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Smart Nanobots: The Future in Nanomedicine and Biotherapeutics

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Abstract

Nanobots are considered to be the next generation of nanomachines. Several new therapies have already received FDA approval for use treating cancer that rely on nanoparticle delivery vehicles, but till date; none have used computer programs that control smart nanobots capable of performing targeted drug delivery. Scientists hope that by creating smart nanobots, they will be able to program them to deliver highly toxic medicines directly to cancer tumors without compromising surrounding tissue. We present here nanobots as the future of nanomedicine and biotherapeutics.

Introduction

The concept of nanotechnology first appeared in 1959 by the late Nobel physicist Richard P. Feynman, who worked on the Manhattan Project at Los Alamos during World War II and later taught at CalTech for most of his professorial career. In his lecture, "There's plenty of room at the bottom", Feynman explored the possibility of manipulating materials at the scale of nanometers [1]. He was aware of the wide applications of his concept in medicine and therefore offered his first proposal for a nanomedical procedure to cure heart disease. He says, "A friend of mine Albert R Hibbs suggests a very interesting possibility for relatively small machines. He says that, although it is a very wild idea, it would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes into the heart and looks around. It finds out which valve is the faulty one and takes a little knife and slices it out. Other small machines might be permanently incorporated in the body to assist some inadequately functioning organ" [1]. However, the term "nanotechnology" remained a concept and was not used until 1974, when Norio Taniguchi, a researcher at the University of Tokyo, used it to refer to the ability to engineer materials precisely at the nanometer level [2]. Many of the early definitions of nanotechnology employ a cut-off around 100 nm including that of the National Nanotechnology Initiative focusing on the former, where quantum effects are often restricted to structures on the order of ones to tens of nanometers [3-5]. However, unique physiochemical behaviour sometimes emerges for nanomaterials with defining features greater than 100 nm (e.g., the plasmon-resonance in 150 nm diameter gold nanoshells that are currently under clinical investigation for cancer thermal therapy) [6]. A lot of evidences emerged out as technology advanced and now size of nanotechnology and nanomedicine products occupy wide range of 2-1000 nm. Many novel breakthrough researches has been done recently for imaging, diagnostic and therapeutic purposes by using liposomes [7,8], nanoparticles [9,10], nanoemulsions [11], in-vitro diagnostic devices etc. and has been patented [12]. Research is underway on dendrimers and carbon nanotubes as effective tool in targeted drug delivery systems for cancer therapeutics. But the focus of this editorial is not to discuss about the advances in existing drug delivery systems but to brief about emergence of smart engineered nanodevices as a tool for imaging, diagnosis and therapy in future nanomedicine and biotherapeutic research.

Engineered Nanobots for Therapeutics

Nanorobots or popularly known as nanobots are nanoelectromechanical systems designed to perform a specific task with precision at nanoscale dimensions. Its advantage over conventional medicine lies on its size. The concept to use nanobots in nanomedicine is derived from the fact that most of the biological systems as seen at molecular level in nanometer range. One nanometer (nm) is one billionth, or 10^{-9} of a meter. By comparison, typical carbon-carbon bond lengths, or the spacing between these atoms in a molecule, are in the range 0.12–0.15 nm, and a DNA double-helix has a diameter around 2 nm. On the other hand, the smallest cellular life-forms, the bacteria of the genus Mycoplasma, are around 200 nm in length. Design and engineering of these medical nanobots depends upon the intended use within the body. Some are used for imaging and diagnosis while many are capable of delivering active pharmaceutical ingredients to desired site. Components in nanorobot design may include on-board sensors, motors, manipulators, power supplies, and molecular computers. Many nanobots have chemical sensors which detect the target molecules. As a response they would emit a power signal proportional to the detected amount in the biological system. This signal would arrive to a programmed microprocessor which controls the direction and velocity of the nanobot. This assembly makes the robot in the pursuit of its objective.

Nanobot Applications in Nanomedine

Earlier, miniaturization of technology was only a part of science fiction and illustrations. In 1966 a movie "*Fantastic voyage*" first showed a miniaturized machine named Proteus through which a crew went inside a scientist's body to remove a clot in the brain. It sounds weird to talk of such things in reality. But scientists in twenty first century have achieved some success to transform that fiction into reality. Nanobots have wide applications in nanomedicine and some of its features have been used for diagnostic and therapeutic purpose. Recently Professor Ido Bachelet, Principal Investigator at Nanotechnology Centre, Bar

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Ilan Univeristy announced treatment of cancer with nanomedicine. He indicates DNA nanobots can currently identify twelve different kinds of cancer tumors in humans and believes that within very short time span nanobots could cure cancer and repair spinal cord damages [13]. Apart from detecting and identifying cancer cells, smart engineered nanobots have ability to deliver medicaments in controlled release form [14]. Some other breakthrough in nanobots includes "Respirocytes", an artificial mechanical red blood cell capable of delivering 236 times more oxygen to cells than natural RBC [15]. Other nanobot known as "Microbivores" capable of destroying microbiological pathogens inside humans [16]. "Clottocytes" have capability to heal by making fibre mesh upon command at the site of wound. "Chromallocytes" are hypothetical mobile cell repair nanorobots capable of reversing the effect of genetic diseases by replacing its entire chromosome. Artificial micromotors have great potential to operate locally in-vivo for diverse medical applications (Figure 1) [17].

Conclusion

For years people have been told about robots replacing doctors completely, but so far little success has been achieved in this regard. When we imagine of nanorobots, we end up believing that they will do the entire task just like any other automatic robot. But in reality all available nanobots needs a specialized team of experts to handle it especially when delivering inside a human body. However, as progress in nanotechnology advances, investigators around the world are trying to maximize the benefits by equipping the nanorobot with instruments by which it can successfully image, diagnose, deliver drugs and perform minor surgical operations. For sure, within next few decades nanorobots could be the future in nanomedicine and biotherapeutics replacing the older versions of drug delivery.

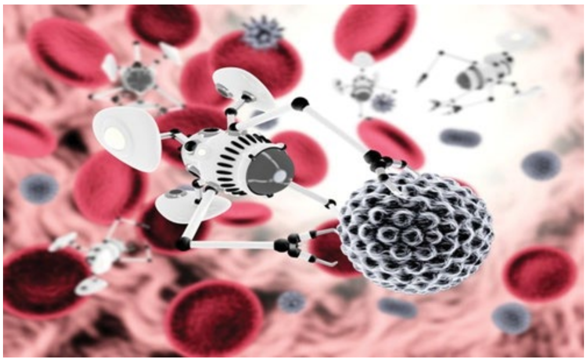

Figure 1: Nanobot at work.

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