NANOROBOTICS: A THERANOSTIC APPROACH

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ABSTRACT
Scientific advancements and modern vision holds a hand over every field of technology and sciences. The technology which, works at atomic level is called nanotechnology, deals with everything from medical sciences to electronics and a broad area of techniques. The high reactivity and desirable properties can be obtained after manipulation of bulk material at atomic level. Nanorobotics is a branch of nanotechnology – having characteristic features of actuating, sensing, signaling, information, processing and intelligence at nano scale. Nanorobotics in medication conveyance and therapeutics would be the next breakthrough in the medical sciences. In recent times, scientists are working towards developing smarter drug delivery system for rigid and complex diseases like Cancer, Alzheimer's, Parkinson's disorders and many more. The present review article focuses on the nanomaterial in the field of diagnostics and treatment with the brief introduction to the composition, mechanisms and their application in medicine. This technology has the potential to solve prime problems of the world. Due to nanotoxicity that comes along with these experiments, the field is yet to explore the depth of these techniques.

Key Words: Nanotechnology, Nanorobots, Medicine, Pharmaceutics, Theranostic nanomaterial.

I. INTRODUCTION

1.1. Brief History

Albert Hibbs suggested Richard Feynman(circa 1959), the therapeutic possibility of Feynman's hypothetical micro machines.[1] This opened the possibility, that specific fix machines could one day be diminished in size to the point that it would, in principle, be convenient to (as Feynman put it) "swallow the surgeon". In 1974, the professor of Tokyo University of science, Norio Taniguchi coined the term "Nanotechnology". Prof. Taniguchi described the process of thin-film deposition and ion beam milling in semi-conductor, exhibiting characteristics control in the order of a nanometer; nanotechnology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule. He studied the developments in machining techniques and predicted correctly the late 1980s.[2] In 1981, Gerd Binnig and Heinrich Rohrer discovered scanning tunneling microscopethat worked at individual atoms. In 1985 Harry Kroto, Richard Smalley & Robert curl discovered fullerenes which worked as molecular scale electronic.[3] A listed hypothetical exchange of nanorobotics, including specific design issues, for example sensing, power communication, route, control, movement, and locally available calculation, has been introduced in the therapeutic setting of nanomedicine by Robert Freitas (circa 1999).[4]

1.2. Contribution of the scientists:

NAME OF THE SCIENTIST	CONTRIBUTION
Heinrich Rohrer	Father of nanotechnology
Prof. C.N.R. Rao	Father of Indian nanotechnology
Richard Feynman	Historical development of nanotechnology
Norio Taniguchi	The processing of deformation of materials from one atom.
K. Eric Drexler	Handling of individual atom
Mohamed Atalla & Dawon Kahng	Nano layer-base transistor
Gerd Binning & Heinrich Rohrer	The first atomic force microscope
Irving Langmuir and Katharine	Study of gold sols and other nanomaterial's
Richard Adolf Zsigmondy	B. Blodgett concept of monolayer

Derjaguin and Abrikosova	The first measurement of surface forces
Tuomo Suntola	Atomic layer deposition
Louis Brus	Created Nano crystals
Harry Kroto, Richard Smalley & Robert curl	Discovery of fullerenes
Sumio Lijima	Discovery of carbon nanotubes
Michael Crichton	Artificial swarm of Nanorobots
Adriano Cavalcanti	Invented Nanorobots

Progression of science and technology at small scale has increased by manipulating by matter on an atomic, molecular and supra molecular scale at size of 1 – 100 nm in one dimension.[5] It includes field like surface science, organic chemistry, molecular biology, semiconductor physics and many more.[6]In other words it can be define as *"The bracing and brisky technology which deals with the manipulation of atom and molecule below the threshold size of the component is termed as nanotechnology."*

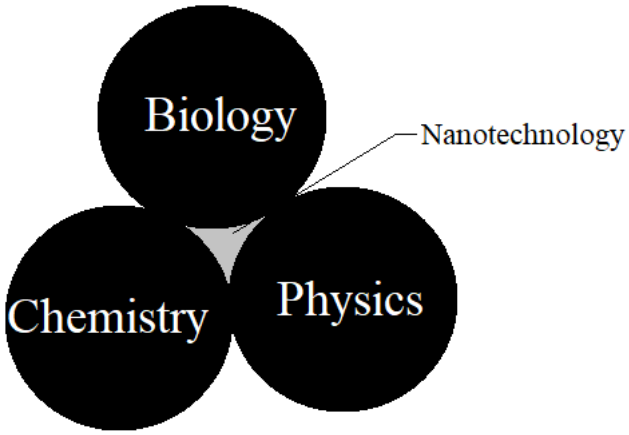


Figure 1 Illustrative model is showing application of nanotechnology in all main three branches

Nanomaterial's and gadgets assume a significant job in the field of pharmaceutical nanotechnology.[7] The recent progressions in health: drug delivery; agriculture: crop protection and livestock productivity; waste water treatment; early detection of diseases; energy storage: solar power. By utilizing Nanodevices we can make exact imitation of appendages and reestablish vision. The zones which are canvassed in pharmaceutical industry are biosensor, nanorobot, liposome, quantum spot, polymeric nanoparticles etc.

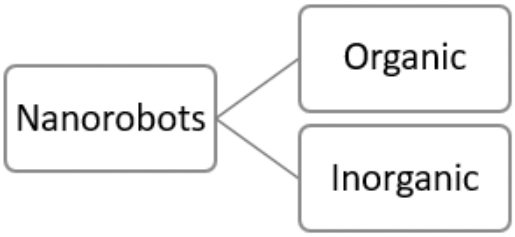
2. Nanorobots

The term nanorobot comes from an amalgam of Robot and Nano. Other synonymous names for robots of this size incorporate nanobots, Nano mites, and Nanites with sizes going from 0.01 to 0.1 micrometers.[9]Currently, most nanobots research is being done in the therapeutic and military fields.[10] The more the innovation builds, the more prominent the quantity and quality of potential uses that emerge. An elective advancement for nanorobots is the connections that a robot can achieve on the nanoscale goals with no confinement on the general size of the robot.[11]Nanotechnology is assuming a key job in transforming this fantasy into reality with the assistance of nanorobots. These Nanorobots are equipped for working as performing various tasks operators for fighting focused on contaminations and fatal ailments like malignancy.[12]Analysts everywhere throughout the world are dealing with creating more up to date and increasingly effective strategies to make these tiny nanorobots go swimming in the body liquids to convey anticipated remedial advantages.[13]

2.1. Nanorobotics

A functional methodology with advance computer aided manufacturing analysis is introduced for the issue of nanorobot, gets together automation and instrumentation.[14]The prototyping improvement focuses its fundamental focus on down to earth test, nanorobot equipment assembling structure and control framework for insightful neurotic detecting and control.[15]Medical nanodevices give a reasonable method to empower the clinical treatment of patients with constant ailments.[16] Thus, the nitty-gritty tasks use inside body 3D continuous representation and equipment check strategies, tending to key viewpoints required to accomplish effective assimilated nanoelectronics item usage.[17]

2.2. Type of Nanorobots



Two kinds of nanorobots most generally looked into are, organic and inorganic. The natural nanorobots, called bionanorobots, are produced by utilizing viruses and microscopic organisms DNA cells.[18] Such nanorobot is less lethal to the life form. Inorganic nanobots are made of diamond structures, incorporated proteins and others sorts of material.[19] These kinds of robots are progressively poisonous, a method for diminishing this issue is to exemplify the robot, this technique additionally stays away from its devastation by the body's guard framework, this issue, has been a noteworthy test looked by specialists.[20]Through information about natural engines of living cells, researchers can figure out how to control miniaturized scale measured and nano-sized machines with catalytic reaction.[21]

2.3. How does Nanorobots work?

Nanorobots response to external stimuli such as chemical reaction temperature or radio waves. The way a nanorobot moves in a liquid environment is of main consideration during designing. It is important that the device can have a smooth trajectory path while navigating in the blood environment and at the same time it doesn't cause any damage to other cells. The tentacles need to have a high responsive rate in order to move its tentacles further forward just in time to capture the infectious cell once it is detected.[22, 23]

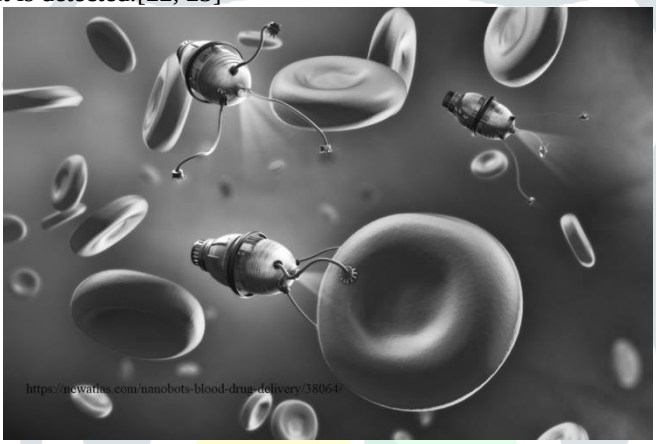


Figure 2 Model showing nanorobots swimming in blood stream

Switch: Nanorobotics switch functions by making a charge from an "off" position to "on" by receiving external stimuli. A conformational change is the point at which nanobots changes its shape in light of outside upgrades.[24]

Motor: A nanomotor is to some degree more mind boggling than a nanorobotic switch and can utilize the vitality created by the conformational change to produce physical development in the encompassing particles.[25]

Shuttle: A nanorobotic transport alludes to a gadget that transports explicit medications or synthetic compounds to a decided spot. Researchers are presently attempting to match these with nanomotors so they can have a more prominent level of power over how they travel in their condition.

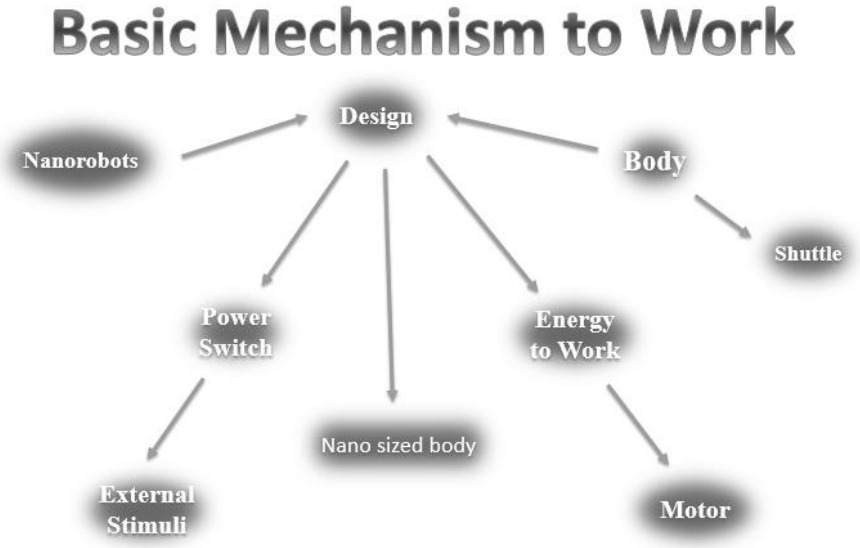


Figure 3 Showing the basic working mechanism of nanorobots

2.3.1. Components

Power source: Nanorobots are generally utilized in therapeutic applications to fix basic issues of a patient. For this situation, the nanorobots are sent inside a human body and made to swim in the blood utilizing driving frameworks. As like route frameworks, the fueling frameworks of nanorobots likewise utilize internal or external power sources.

- **Internal Power Source:** A nanorobot can be controlled internally by the accompanying systems:
  - Usage of installed power source in the nanorobot
  - Human blood flow
  - Creation of warmth in the human body
  - Incorporation of anodes in nanorobots and electrolytes in human blood will act as battery.
  - Blend of synthetic responses in human blood and synthetic concoctions in nanorobots will prompt the development of fuel source.

An installed battery can likewise be consolidated in the nanorobots for fueling purposes. But, this power source will just convey power supply dependent on the size of nanorobots and weight. Additionally, a capacitor could be a convenient gadget since it can give somewhat improved capacity to weight proportion than a battery.[26, 27]

- **External Power Source:** A nanorobot can be powered externally by tethering wires between the powering system and nanorobot. This technique requires strong wires, which can move easily inside the human body without causing any damages. The power can be provided either by optical or electrical systems. The optical systems will pass light via fiber optics, and then it will be converted into electrical power. There are also wireless external power systems including ultrasonic signals, microwave radiation, and magnetic fields.[28]

Actuator: An actuator is a type of motor that is in charge of moving or controlling an instrument or framework. It is worked by a wellspring of vitality, normally electric flow, water powered liquid weight, or pneumatic weight, and changes over that vitality into movement. An actuator is the component by which a control framework follows up on a situation. The control framework can be straightforward (a fixed mechanical or electronic framework), programming based (for example a printer driver, robot control framework), a human, or some other information.[29]

Sensor: The nanorobot sensing strategy relies on the mobility of artificial nanomotors with functionalized different bio receptors. The designing of these sensors gives them vision enabled-insertion on their structure. They are used to measure velocity and locate the robots position.[30]

Navigation: Setting up total or relative physical situation crosswise over numerous systems including circulation system, tissues, organs, and cells; positional route by dead retribution, cartotaxis, full scale/miniaturized scale transponder systems.

Manipulation: Arrangement and incitation of controllers including ciliary, pneumatic, or extending frameworks; stowage, recovery, choice, establishment, use, and separation of tooltips and opposite end-effectors; the board of hardware and controller carports; the executives of facilitated controller clusters; and control of locally available transfer or dismantling frameworks including morcellation, granulating, sonication, warm or concoction deterioration frameworks.[20]

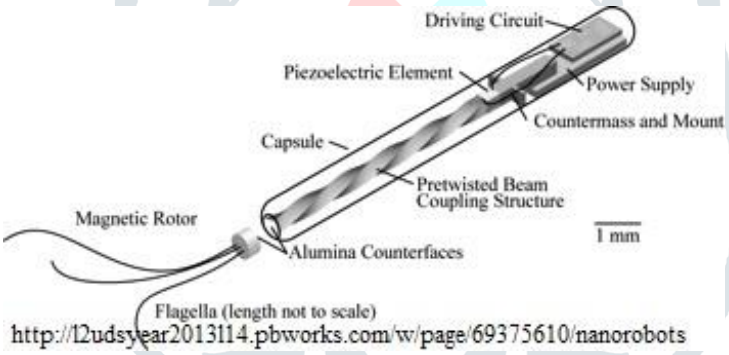


Figure 4 Labelled components' of nanorobots

Locomotion: Control of explicit in vivo velocity frameworks including ciliary or catch frameworks, surface disfigurement, slanted planes/screws, volume relocation, and gooey tying down frameworks; control of headway crosswise over cell-covered tissue surfaces, amoeboid movement or inchworm motion.[31]

2.4. Model Characteristics of Nanorobots

Actuation: The component of nanorobots that is responsible for moving and controlling mechanism of the system. It required and external stimuli or direct source of energy. The control system can be simply software based or other input.[32]

Nanosensor: They are the device that measure physical quantities and convert those quantities to signal that can be detected and analyzed.[33] There are different types of nano sensor in the market and in development for various applications. As they are operated at similar scale as natural biological processes following functionalization with chemical and biological molecules recognizing event that cause detectable physical changes.[34]

Information Processing: Artificial intelligence: by combining all the different types of nanorobots that are being developed, together in a symbiotic symphony of regeneration throughout the entire body. By developing this kind of colony controlled by AI, it can be organized. According to John McNamara from IBM Hursley innovation Centre "AINano machine implanted into the human body will offer huge medical benefits which include being able to repair cells and organs."[35, 36]

By combining all the different type of nanorobots that are being developed together in a symbiotic symphony of regeneration throughout the entire body. By developing this kind of colony controlled by artificial intelligence is organized as a hire. According to John MC Namara, from IBM Hursley innovation center, (who submitted evidence to the Hous) said that "Artificial intelligence Nano machine implanted into the human body will offer hug medicine benefits, which include being able to repair cells and organs.[37]

2.5. Nanorobots in the field of medicine

Nanorobots are gadgets with segments produced on the nanoscale which can perform medical procedure at the cellular level, expelling individual ailing cells and fixing flawed segments of individual cells, they can wipe out the bacterial contaminations in the patient within minute, rather than utilizing treatment with anti-microbial over a time of

weeks.Nanomedicine is a new branch of medicine that seeks to bring the promise of nanotechnology to open up an entirely new avenue for treatment.[22]Nanorobots are relied upon to empower new medications for patients experiencing various ailments, and will bring about an amazing development throughout the entire existence of medication.[38] Ongoing advancements in the field of bimolecular registering have exhibited the plausibility of preparing rationale undertakings by bio-PCs.[39] This is a promising initial step to empower future nanoprocessors with expanded intricacy. Studies focused at structure biosensors and nano-active gadgets required to empower medicinal Nanorobotics activity and motion, have likewise been advancing.[40]

2.5.1. Nanorobots in biomedical application

They can perform surgery at the cellular level removing individual disease cell and repairing defective portion of individual cell.[40, 41]Mainly research are focusing on

Cancer:

Nanorobot with embedded biosensor can be used to detect tumor cells in early stage of development.[42] Therefore, a hardware architecture based on nano electronics is based on the application of nanorobots in Cancer therapy.[43]Nano particles play a key role in developing new methods for detecting cancer. The science of Arizona State University has developed "DNA robotic system" for a very precise drug design and targeted cancer therapy. This "DNA robotic system" can be used for many type of cancer.[44]

Cancer associated fibroblasts (CAF) speaks to most of cells found into the tumor stroma, applies complex connections with threatening epithelial cells by straightforwardly or in a roundabout way collaborations.[45] Through the immense group of stars of cytokines and development factor discharged, the phones are engaged with a huge number of flagging pathways and are planning a few atomic falls associated with tumoral movement and metastasis,[46] for example, epithelial-mesenchymal change, angiogenesis and variation from the norm of apoptosis. The multifaceted nature of flagging procedures associated with pancreatic malignant growth was additionally represented by Gaianigo et al. We may affirm that CAF are arranged in the focal point of metastatic procedure and manage the principle pattern of tumorigenesis. Therefore, reestablishing ordinary homeostasis might be accomplished by either expelling CAF, hindering their advancement, or by obstructing the flagging pathways controlled. It has been as of late announced that CAF can prompt EMT in prostate malignant growth cells. The connection between the two kinds of cells was observed as interleukin 6, discharged via carcinoma cells, which prompted fibroblast enactment. Focusing on CAF has come to by taxane nanoparticles and demonstrated profoundly compelling methodology, by diminishing the tumoral mass and hinder metastasis arrangement in pancreatic disease mouse model. Reestablishing epithelial homeostasis requires multi-focused methodologies, as proposed by Navarro P Et Al.[47]who revealed that reestablishing E or P-Cadherin capacity isn't sufficient to balance out epithelial cells in axle cell carcinoma. By permitting numerous functionalization of different nanostructures, making multi-directional focusing on conceivable, nanotechnology may discover its commitment as a possible methodology. As of late, Watson KD et al.[48] revealed that ultrasound introduction empowers the limit of liposomes to amass into the essential EMT tumors, expressing the utilization of nanotechnology for medication conveyance upgrade.[49]

Alzheimer's:

BBB is the primary barrier to the delivery of therapeutic drugs to the brain, some treatment have focused to open it, by causing structural damage to the BBB, at which point the BBB losses its selectivity for drug passage.[50] The carrier system combined with nano technology is the most promising treatment strategy for drug delivery.

Nanorobots can be used to screen blood, biomarkers of AD, thereby monitoring diseases onset and progression moreover if extravasation out of the blood across the Blood Brain Barrier (BBB) nanorobot could enter the CNS to directly combat pathology.[51]

Medical nano robot will provide a single powerful general-purpose therapeutic platform that can simultaneously address many different kind of biological malfunction, using platform variant is specifically and efficiently targeted to each of the multifactorial pathologist companies Alzheimer disease.[52]

2.6. Advantages:

a) Nanorobots can treat and find diseases and restore tissue at cellular level.
b) Useful in monitoring, diagnosing and fighting diseases.
c) Nanorobots might also produce copies of themselves to replace worn out units, a produce called self-replication.[9][53]

2.7. Disadvantages:

a) The cost of robotic is very high and complex
b) The uses of this kind of artificial intelligent and small scale or nanoscale can add more advantage in field of terrorism.
c) These should be accurate or a harmful effect can be produced.

Privacy is other potential risk involved with nanorobot. As nanorobots deals with the designing of compact and minute device, there are chances for more eavesdropping than that always exists.

3. Conclusion:

Science instills the desire for the compelling utilization of this innovation in therapeutic field. This paper begins by giving a prologue to nanorobots. Assembling advances are inventive works which can encourage building and utilizing of nanorobots most adequately for medication issues. Nano robotics are still in developing stages and much of it is still untouched. In the coming future, nanorobots could change prescription. Specialists could treat everything from coronary illness to malignancy by using little robots of the size of microbes, in a scale lot smaller than the present robots. Robots would be able to function according to the need, can work alone or in groups to destroy illness and treat different conditions. Thus, utilization of nanorobotics in the field of medication has a more extensive scope. This dramatic change will let the world witness an extraordinary transformation in medication, practically identical to the mechanical insurgency which will reshape the world. In next few decades we could sensibly free ourselves from diseases that plague us, which looks impossible in today's world where Nano robotics is yet to take over.

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