to its exceptional hardness, modulus of elasticity, translucency, aesthetic appeal, and color density, the nano iller has a refractive index of 1.503. 50% less illing shrinkage and high polish. They mix in considerably better with the natural tooth structure and are superior to traditional composites.

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 ordinary medical uses like as for drug delivery, surgical instrumentation & diagnosis, it may be used. The electronics industries currently use the biochips for manufacturing. The nano robots with the biochips can be integrated in the nano electronics gadgets that will enable improved medical instrumentation capabilities and teleoperation.

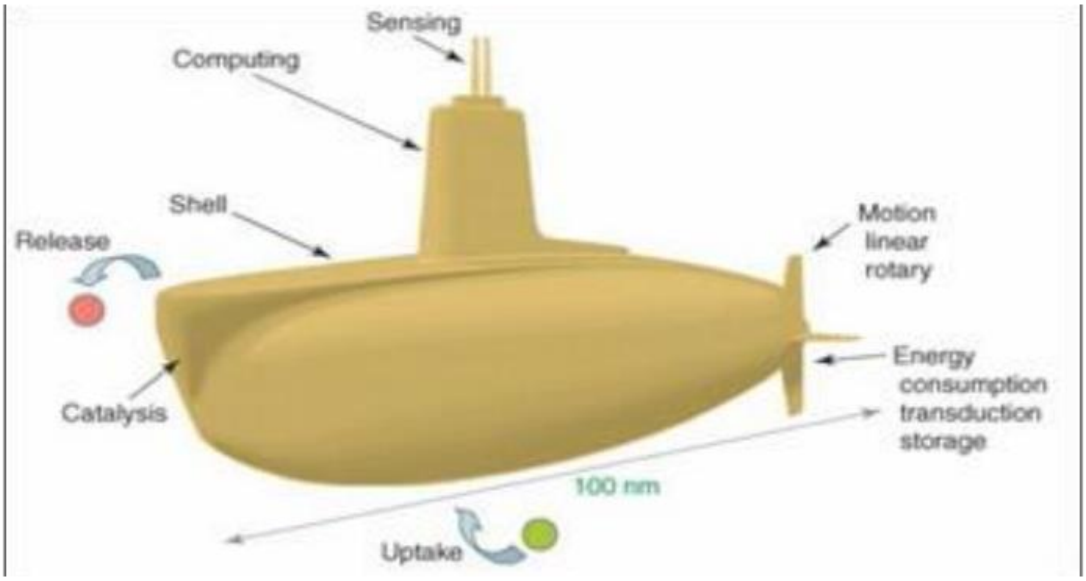
B] Based on Bacteria These methods make use of biological microbes such as the bacteria Escherichia coli. The flagellum is used by the model to propel itself forward. Electromagnetic fields are typically used to regulate the mobility of this type of biologically integrated gadget.

C] Positional Nano Assembly The development of positional controlled diamond mechanic synthesis and a diamonded nano factory that could construct diamonded medical nano robots is the explicit goal of the practical research agenda that Robert Freitas and Ralph Merkle developed in 2000.

D] Nubots The term "nucleic acid robots" is shortened to "nubot." Thenubots are nanoscale synthetic robotics devices. The several DNA walkers that were reported by the teams of Ned Seaman at NYU, Niles Pierce at Caltech, John Reif at Duke University, Chengde Mao at Purdue, and Andrew Turberfield at the University of Oxford are examples of typical nubots.

Pharmacyte

This medical nanorobot, which is 1-2 μm in size, can carry up to 1 μm3 of a specific medicine in its tanks. Mechanical systems for sorting pumps are used to control them. To ensure complete targeting precision, they are equipped with chemotactic sensors or molecular markers. The onboard power source is made up of glucose and oxygen that are taken from the surrounding environment, such as blood, intestinal fluid, and cytosol. Centrifuge nanopheresis can be used to remove or recover the nanorobot after it has finished its job.[59]



Figare: Fictitious Pharmacyte.

Overview of the existing and emerging nanorobotic applications across specialties of medicine

Specialty	Brief Description	Reference
Microbiology	Use of magnetotactic bacteria to transport and navigate nanorobots	60,61,62
	Circulating “respirocyte” nanorobots to deliver oxygen and return remove waste products from periphery	63
	Circulating “clottocyte “nanorobot with hemostatic functions	64
	Phagocytic “microbivores” with customizable antigen binding sites for targeting of pathogens	65
Dentistry	Dental anesthesia and sensitive teeth through nanorobot penetrating dentinal tubules for occlusion or delivery of a specific analgesic.	66,67,69,70
	increasing the likelihood that root canal treatments will be successful by giving root.	68
	improved oral hygiene and tooth aesthetics through enamel layer replacement	67
Neurosurgery	Nanoknife manipulation and	71,72

	transsection of a single axon	
	Circulating nanorobot for tracking the onset and evolution of cerebral aneurysms	74
Oncology	Monitoring and screening circulating nanorobots for neoplasia	74
	Drugs are delivered directly to malignant tissue to reduce systemic toxicity and boost efficacy.	75
	Mapping the tumor's edges to enhance excision during surgery	76,77
Vascular	Checking for aneurysms, malignancy, atherosclerosis, and other conditions	78,79
	Finding the bleeding spot to aid in embolization	80

NANOROBOTS: MEDICINE OF THE FUTURE

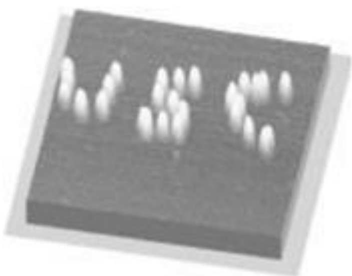
The above statement raises the interesting possibility that machines constructed at the molecular level (nanomachines) may be used to cure the human body of its various ills. This application of nanotechnology to the field of medicine is commonly called as nanomedicine. NANOROBOTS: WHAT ARE THEY? Nanorobots are nanodevices that will be used for the purpose of maintaining and protecting the human body against pathogens. They will have a diameter of about 0.5 to 3 microns and will be constructed out of parts with dimensions in the range of 1 to 100 nanometers. The main element used will be carbon in the form of diamond / fullerene nanocomposites because of the strength and chemical inertness of these forms. Many other light elements such as oxygen and nitrogen can be used for special purposes. To avoid being attacked by the hostís immune system, the best choice for the exterior coating is a passive diamond coating. The smoother and more flawless the coating, the less the reaction from the bodyís immune system.

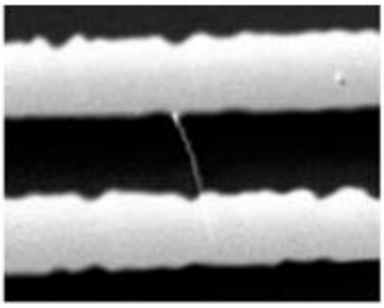
Such devices have been designed in recent years but no working model has been built so far. The powering of the nanorobots can be done by metabolising local glucose and oxygen for energy. In a clinical environment, another option would be externally supplied acoustic energy. Other sources of energy within the body can also be used to supply the necessary energy for the devices. They will have simple onboard computers capable of performing around 1000 or fewer computations per second. This is because their computing needs are simple. Communication with the device can be achieved by broadcast-type acoustic signalling.

A navigational network may be installed in the body, with stationkeeping 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 (they are different for each type of cell). This is accomplished by the use of chemotactic sensors keyed to the specific antigens on the target cells.[81]

Example:

[a] [b]



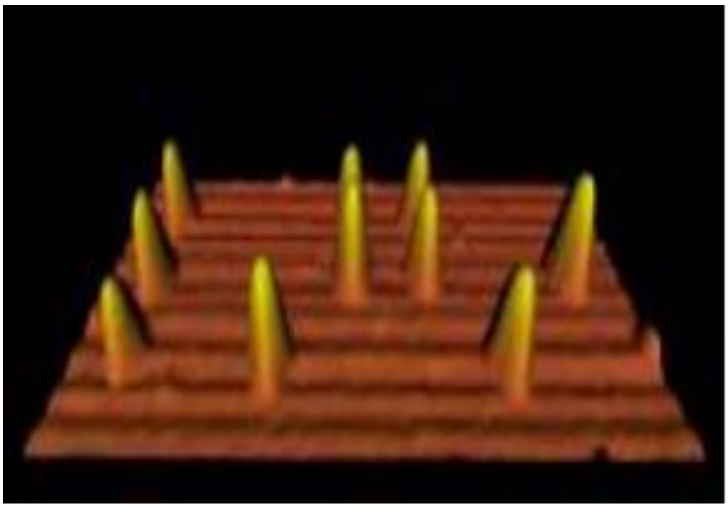


[a] Pattern of 15 nm Au partical build by AFM manipulation

[b] In 203nanowire sensor for N O2built by CVD

[c] Nanomanipulated 15 nm Au particle

[c]



WHAT TO EXPECT IN THE NEAR FUTURE

PREDICTED USES OF NANOROBOTICS

If the ideas mentioned above do become reality any time soon, every branch of medicine ought to benefit. Frankly, nanorobotics holds such a vast scope, that a single paper can't cover it all. Hence, the focus here is limited only to its revolutionary impact on the field of medicine.

Central Nervous System (CNS): Nanobots could be used to treat the cancers in the CNS too. At times, they themselves could act as implants, replacing damaged neurons in some patients. Nanobots will also be able to perform neural surgeries as well as surgeries of the brain, with a high success rate. It would also prevent the necessity of today: drilling a hole in the skull to gain access to the brain. Nanobots can also be used to help people suffering from motor neuron diseases, as well as paralysis. Once injected into the patient, they can locate themselves at specific places in the brain, and pick up impulses which would normally be delivered to the body's motor neurons. These impulses can be used to drive external prosthetics, such as a robotic arm. Thus, it would help a lot of people from overcoming their disabilities.

Cancer treatment: This is probably the main reason for the development of nanorobotics. Drug delivery for cancer today is difficult to control. Chemotherapy harms healthy tissue in addition to cancerous tissue. We cannot prevent adverse effects of chemotherapy on other parts of our body. Nanorobotics will change it all. Nanobots could be used to deliver drugs specifically to the tumour only, thus preventing the peripheral impact of the drug. One of the many methods to achieve this is the following: Primary nanobots are sent to the target tissue (tumour) to inflame it. This is partly a machine gun approach; a lot of the bots will be wasted. However, only the tumour is inflamed and not any other tissue in the entire body. Now, a second wave of bots is sent, to target the inflamed tissue. This wave of bots contains the actual chemotherapy drug. It releases its payload i.e. the drug only after sensing the inflamed tissue. Thus, we have a highly concentrated targeted action, with no peripheral impact. We could liken it to a sniper's rifle.

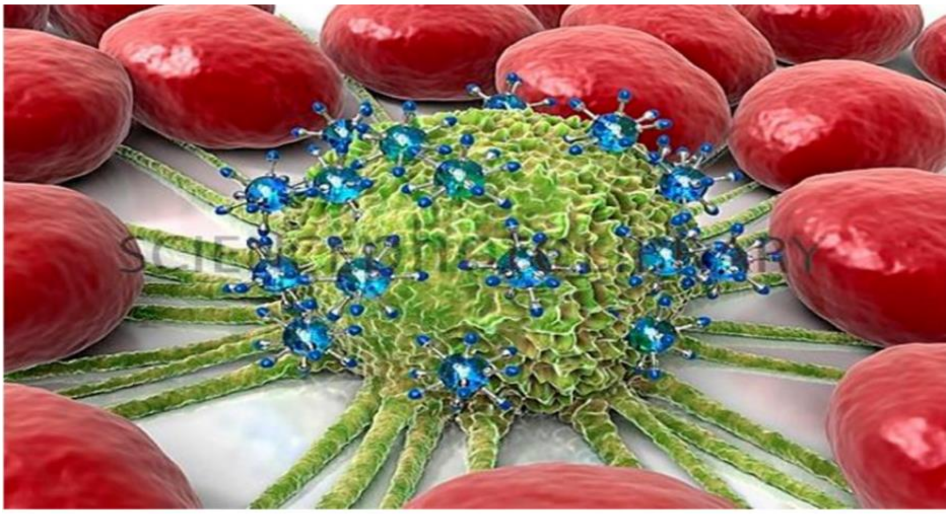


Figure 2: Nanobot targeting tumour site.

Source: Image courtesy http://www.sciencephoto.com/media/154352/enlarge.[82]

Body surveillance: Continuous monitoring of vitals and wireless transmission could be possible using nanobots, leading to a quantum leap in diagnostics. This would also help in rapid response in case of sudden change in vitals, or could warn against a possibility of a risk, such as high blood glucose in case of diabetics. Also multi-functional bots could convert themselves into stents, say to open up a blockage in an artery. The bot itself can be used as a tool, to remove unwanted materials such as blockages in the circulatory system. Nanobots could be used in large quantities inside the body to sense and repair anomalies/ abnormalities. Current macroscopic robots are being programmed and tested with what is known as "swarm intelligence", in which they share information available to each one of them, pool it together, and take collective decisions. Such behaviour is seen in ant colonies too; they communicate with the help of chemicals and behave like one large organism, often referred to as a "super organism". Using the strategy of swarm intelligence, in intra-body nanobots could help in creating a single strong defensive shield against pathogens and toxins. It would also help prevent vitals from going out of medically defined bounds.

Delicate surgeries: Surgeries such as those of the eye are even today performed successfully only by a few skilled surgeons. Immense risk is involved in these delicate surgeries and they require a steady hand as well as a strong constitution. It may soon be possible to take the human element of risk out of this equation. Micro surgery of the eye as well as surgeries of the retina and surrounding membranes could soon be performed using nanobots. In addition, instead of injecting directly into the eye, nanobots could be injected elsewhere in the body and guided to the eye to deliver drugs, if necessary. Similarly, other difficult surgeries will also benefit from advances in nanorobotics. Foetal surgery, risky even today due to high mortality rate of either the baby or the mother, could soon have a 100% success rate, due to the fact that nanobots can provide better access to the required area inducing minimal trauma.[84]

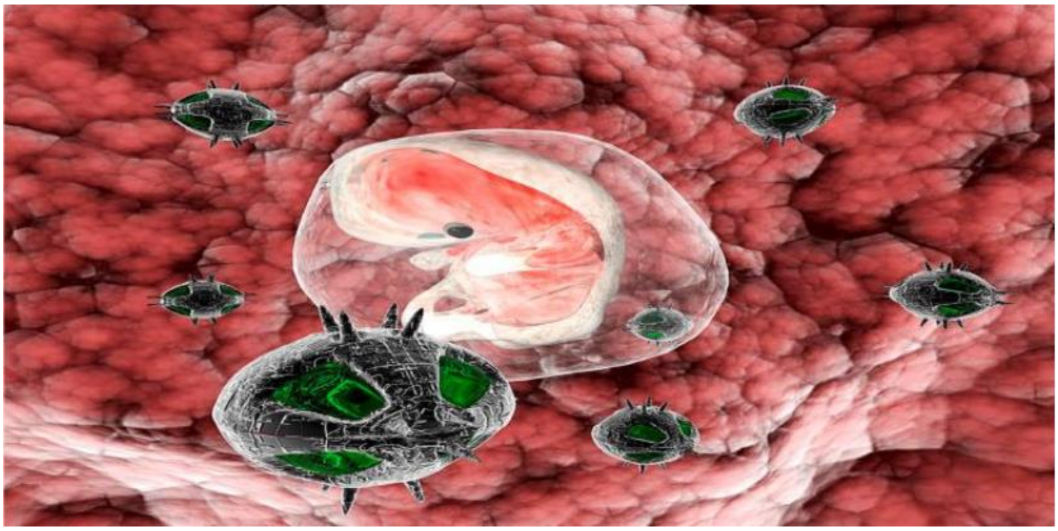


Figure 3: Nanobots being used in foetal surgery (concept) Source: Image courtesy. http://fineartamerica.com/featured/nanorobots-with-human-embryo-christian-darkin.html.[83]

Advantages

Current improvement in drug delivery is to identify the specific cells with the self of nanosensors and regulate the discharge by use of smart drugs.

Currently there is no permanent vaccine or medicine is available to cure the disease.

At present available drugs in the market can increase the patient's life to a few years only, so the invention of this nanorobot will make the patients to get rid of the disease with no side effects. It operates at specific site only.[85]

Cancer research illustrates many of the medical potentials of nanotechnologies in the longer term. It is hoped that nanoscale devices and processes will help to develop. Imaging agents and diagnostics will allow clinicians to detect cancer in its earliest stages.

Multifunctional, targeted devices capable of by passing biological barriers to deliver multiple therapeutic agents directly to cancer cells and those tissues in the microenvironment that play a critical role in the growth and metastasis of cancer.

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