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Implantable Nanodevices for Diagnosis and *In Vivo* Imagine: Where We Stand?

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Editorial

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INTRODUCTION

Change is the only constant even in science. From a time when scientist thought atom is the smallest unit of matter, we have come to an age where we talk about GOD particle and whole set of new theories are taking shape. The pace of technology change is getting faster as we move into future. Various fields ranging from medicine, agriculture, electronics and space research have opened a large window of possibilities. Nanotechnology is one of those signature areas that have revolutionized many research areas. Medicine and Healthcare domain have seen a transformation with applications of nanotechnology and a new branch of “Nanomedicine” has evolved. It provides several promising possibilities to improve medical diagnosis and can play a critical role in achieving a long-sought goal of affordable healthcare.

Although nanotechnology is benefiting medical sciences in different aspects, the prime focus here is to discuss current progress in the field of *in vivo* diagnostics and imaging application of nanotechnology and identify new avenues. The foundation of modern medicine was laid in 19th century and it has evolved significantly since then with new therapy options and diagnostics techniques. Nanomedicine is a vast research arena and impacts every section of healthcare domain i.e., preventive medicine, diagnosis and therapy. In an estimate, around 250 nanomedicine products have been tested or used in humans. Apart from the drug delivery and therapeutic applications, medical diagnosis is another area that has been the beneficiary of nanotechnology advancements [1].

Due to rapid growth of computational technique, computed tomography (CT) of X-rays, magnetic resonance imaging (MRI), positron emission tomography (PET), now a days sophisticated instrumentation for disease detection is available. Although these techniques reveals different information about structures of bones, soft tissues, organs and metabolic parameters, a lot more is needed to improve their performance in terms of resolution for better prediction of complex diseases. Moreover, with the rising quest of monitoring the effects of treatment regimen and continuous monitoring of patients, past decade has seen a sharp growth in implantable device and *in vivo* imaging tools [2]. This is a popular research area where nanotechnology plays a substantial role and provides a paradigm shift for medicine and healthcare sector. Most importantly, nanotechnology allows the manufacturing and manipulation of matter from single atoms and molecules to micrometer-sized objects that enables the miniaturization of many current devices, resulting in faster operations; integration of device functions and due to smaller size, a new vista opens for *in vivo* applications.

In recent years, the fields of MEMS/NEMS (Microelectromechanical systems/ nanoelectromechanical systems) have also evolved profoundly and have opened enormous biomedical opportunities for precise disease diagnostics and on-line monitoring. Generally, *in vivo* diagnosis refers to imaging based on fluorescent nanoparticles or dyes to evaluate the response of targeted drug delivery or organ specific accumulation of drugs. But in broader sense miniaturized implantable devices can also be included in this domain. An enormous amount of data obtained from *in vitro* diagnostic devices has given a strong thrust for their translation into *in vivo* applications [1,3].

It is said that ‘necessity is mother of all inventions’ and that’s the basis for implantable devices also. Despite of considerable progress in *in vitro* techniques, in majority of cases they fail in real time monitoring of complex biological events especially

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occurring in brain and to collect rational data from organs [4]. State of art nanotechnology is a boon for *in vivo* diagnosis systems and today continuous supervision of biological processes and to deliver drug load at particular site of interest is possible in the form of nanosensors, nano-implants or nanorobotic devices. These technologies are showing a huge potential for early detection of fatal diseases like cancer, monitoring of diseases stages and better understanding of therapeutic and surgical efficacy.

Nanotechnology can be implemented in various ways for *in vivo* diagnostics like swallow able pills for imaging and drug delivery, tiny nano devices/implantable nanosensors as circulating modules to gather information for chronic diseases like HIV, cancer and other infections also where timely detection and prompt action could be possible. Although some of these are futuristic concepts but clinical approval of *in vivo* glucose monitor for diabetes is the best example where continuous monitoring of glucose in the interstitial fluid of patients provides better glycaemic control in patients [1,4,5]. Apart from this, cardiac stents, nano-scaffolds as orthopaedic implants and a nano retinal implant developed by Nano Retina; a company in Israel projects a promising picture of implantable nanodevices. These devices are capable of performing specific tasks at targeted site and can provide a better understanding about the biological function, mode of action of therapeutic agents and on-line monitoring of patients. However, despite of tremendous advancements in microfabrication technology, nanotechnology and other related areas of biomedical sciences to design implantable device, this field is in its infancy and the effects of these implants in physiological environment is still unclear. Ideally an *in vivo* implant should be biocompatible, stable and have the ability to generate signals preciously for accurate information transfer. In spite of all the possibilities that nanotechnology offers, there are some challenges too. Toxicity of nanoparticles is a major cause of concern and in case of tiny implants, renal clearance, interaction with proteins and body fluids; coagulation, immunogenicity, possible tissue injury at the site of implantations and signal amplifications from inside the body are prime issues to deal with.

Implantable nanodevices are an emerging branch of biomedicine with magnificent future potential. Since its inception in the movie “The Fantastic Voyage” in 1966, where a submarine is shrunk down and injected into the blood stream of a human, science has materialized the idea to fabricate nanodevices or micromachines to perform delicate tasks at specific site into our organs or tissues. Nanotechnology is progressing in a fast pace that indicates a bright future for *in vivo* nanodevices that will transform healthcare. However, not many products have reached to commercialization stage and still a long way to go before these implants will become a medical necessity from drug delivery to on line disease monitoring. With focused effort on the issues related with toxicity, stability and signal amplification for accurate monitoring and detection we shall be able to utilize nanotechnology to its fullest potential and it’s exciting to envisage how it can help solve some of basic problems humanity is facing today and make nanodevices a success story.

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