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NANOROBOTICS: A NOVEL AND CONCEPTUAL TECHNIQUE FOR DRUG DELIVERY SYSTEM AND ITS APPLICATIONS IN PHARMACEUTICALS: A REVIEW

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ABSTRSCT

Nanorobotics is the futuristic aspect of nanotechnology which is utilized in various sectors like Engineering, Medical Science, Pharmaceuticals etc. Nanorobotics is concept based phenomenon which is utilized to diagnosed & Treat a patient without any side effects and well accepted by body due to invisible to the RES (Reticuloendothelial System) which is a defence system of our body & it is invisible due nano (10^{-9}m) size of the system. Generally, the size range of the nanorobotics is 20 -200 nm which is as similar than the Pharmaceutically and biologically nanosized products which is easily absorbed and highly effective to produce therapeutic effects in body because lower than this range of size the development of a system is a crucial task and may be impossible at present time. Nanoides, Nanobots, Nanomites are the different names of Nanorobotics which are based on the what kind of structure of the nanorobots which are developed on 3D graphical scale but the development of these nanorobots in trail stage.

KYEWORDS: Nanorobotics, Medical Science, Pharmaceuticals, Nanosized, Reticuloendothelial System, Nanomites.

INTRODUCTION

Nanorobots are nanometer size programmable assemblies which can be constructed by manipulating macro/micro devices or by self-assembly on pre-programmed templets or scaffolds.[1] Nanorobots are basically nanoelectromechanical devices (NEMS). These are similar to the biological cells and organelles and other nanosized pharmaceutical preparations. The technology of design, fabrication, and programming of these nanorobots is called as Nanorobotics.[2,3] It's a multidisciplinary use in various areas of science and technology including, Physics, Chemistry, Biology, Medicine, Pharmaceutical Science, Engineering, Biotechnology, and other Biomedical sciences. Richard Feynman, Nobel laureate and a scientist predicted nanomachines to be devices of the future.[4] Nanodevices have become the matter of scientific or technical curiosity and debate for researchers. It is predicted that nanorobotics would deliver unprecedented results in medicine and drug delivery applications.[5] These systems would be useful for drug targeting, controlled drug release, tumor diagnosis, cellular as well as genetic repairing of biological system.

Nanorobots would be constitute of any active or passive structure (Nano scale) capable of actuation, sensing, information processing, intelligence, swarm behaviour at nano scale. There are some of the characteristics abilities that are desirable for a nanorobot to function are:

- Swarm Intelligence- decentralization and distributive intelligence
- Cooperative behaviour- emergent and evolutionary behaviour
- Self assembly and replication- assemblage at nano scale and 'nano maintenance'
- Nano Information processing and programmability- for programming and controlling nanorobots (autonomous nanorobots)
- Nano to macro world interface architecture- an architecture enabling instant access to the nanorobots and its control and maintenance

They are generally invisible to naked eye, which makes them hard to manipulate and work with Techniques like scanning electron microscopy (SEM) and Atomic Force Microscopy (AFM) are being employed to establish a visual and haptic interface to enable us to sense the molecular structure of these nanosized devices. Virtual Reality (VR) techniques are currently being explored in nano- science and biotechnology research as a way to enhance the operator's perception by approaching more or less a state of 'full immersion' or 'telepresence'.

Elements of nanorobotics

Carbon will likely be the principal element comprising the bulk of a medical nanorobot, probably in the form of diamond or diamondoid/fullerene nanocomposites. Many other light elements such as hydrogen, sulfur, oxygen, nitrogen, fluorine, silicon, etc. will be used for special purposes in nanoscale gears and other components. The chemical inertness of diamond is proved by several experimental studies. One such experiment conducted on mouse peritoneal macrophages cultured on DLC showed no significant excess release of lactate dehydrogenase or of the lysosomal enzyme beta N-acetyl-Dglucosaminidase (an enzyme known to be released from macrophages during inflammation). Morphological examination revealed no physical damage to either fibroblasts or macrophages, and human osteoblast like cells confirming the biochemical indication that there was no toxicity and that no inflammatory reaction was elicited in vitro. The smoother and more flawless the diamond surface, the lesser is the leukocyte activity and fibrinogen adsorption. An experiment by Tang et al. showed that CVD diamond wafers implanted intraperitoneally in live mice for 1 week revealed minimal inflammatory response. Interestingly, onthe rougher “polished” surface, a small number of spread and fused macrophages were present, indicating that some activation had occurred. The exterior surface with near-nanometer smoothness results in very low bioactivity. Due to the extremely high surface energy of the passivated diamond surface and the strong hydrophobicity of the diamond surface, the diamond exterior is almost completely chemically inert.

The typical size of a blood born medical nanorobot will be 0.5-3 micrometers as it is the maximum size that can be permitted due to capillary passage requirement. These nanorobots would be fabricated in desktop nanofactories specialized for this purpose. The capacity to design, build, and deploy large numbers of medical nanorobots into the human body would, make possible the rapid elimination of disease and the effective and relatively painless recovery from physical trauma. Medical nanorobots can be of great importance in easy and accurate correction of genetic defects, and help to ensure a greatly expanded health span. More controversially, medical nanorobots might be used to enhance natural human capabilities. However, mechanical medical nanodevices would not be allowed to self-replicate inside the human body, nor would there be any need for self-replication or repair inside the human body since these nanobugs are manufactured exclusively in carefully regulated nanofactories with outmost precision.

Biochip

The joint use of nanoelectronics, photolithography, and new biomaterials, can be considered as a possible way to enable the required manufacturing technology towards nanorobots for common medical applications, such as for surgical instrumentation, diagnosis and drug delivery.[2,3,4] Indeed, this feasible approach towards manufacturing on nanotechnology is a practice currently in use from the electronics industry.[4] So, practical nanorobots should be integrated as nanoelectronics devices, which will allow tele-operation and advanced capabilities for medical instrumentation.[5]

Nubots

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

Positional nanoassembly

Nanofactory Collaboration,[6] founded by Robert Freitas and Ralph Merkle in 2000, is a focused ongoing effort involving 23 researchers from 10 organizations and 4 countries that is developing a practical research agenda specifically aimed at developing positionally-controlled diamond mechanosynthesis and a diamondoid nanofactorythat would be capable of building diamondoid medical nanorobots.

Bacteria based

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

Nanomedicine

Potential applications for nanorobotics in medicine include early diagnosis and targeted drug delivery for cancer biomedical instrumentation, surgery, pharmacokinetics, monitoring of diabetes, and health care.[9] In such plans, future medical nanotechnology is expected to employ nanorobots injected into the patient to perform treatment on a cellular level. Such nanorobots intended for use in medicine should be non-replicating, as replication would needlessly increase device complexity, reduce reliability, and interfere with the medical mission. Instead, medical nanorobots are posited to be manufactured in hypothetical, carefully controlled nanofactories in which nanoscale machines would be solidly integrated into a supposed desktop-scale machine that would build macroscopic products. The most detailed theoretical discussion of nanorobotics, including specific design issues such as sensing, power communication, navigation, manipulation, locomotion, and onboard computation, has been presented in the medical context of nanomedicine by Robert Freitas. Some of these discussions remain at the level of unbuildable generality and do not approach the level of detailed engineering.

Possible uses of nanorobots in medicinal field

Nanorobots in cancer Detection and Treatment

Cancer can be successfully treated with current stages of medical technologies and therapy tools. However, a decisive factor to determine the chances for a patient with cancer to survive is: how earlier it was diagnosed; what means, if possible, a cancer should be detected at least before the metastasis has began. Another important aspect to achieve a successful treatment for patients, is the development of efficient targeted drug delivery to decrease the side effects from chemotherapy. Considering the properties of nanorobots to navigate as bloodborne devices, they can help on such extremely important aspects of cancer therapy. Nanorobots with embedded chemical biosensors can be used to perform detection of tumor cells in early stages of development inside the patient's body. Integrated nanosensors can be utilized for such a task in order to find intensity of E-cadherin signals.Therefore a hardware architecture based on nanobioelectronics is described for the application of nanorobots for cancer therapy. Analyses and conclusions for the proposed model is obtained through real time 3D simulation.

Nanorobots in the Diagnosis and Treatment of diabetes

Glucose carried through the blood stream is important to maintain the human metabolism working healthfully, and its correct level is a key issue in the diagnosis and treatment of diabetes. Intrinsically related to the glucose molecules, the protein hSGLT3 has an important influence in maintaining proper gastrointestinal cholinergic nerve and skeletal muscle function activities, regulating extracellular glucose concentration. The hSGLT3 molecule can serve to define the glucose levels for diabetes patients. The most interesting aspect of this protein is the fact that it serves as a sensor to identify glucose.

The simulated nanorobot prototype model has embedded Complementary Metal Oxide semiconductor (CMOS) nanobioelectronics. It features a size of ~2 micronmeter, which permits it to operate freely inside the body. Whether the nanorobot is invisible or visible for the immune reactions, it has no interference for detecting glucose levels in blood stream.

Even with the immune system reaction inside the body, the nanorobot is not attacked by the white blood cells due biocompatibility. For the glucose monitoring the nanorobot uses embedded chemosensor that involves the modulation of hSGLT3 protein glucosensor activity. Through its onboard chemical sensor, the nanorobot can thus effectively determine if the patient needs to inject insulin or take any further action, such as any medication clinically prescribed. The image of the NCD simulator workspace shows the inside view ofa venule blood vessel with grid texture, red blood cells (RBCs) and nanorobots. They flow with the RBCs through the bloodstream detecting the glucose levels. At a typical glucose concentration, the nanorobots try to keep the glucose levels ranging around 130 mg/dl as a target for the Blood Glucose Levels (BGLs). A variation of 30mg/dl can be adopted as a displacement range, though this can be changed based on medical prescriptions. In the medical nanorobot architecture, the significant measured data can be then transferred automatically through the RF signals to the mobile phone carried by the patient. At any time, if the glucose achieves critical levels, the nanorobot emits an alarm through the mobile phone.

Nanorobots in surgery

Surgical nanorobots could be introduced into the body through the vascular system or at the ends of catheters into various vessels and other cavities in the human body. A surgical nanorobot, programmed or guided by a human surgeon, could act as an semiautonomous on-site surgeon inside the human body. Such a device could perform various functions such as searching for pathology and then diagnosing and correcting lesions by nanomanipulation, coordinated by an on-board computer while maintaining contact with the supervising surgeon via coded ultrasound signals.

The earliest forms of cellular nanosurgery are already being explored today. For example, a rapidly vibrating (100 Hz) micropipette with a <1micron tip diameter has been used to completely cut dendrites from single neurons without damaging cell viability.

Axotomy of roundworm neurons was performed byfemtosecond laser surgery, after which the axons functionally regenerated. A femtolaser acts like a pair of “nano-scissors” by vaporizing tissue locally while leaving adjacent tissue unharmed.

Cryostasis

The extraordinary medical prospects ahead of us have renewed interest in a proposal made long ago: that the dying patient could be frozen, then stored at the temperature of liquid nitrogen for decades or even centuries until the necessary medical technology to restore health is developed. Called cryonics, this service is now available from several companies. Because final proof that this will work must wait until after we have developed a medical technology based on the foundation of a mature nanotechnology, the procedure is experimental. We cannot prove today that medical technology will (or will not) be able to reverse freezing injury 100 years from now. But given the wonderful advances that we see coming, it seems likely that we should be able to reverse freezing injury - especially when that injury is minimized by the rapid introduction through the vascular system of cryoprotectants and other chemicals to cushion the tissues against further injury.

Diagnosis and Testing

Medical nanorobots can perform a vast array of diagnostic, testing and monitoring functions, both in tissues and in the bloodstream. These devices could continuously record and report all vital signs including temperature, pressure, chemical composition, and immune system activity, from all different parts of the body. Nanorobots swallowed by a patient for diagnostic purposes approach the surface of the stomach lining to begin their search for signs of infection.

Nanorobots in gene therapy

Medical nanorobots can readily treat genetic diseases by comparing the molecular structures of both DNA and proteins found in the cell to known or desired reference structures. Any irregularities can then be corrected, or desired modifications can be edited in place. In some cases, chromosomal replacement therapy is more efficient than in cytorepair. Floating inside the nucleus of a human cell, an assembler-built repair vessel performs some genetic maintenance. Stretching a supercoil of DNA between its lower pair of robot arms, the nanomachine gently pulls the unwound strand through an opening in its prow for analysis. Upper arms, meanwhile, detach regulatory proteins from the chain and place them in an intake port. The molecular structures of both DNA and proteins are compared to information stored in the database of a larger nanocomputer positioned outside the nucleus and connected to the cell-repair ship by a communications link. Irregularities found in either structure are corrected and the proteins reattached to the DNA chain, which re-coils into its original form.

With a diameter of only 50 nanometers, the repair vessel would be smaller than most bacteria and viruses, yet capable of therapies and cures well beyond the reach of present-day physicians. With trillions of these machines coursing through a patient's bloodstream, "internal medicine" would take on new significance. Disease would be attackedat the molecular level, and such maladies as cancer, viral infections and arteriosclerosis could be wiped out.

CONCLUSION

Nanotechnology as a diagnostic and treatment tool for patients with cancer and diabetes showed how actual developments in new manufacturing technologies are enabling innovative works which may help in constructing and employing nanorobots most effectively for biomedical problems. Nanorobots applied to medicine hold a wealth of promise from eradicating disease to reversing the aging process (wrinkles, loss of bone mass and age-related conditions are all treatable at the cellular level); nanorobots are also candidates for industrial applications. They will provide personalised treatments with improved efficacy and reduced side effects that are not available today. They will provide combined action– drugs marketed with diagnostics, imaging agents acting as drugs, surgery with instant diagnostic feedback. The advent of molecular nanotechnology will again expand enormously the effectiveness, comfort and speed of future medical treatments while at the same time significantly reducing their risk, cost, and invasiveness. This science might sound like a fiction now, but Nanorobotics has strong potential to revolutionize healthcare, to treat disease in future. It opens up new ways for vast, abundant research work. Nanotechnology will change health care and human life more profoundly than other developments. Consequently they will change the shape of the industry, broadening the product development and marketing interactions between Pharma, Biotech, Diagnostic and Healthcare industries. Future healthcare will make use of sensitive new diagnostics for an improved personal risk assessment. Highest impact can be expected if those major diseases are addressed first, which impose the highest burden on the aging population: cardiovascular diseases, cancer, musculoskeletal conditions, neurodegenerative and psychiatric diseases, diabetes, and viral infections. Nanomedicine holds the promise to lead to an earlier diagnosis, better therapy and improved follow up care, making the health care more effective and affordable. Nanomedicine will also allow a more personalised treatment for many diseases, exploiting the in-depth understanding of diseases on a molecular level.

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