NANOBOTS and their application in Biomedical Engineering

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***Abstract*— This paper proposes a simple overview of NANOBOTS. Nanotechnology is the study, design, creation, synthesis, manipulation and application of materials, devices and systems at the nanometer scale. Nanorobotics is the emerging technology field of creating machines or robots whose components are at or close to the microscopic scale of a nanometer. Nanorobotics can play a major role in medical applications, especially for target interventions into the human body through the vascular network.**

Keywords- Nanobots, nanotechnology, application in medical science

I. INTRODUCTION

Nanorobotics is the emerging technology field of creating machines or robots whose components are at or close to the microscopic scale of a nanometer (10^{-9} meters). More specifically, nanorobotics refers to the nanotechnology engineering discipline of designing and building nanorobots, with devices ranging in size from 0.1-10 micrometers and constructed of nanoscale or molecular components. The names nanobots, nanoids, nanites, nanomachines or nanomites have also been used to describe these devices currently under research and development. Another definition is a robot that allows precision interactions with nanoscale objects, or can manipulate with nanoscale resolution. Such devices are more related to Microscopy or Scanning probe microscopy, instead of the description of nanorobots as molecular machine. NanoBots consists of two words Nano and Bots. Nano is a prefix meaning extremely small. It may be measurable as in the word nano-second, which is one billionth of a second. 10^{-9} and Bot is short for robot, a machine which may be programmed to carry out certain tasks, or operated by remote control. Robots can be very useful in situations where it would be dangerous for a human being to work, such as in handling hazardous materials or deep mining work. A nanobot is therefore a very tiny robot that we would need a microscope to see. In recent years, remotely controlled robotics has been greatly advanced and the NASA Johnson Space Center's robotic astronaut, "Robonaut," is one such example. Unfortunately, due to the unavailability of force and tactile feedback the operator must determine the required action by visually examining the remote site and therefore limiting the tasks that Robonaut can perform. There is a great need for dexterous, fast, accurate teleoperated robots with the operator's ability to "feel" the environment at the robot's field.

In the others words we can say nanotechnology is the study, design, creation, synthesis, manipulation and application of materials, devices and systems at the nanometer scale. It is becoming increasingly important in fields like engineering, agriculture, construction, microelectronics and health care to mention a few. The application of nanotechnology in the field of health care has come under great attention in recent times. There are many treatments today that take a lot of time and are also very expensive. Using nanotechnology, quicker and much cheaper treatments can be developed. By performing further research on this technology, cures can be found for diseases that have no cure today.

II. NANOROBOTICS

Nanorobotics (Figure 1) is the study of robotics at the nanometer scale, and includes robots that are nanoscale in size, i.e., nanorobots (which have yet to be realized) and large robots capable of manipulating objects that have dimensions in the nanoscale range with nanometer resolution, i.e., nanorobotic manipulators. Knowledge from mesoscopic physics, mesoscopic/supramolecular chemistry, and molecular biology at the nanometer scale converges to form the field. Various disciplines contribute to nanorobotics, including nanomaterial synthesis, nanobiotechnology and microscopy for imaging and characterization. Such topics as self-assembly nanorobotic assembly and hybrid nanomanufacturing approaches for assembling nano building blocks into structures, tools, sensors and actuators are considered areas of nanorobotic study. A current focus of nanorobotics is on the fabrication of nanoelectromechanical systems (NEMS), which may serve as components for future nanorobots. The main goals of nanorobotics are to provide effective tools for the experimental exploration of the nanoworld, and to push the

boundaries of this exploration from a robotics research perspective. The vision is to develop intelligent nanorobots that can be injected into the subsurface (reservoir) and possibly be steered from the surface. Nanotechnology is science and engineering at the scale of atoms and molecules. It is the manipulation of atoms, molecules and materials to form structures on the scale of nanometers, normally 1 to 100 nanometers.

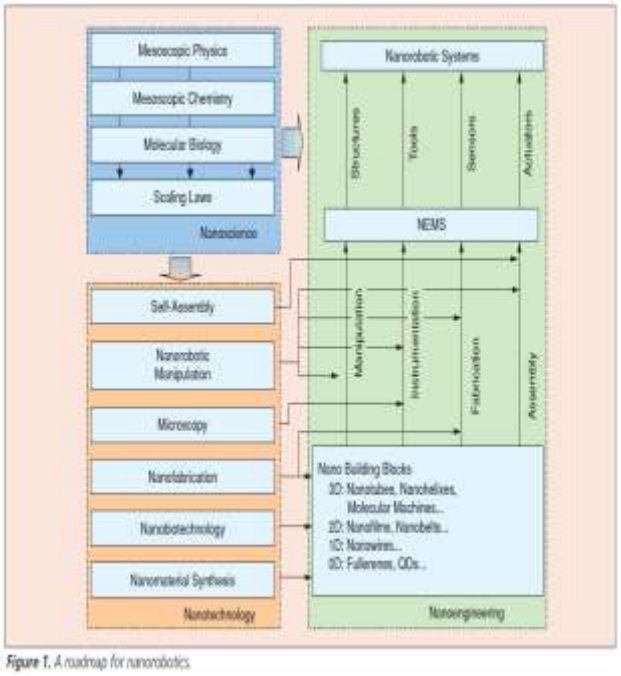

Figure 1. A roadmap for nanorobotics

Fig.1*. A roadmap for nanobotics*

"Nanorobotics can play a major role in medical applications, especially for target interventions into the human body through the vascular network," says Sylvain Martel, director of the nanorobotics laboratory at Ecole Polytechnique de Montreal. In many types of interventions, medical specialists are lacking appropriate tools to do a good job and it is believed that nanorobotics could bring new methods and tools to these particular applications.

There are two basic kinds of nanobots; assemblers and self-replicators. Assemblers are simple cell-shaped nanobots that are able to interpret molecules or atoms of different types, and are controlled by specific specialised programs. Self-replicators are fundamentally assemblers that are capable of duplicating themselves at a very large, fast rate; it is this sort of duplication that aids the construction of large-scale applications or deployment of nanobots for large-scale tasks.

III. KEY COMPONENTS OF NANOBOTS

In order for the nanorobot to function as desired, the following are key components and design attributes that should be considered:

- Size and shape
- Sensors
- Means of mobility/propulsion
- Power generation
- Data storage
- Telemetry and transmission
- Control and navigation

Size and Shape

The size and shape will depend on the intended function and operating environment of the nanorobot. The "near wellbore prospector" may be much different from "deep wellbore prospector" in size and shape. The first generation reservoir nanorobots may be a simple spherical ball like shape. Latter designs may be shaped like bacteria or other "crawlies" to enhance movement within different pore systems. A major design criterion is the minimum size.

Sensors

For the nanorobot to fulfill some of its functions, it must be capable of sensing different borehole and reservoir parameters. Thus, it should be capable of sensing (a) reservoir fluid type, (b) reservoir temperature, (c) formation pressure, (d) basic petrophysical properties, (e) fluid analysis, (f) trajectory and position, etc. One or two sensors may suffice for the early prototypes. That will be several steps ahead of current smart tracers. The latter design may incorporate more of the desired sensors.

Means of Mobility/Propulsion

This is quite an important design consideration for the reservoir nanorobot. Early prototypes can be simple "ball like" robots without self-propulsion mechanisms. They may simply be injected into the reservoir with normal injection water and are allowed to navigate their paths through the reservoir following the natural path created by the injection water or the oil flowing naturally to the producers.

Power Generation

Another major requirement is power for the device. The intelligent nanobot will need power to perform its assigned operations and tasks. At the nano-scale, the power needed is probably low, probably tens to hundreds of pico-watts to even micro-watts, depending on the functions. Potential means of generating power for the nanobot are:

1. Power from fluid flow or counter-current motion.
2. Power derived from the reservoir temperature.
3. Power from friction with rock fabrics.
4. Downhole fuel cell generation from in-situation hydrocarbon.
5. Use of downhole recharges station

Data Acquisition and Storage

Data acquisition and storage are other key components for the nanorobot to fulfill some of its functions. Early prototypes with single or few data storage memory will be a step change. Quantum computing may help in the future nano-sized data storage.

Telemetry and Data Transmission

This will be a tough design function to be incorporated into these tiny wonders. Although recent findings by UC Irvine researchers, Zettl et al. and Burke who unveiled a working radio built from carbon nanotubes that are only a few atoms across, show some possibilities of transmitting data at nano-scale.

Control and Navigation System

Another desirable feature is the ability to control the bots from the surface.

IV. APPLICATIONS IN MEDICAL SCIENCE

This section discusses the applications of nanotechnology in the field of health care. These applications can remarkably improve the current treatments of some diseases and help save the lives of many.

Drug Delivery System

Nanobots are robots that carry out a very specific function and are just several nanometers wide. They can be used very effectively for drug delivery. Normally, drugs work through the entire body before they reach the disease-affected area. Using nanotechnology, the drug can be targeted to a precise location which would make the drug much more effective and reduce the chances of possible side-effects. Figure 1 below shows a device that uses nanobots to monitor the sugar level in the blood. (Perkel, 2004) . The drug carriers have walls that are just 5-10 atoms thick and the inner drug-filled cell is usually 50-100 nanometers wide. When they detect signs of the disease, thin wires in their walls emit an electrical pulse which causes the walls to dissolve and the drug to be released. Aston Vicki, manager of BioSante Pharmaceuticals, says "Putting drugs into nanostructures increases the solubility quite substantially".

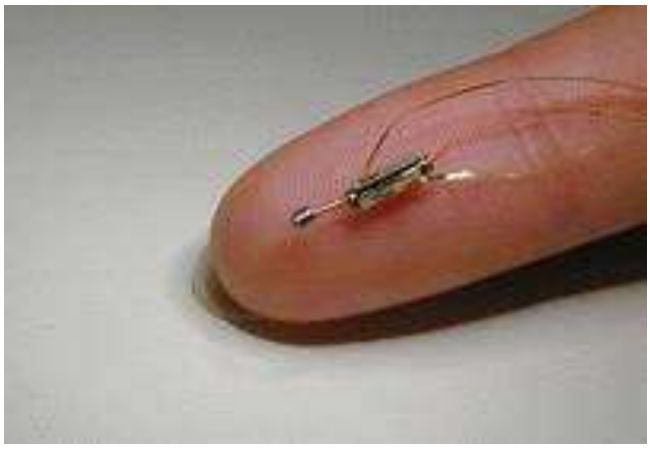

Fig.2. *Device Using Nanobots for Checking Blood Contents (Amazing Nanobots)*

A great advantage of using nanobots for drug delivery is that the amount and time of drug release can be easily controlled by controlling the electrical pulse (Harry, 2005). Furthermore, the walls dissolve easily and are therefore harmless to the body. Elan Pharmaceuticals, a large drug company, has already started using this technology in their drugs Merck's Emend and Wyeth's Rapamune (Adhikari, 2005).

Disease Diagnosis and Prevention

Nanobiotech scientists have successfully produced microchips that are coated with human molecules. The chip is designed to emit an electrical impulse signal when the molecules detect signs of a disease. Special sensor nanobots can be inserted into the blood under the skin where they check blood contents and warn of any possible diseases. They can also be used to monitor the sugar level in the blood. Advantages of using such nanobots are that they are very cheap to produce and easily portable. (Harry, 2005)

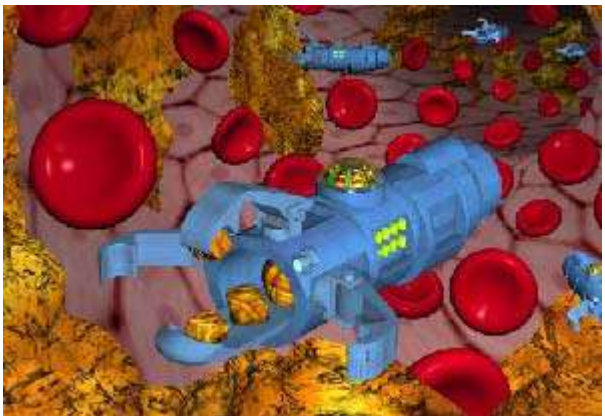

Fig.3. *Nanobots Preventing Heart-attacks (Heart View)*

Nanobots can also be used to prevent heart-attacks. Heart-attacks are caused by fat deposits blocking the blood vessels. Nanobots can be made for removing these fat deposits (Harry, 2005). The following figure shows nanobots removing the yellow fat deposits on the inner side of blood vessels.

V. USE OF NANOBOTS IN DETECTION AND TREATMENT OF DISEASES

A lot of the damage that is caused through injury and disease happens on a cellular level. Therefore, the development of nanobots is crucial, as they are able to handle repairing these damaged cells which could not be repaired otherwise without pain and trauma. Unfortunately the ideal nanobot is not yet fully complete, however, researchers know that they need to be agile enough to navigate through the human blood stream unnoticed. The human circularity system is made up of extremely complex veins, arteries and tiny capillaries. Nanobots don't just have to be small and agile, their purpose is to identify what is causing a disease and then, hopefully, treat it. This means that nanobots need to be small, agile and able to carry a camera, medication and tools, as shown in Figure

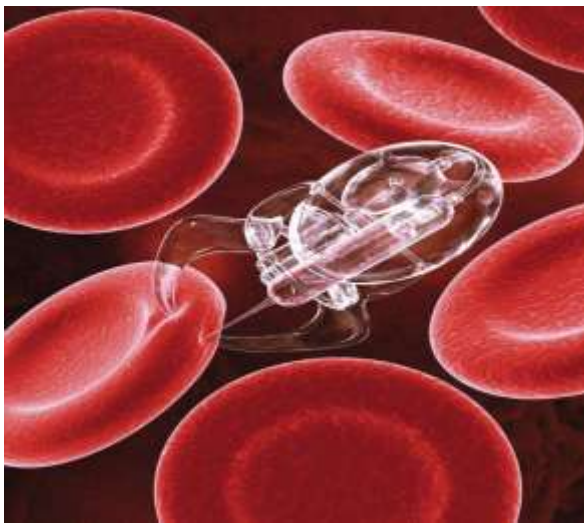

Fig. 4. Small nanobots carrying a camera, tools and medication.

Discussion

Detection of Diseases

At present, current diagnostic techniques are limited in the way of accuracy and duration of time between the test and finding out the results. Nanotechnology will be able to revolutionise how we diagnose an illness, so that the patient will not just be able to instantly find out the results of the test, but can find out so early in advance that the disease will not have made any significant damage to the tissue and therefore can be treated or even cured much more quickly and efficiently.

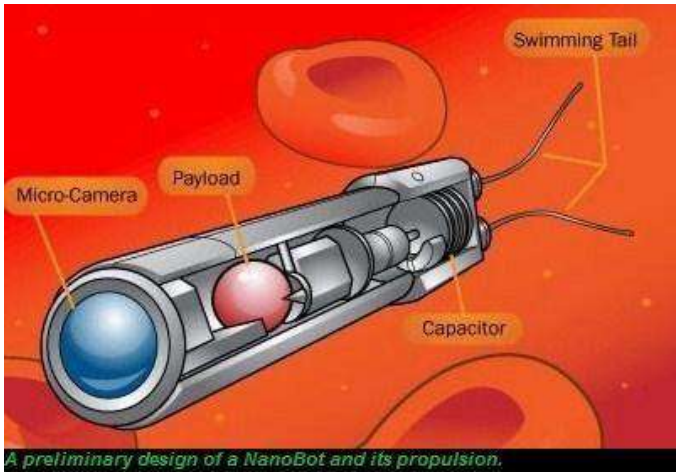

Fig:5. *A preliminary design of a nanobots & its propolsion*

Nanobots will be able to perform a range of diagnostic and testing functions, both in tissues and in the bloodstream. The nanobots would be able to continuously record variables, such as temperature, pressure, chemical composition and immune system activity all from different parts of the body, which could indicate the presence of a disease. In some cases, nanobots could be swallowed by a patient and be able to approach the surface of the stomach lining to search for signs of infection.

Treatment of Diseases

Currently a large number of the medical procedures used cause patients a great deal more pain and suffering, medical scientists want to be able to use nanobots to not only detect but to treat disease and repair damaged tissues without pain and trauma. Medical scientists also believe that nanobots will not only be able to repair damaged tissues but re-grow them by rebuilding individual molecules to create a new layer of tissue. Nanobots are believed to work quickly and neatly so this new layer of tissue would be made without leaving any nasty scarring.

Take a cancer patient for example, most cancer is treated with chemotherapy or radiotherapy, the treatment received by these patients often makes them feel much worse and causes them additional pain. This is because these treatments are unable to just distinguish and treat the cancerous cells. The chemotherapy and radiotherapy kills many healthy cells in the quest to kill off their malignant cancer cells. It is hoped that when the nanobot is complete doctors will be able to use them to inject into cancer patients, allow the nanobots to locate the cancer cells and

kill them without causing too much, if any, harm to the body's healthy cells, this way the patient becomes free of cancer without needing surgery. Nanobots will not only be used to repair damaged tissues but to also administer drugs. Drugs operate by the way of the circularity system, as the bloodstream is an indiscriminate cycle that delivers its contents to many parts of the body. Many drugs have side effects, side effects that can sometimes make the patient feel worse, this is because any drug that is administered will automatically effect cells within the body that are perfectly healthy. This can result in some cells being worse off than before the patient took the medication. It is circumstances like this where nanobots will be useful and helpful in medicine as doctors will be able to inject nanobots into the bloodstream where they will be taken to the necessary cells in the body that require their attention and medication without causing unnecessary harm and damage to other healthy cells.

VI. FUTURE SCOPE AND CONCLUSION

Research believe nanobots will be able to act as antibodies for patients with weak immune systems, they will be able to patrol the bloodstream searching for harmful bacteria and viruses and eliminating them before they cause the patient any harm. This will become extremely useful when tackling more common illnesses. Nanobots will not only be able to help doctors and surgeons fight life-threatening diseases but more common bacterial and viral cases.

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