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Review

Nanorobots in drug delivery system

P. SelvaKumar*, K. Rupa, S. Sivanandhini, K. Varshini, A. Priya Dharshini,
Dr. P. Kavitha

Krishna Pharmacy College, Kottaimedu, Irungular, Trichy 621105, Tamilnadu, India.

Corresponding Author: P.Selvakumar
Email: selvakingdoms3052002@gmail.com

	Abstract
Published on: 13 Apr 2025	<p>The nanorobotics is the technology of the creating machines or the robots at or close to a scale of the 10-9metres [nanometre] nanorobots. Nanotechnology can be defined as a description of activities at the level of atoms and molecules. The nanorobots will be used for maintaining and protecting the human body against pathogens. Benefits of robotic devices are controlled, Precise and site specific drug delivery capability. Nanomedicine is the branch of medicine that utilizes the science of nanotechnology in the preclusion and cure of various diseases using the nanoscale materials, such as biocompatible, nanoparticles and nanorobots for various applications including, diagnosis, delivery, sensory, or actuation purposes in a living organism nanorobots. It is specific targeted therapy, increaseth the bioavailability and noninvasive technique. Recent times nanorobots having many applications in cancer treatment, surgery, heart attack and kidney disease.</p>
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	Keywords: Nanorobots

INTRODUCTION

The phrase “nano” originates from the Greek phrase "dwarf". The concept of nanotechnology turned into first elaborated in 1959 by means of Richard Feynman, a Nobel Prize triumphing physicist, in a lecture titled, “There’s lots of room at the lowest”. He ended the lecture concluding “this is an improvement which I think can't be prevented”. seeing that then, nanotechnology has discovered use in a myriad of applications which includes dental analysis, material and therapeutics. The term nanotechnology become coined by using a pupil of Tokyo technological know-how college in 1974.

Nanotechnology is the take a look at, layout, introduction, synthesis, manipulation, and application of materials, devices and systems on the nanometer scale (One meter consists of 1billion nanometers). Nanotechnology can first-rate be described as an outline of activities at the level of atoms and molecules that have applications in the actual global. A nanometer is a billionth of a meter, that is, approximately 1/80,000 of the diameter of a human hair, or 10 instances the diameter of a hydrogen atom. Nanotechnology is part of applied science whose subject matter is to manipulate the matter on atomic and molecular scale. it is turning into an increasing number of vital in fields like engineering, agriculture, construction, microelectronics and fitness care to mention some. The utility of nanotechnology within the field of health care has come beneath super interest

these days. there are numerous remedies today that take a lot of time and are also very pricey. using nanotechnology, faster and plenty less expensive remedies may be advanced. [4] Nanomedicine is the sector in medicine that is carried out in prognosis to remedy of sickness and nanotechnology is used for growing diagnostic machine. consisting of mobile imaging by nanoprobes like quantum dots, plasmonic nanoparticle, magnetic nanoparticle, nanotubes, nanowires and multifunctional nanomaterials may be done for prognosis.[8]

Robots have emerged as a beneficial alternative for the centered and controlled delivery of medication. the primary benefit of robot devices is their controlled, unique, and placement-specific drug transport capability, in comparison to different conventional healing transport structures of smaller sizes. Robots like stimuli-responsive and floor-functionalised magnetic helical micro swimmers have not best the functionality to goal specific single cells however also the desired regions of the tissues for the controlled and centered shipping of cells, genes, or capsules. usually, the mechanism of shipment/drug release in a small robotic-like (micro/nanorobots) is initiated not actively thru confined modifications in physiological environments (consisting of temperature, pH) at the goal website online. however, the transport of promising off- target remedy may be produced thru complex physiological environments or unexpected neighborhood variations. [4]

Ideal characteristics of Nanorobots

- Nanorobots must have length in among zero.five to three microns big with 1-one hundred nm parts.
- Nanorobots of large size than the above will block capillary drift.
- It's going to save you itself, from being attacked by means of the immune system by way of having a passive, diamond exteriortired.
- It's going to communicate with the health practitioner with the aid of encoding messages to acoustic indicators at service wave frequencies of one-100MHz.
- It ought to have lengthen Bioavailability
- It might produce multiple copies of it tore place worn-out units, a process called self replication.

Advantages of nanoparticles (NPs) administration (adm.) compared to other methods of drug delivery

Bioavailability	High	High	Poor	Poor	Poor
Hepatic first pass Metabolism	Prevent	Prevent	Prevent	Not prevent	Not prevent
Toxicity	Less pronounced side effects because of lower concentrations of therapeutic drugs and more stable release characteristic	Less pronounced side effects because of lower concentrations of therapeutic drugs and direct transport through BBB	Less pronounced side effects because of lower concentrations of therapeutic drugs and more stable release characteristic	High chance and depended side effects	High chance and depended side effects

Property	NPs	Intranasal administration	Transdermal administration	Oral administration	Intravenous administration
Controlled Release	Available	Not available	Available	Not available	Not available
BBB Penetration	Does not depend on the properties of drug	Does not depend on the properties of drug	Depends on the properties of drug	Depends on the properties of drug	Depends on the properties of drug
Ability to targeted delivery	High	Not available	Not available	Not available	Not available

[6]

Design of nanorobots considerations

They're designed to hit upon and get to the affected a part of the frame and send comments, nanobots can be made from nearly any type of materials and may have numerous production technique. the two precept production conventions are,

- I. Top-Down

II. Bottom-Up [8]

Important parts (sensor, motor, power supplier, molecular computers, manipulators)

- Medicine cavity
- Probes, knives and chisels
- Microwave emitters
- Electrodes
- Lasers
- Power supply for nanorobots

Medicine cavity

It's far a hole phase in the nanorobot used to hold small doses of medicine in those robots which are able to freeing remedy without delay to the site of harm or infection.

Probes, knives and chisels: These are used to dispose of plaque and block a long time those probes, knives and chisels are used. those components assist nanorobot to seize and destroy down the material. also they might want a tool to weigh down clots into very small pieces.

Microwave emitters: Those are used for destroying cells like cancerous cells with out rupturing it. by way of the use of high-quality-tuned microwaves or ultrasonic indicators, a nanorobot should smash the chemical bonds inside the cancerous cellular, killing it without breaking the mobile wall.

Electrodes: With the help of electrodes nanorobots generate electric modern-day, heating the cells until it dies.

Lasers: Lasers are used to burn the damaging substances like cancerous cells, blood clots and plaques.

Power supply for nanorobots: The foremost requirement for the nanorobot is, of course, strength. The nanorobots require energy to permit it to perform all of its required operations.

There are possible approaches.

- The primary is just too btain the energy from a supply with in the body, both by means of having a self-contained energy deliver, or by way of getting strength from the blood stream.
- The second one opportunity is to have power supplied from a supply outside to the frame.

Propulsion Equipment: These are needed for movement of nanobots inside the body. Nanomotors are nanodevice with their own propulsion, obtaining the energy by chemical reaction of the medicine, electricity, magnetic or acoustic field. [8]

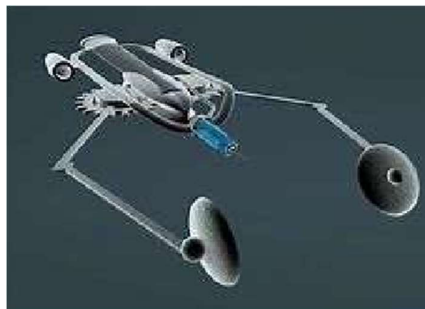
Types of nanorobots:

Nanorobots in drug delivery and therapeutics according to the their applications, which are described below,

- ❖ Pharmacyte
- ❖ Respirocytes
- ❖ Microbivores
- ❖ Clottocytes
- ❖ Chromalloytes

Pharmacyte

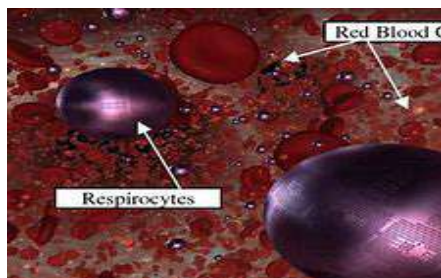
Pharmacyte is a clinical nanorobot with a diameter of 1–2 μ m and a drug maintaining capacity upto 1–3 μ m within the reservoirs, as proven in determine.



They are provided with a molecular markers or chemotactic sensors that guarantee full focused on accuracy. they are added by using molecular signs or chemotactic sensors, which ensure the precision of the targeting system.

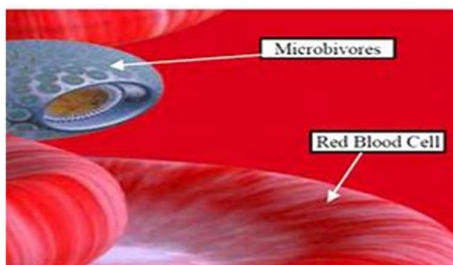
Respirocytes

In this type of nanorobot that consists of oxygen like an artificial purple blood cellular. The energy is achieved through endogenous serum glucose. Such synthetic cells can offer 236 times extra oxygen to the tissues in keeping with unit volume than RBCs (Redblood cells) and direct acidity, the discern shown beneath,



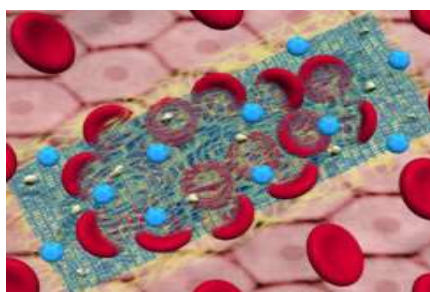
Microbivores

It is an oblate spheroidal device for nano-clinical programs with three.4 μm in diameter along its important axis and a couple of.0 μm in diameter along its minor axis. The nanobot can usually devour upto 200pW. This power is used for digest trapped microbes. any other one of a kind feature is associated with the potential to phagocyte approximately 80 instances extra efficiently than macrophages agents, in phrases of quantity / sec digested according to unit quantity of phagocytic agent. The parent shown above. [4]



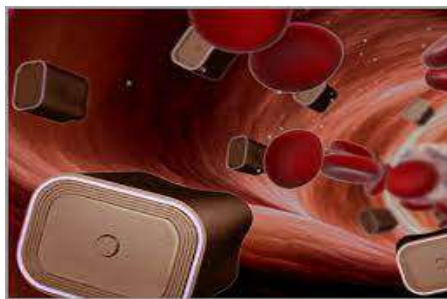
Clottocytes

Clottocytes have a special organic capacity: 'on the spot' hemostasis thru clottocytes, named artificial mechanical platelets. moreover, platelets are coarsely spherical blood cells without a nucleus and nearly 2 μm in size and persist with a bleeding factor and help in clotting the blood vessels to prevent the bleeding. in addition they shipping substances that assist within the coagulation technique. [1]



Chromalloyte

The Chromalloyte might replace complete chromosomes in person cells for this reason reversing the results of genetic sickness and other collected damage to our genes, stopping growing old. inside a cellular, repair gadget will first length up the state of affairs by means of analyzing the cellular's contents and interest, and then take motion via operating along molecule-by means of-molecule and structure-with the aid of shape; restore machines can be able to repair the complete cellular. [1]



Mechanism and action of nanorobots

Nanorobotics works by using the use of robots at nanoscale, which are also called nanorobots. The design and operation of nanorobots can vary relying on their intended use. In general, nanorobots could paintings through the use of numerous technology like nanoscale sensors, manage structures and nanoscale actuators. The sensors in nanorobots should come across particular indicators or conditions like the presence of a certain form of molecule or fabric, and then transmit this statistics to the manage device. The manipulate system could then use this data to determine on the proper motion for the nanorobot. We should use the nanorobots' actuators to perform a huge variety of movements inclusive of movement, freeing of medicine within the human body or the manipulation of systems and materials. so as to perform their meant duties, nanorobots need so that you can navigate and interact with their surroundings. this can be finished by way of a selection of techniques like self-propulsion, remote manipulate, or via chemical or biological approach. [7]

Advantages of nanorobots

- Use of nanorobot drug delivery systems with increased bioavailability.
- Targeted therapy such as only malignant cells treated.
- Reach remote areas in human anatomy not operatable at the surgeon's operating table.
- As drug molecules are carried by nanorobots and released where needed the advantages of large interfacial area during mass transfer can be realized
- Non-invasive technique
- Computer controlled operation with nobs to fine tune the amount, frequency, time of release
- Better accuracy
- Drug inactive in areas where therapy not needed minimizing undesired side effects.
- Small size- The upper limit of the size of nanorobot is 3 micron so that it can easily flow in the body without blocking the capillary flow.
- Cost effective (if mass produced) - Manufacturing by batch processing reduces the cost even if the initial cost of development is high.
- Less post treatment care - As it is minimally invasive technique, therefore less post treatment care is required.
- Using nanoprobes in high volume
- Surface tailorability
- Intrinsic properties. [8]

Drawbacks: The development and implementation of nanorobotics faces several challenges, including such as, **Technical complexity:** Designing and operating nanorobots is a complex manner that entails many technical difficulties like development of nanoscale components, controlling the motion of the nanorobots and ensuring their stability.

Protection concerns: The ability for nanorobots in clinical programs and the surroundings increases issues approximately their protection. for instance, nanorobots, designed for clinical treatments, ought to damage patients in the case of a malfunction.

Regulatory issues: There are presently few rules in place to control the development and use of nanorobots, which may additionally sluggish their huge adoption through public and personal zone entities

Funding and sources: The improvement of nanorobotics is quite expensive and requires massive funding and resources, in addition to specialised device and human knowledge.

Time: The improvement and production of massive numbers of nanorobots may be tough because of the complex and time-eating nature of the manufacturing procedure. [7]

Other demanding situations: one of the mission confronted with the aid of nanobots is multifunctionality. due to their length, present nanobots have a unmarried characteristic and it's far tough to integret a couple of characteristic into one robot. [8]

Applications of nanorobots

Nanorobots in cancer detection and treatment

With the modern-day degrees of the medical technologies & the therapy tools the cancer may be dealt with correctly. therefore, the decisive aspect to decide a hazard for the patient with the most cancers to survive is, how early it was diagnosed, what way, if feasible the most cancers have to be detected at least earlier than the level of metastasis has commenced. the other important element to reap the successful treatment for the patients is the development of the green TDD [targeted drug delivery] to minimize the side consequences from the chemotherapy. [2]

Nanorobots in surgery

Through the vascular device or at the ends of the catheters into numerous vessels or in different cavities within the human body, the surgical nanorobots can be introduced into the body. The surgical nanorobot is programmed or guided by using the human beings urge on ought to act as the semi-autonomous on web site healthcare professional inner a frame of human. Such type of tool should perform the numerous features together with the searching for the pathology & then diagnosing & correcting the lesions via the nano-manipulation coordinated by the on-board laptop even as keeping the touch with a supervising doctor through the ultrasound indicators which is coded. [3]

Heart-attack prevention

Nanorobots also can be used to prevent coronary heart-assaults. coronary heart-attacks are resulting from fats deposits blocking the blood vessels. Nanorobots can be made for disposing of these fat deposits. The nanorobots eliminate the yellow fat deposits on the inner facet of blood vessels. this can permit for each enhancing the ability of the walls of the arteries and improving the blood float through them. From this hypothesis, such era will assist for shipping of drugs like lipid lowering materials such as lovastatin, simvastatin and so forth. these drug molecules will input with nanorobots and give transport on the web site of movement. [1]

Nanorobots in kidney disease

Nanorobots are used to break the kidney stones with the assist of ultrasonic shocks. Kidney stones are painful and a biggest one does no longer pass out in urine. from time to time doctor destroy this stones with the aid of ultrasonic frequency however, these are not effective in always. Nanorobots break up these kidney stones via using small laser and these smaller portions are passing out in urine outdoor the body. [1]

Biopolymeric nanoparticles in diagnosis, detection and imaging

The mixing of therapy and analysis is defined as theranostics and is being extensively utilized for cancer remedy. Theranostic nanoparticles can assist diagnose the sickness, record the location, identify the stage of the disorder, and offer statistics approximately the treatment reaction. further, such nanoparticles can convey a therapeutic agent for the tumour, which could offer the important concentrations of the therapeutic agent via molecular and/or outside stimuli. Chitosan is a biopolymer which possesses distinctive properties with biocompatibility and presence of purposeful businesses. It used within the detection and prognosis of different sorts of disorder. [5]

CONCLUSION

The use of nanotechnology enhancing/improving the solubility, absorbtion, bioavailability and controlled release of drug. Nanoparticles also contains agents for the treatment of neuropsychiatric diseases. Various nano containers are opening up prospects for new forms of medication such as subcutaneous transdermal drug delivery system patches. Considering the severe side effects of the existing therapies like radiation and chemotherapy but the nanorobots can be an innovative, supportive and optimize medicine technology for patients. It will play major role in future health care system, it is used in the treatment and diagnosing of the life threatening diseases.

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