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Nano Biotechnology: The next frontier to conquer

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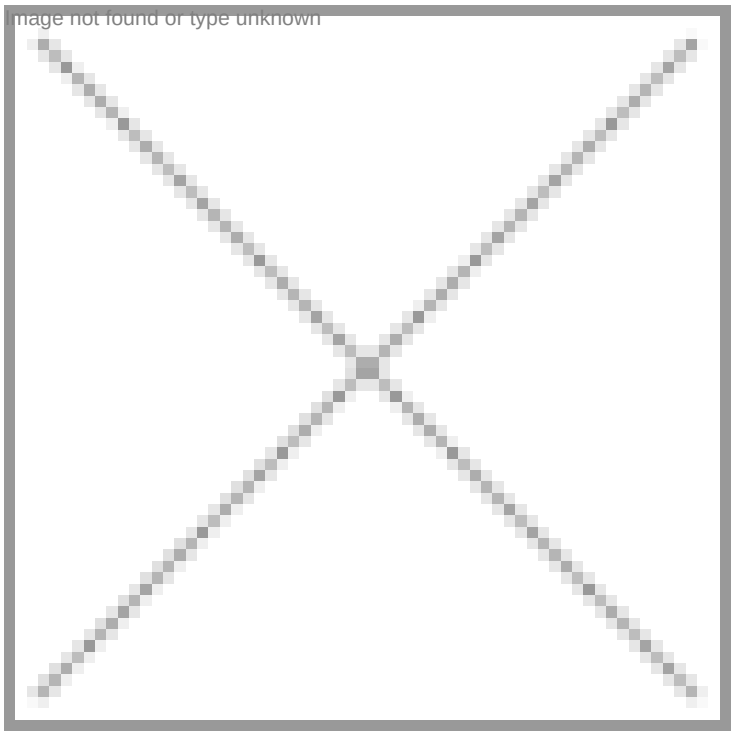

Poised to be a trillion dollar industry by 2015, nanotechnology holds the promise to address a multitude of issues in varied industries by scaling down the size of materials to one billionth of a meter. After creating a revolution in electronics and material sciences, biological sciences seem to be the next frontier to conquer for nanotechnologists

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In 1952, Dr Richard Feynman gave a lecture 'There is plenty of room at the bottom' on the possibility of manipulating matter on an atomic scale. That single lecture not only gave birth to an idea about nanotechnology, but also compelled scientists worldwide to start innovating in fields ranging from medicine to electronics, while using the principles of nanotechnology. Now over 60 years later, Prof C N R Rao, chair of the scientific advisory council to India's Prime Minister and many other eminent scientists are of the opinion that nanotechnology is set to be a trillion dollar industry by 2015.

At the recently concluded Bangalore Nano 2011, scientists and industry representatives expressed hopes about the nanotechnology industry. The fact that nanotechnology is already a part of our lives in many ways was an eye opener for everyone present at the event. PacliALL, a chemotherapeutic drug for metastatic breast cancer by Panacea Biotec, which won the BioSpectrum Product of the Year award this year, is an example of use of nanotechnology in medicine. The packaging of the drug in nanoparticle form can not only help reduce adverse effects such as severe anaphylaxis and sensory neuropathy, but also increase efficacy by three times as compared to conventional solvent-based form of the drug Paclitaxel. Analysts estimate that the global market for chemotherapeutic drug is more than $500 mllion, thus emphasizing the benefits of utilizing nanotechnology in drug delivery.

Broadly, nanotechnology is said to have applications in biosciences drug delivery, in tissue engineering and in therapy. Explaining how nanoparticles play an important role in drug delivery, Dr Shanthikumar Nair, director, Nanosciences, Amrita University, says, â€œMost of the promise that nanotechnology holds in biological sciences is attributed to anti-cancer

therapy. Extrinsic nanomedicine that encompasses the technology in which we package the drug in a nanoparticle by using linkers, such as polyethylene glycol, forms a major chunk of nanomedicine. Drug delivery using carbon nanotubes for chemotherapy has been demonstrated, in clinical trials to be more specific to the particular target than if present in the normal form. This not only allows for a more targeted delivery but also allows for a more sustained and prolonged release of the drug.

FDA-approved drugs such as Abraxane for metastatic breast cancer; Copaxone, a multiple sclerosis drug; DaunoXome for HIV related Kaposis sarcoma; and PEGIntron for the development of chronic hepatitis C vaccine are some examples of nanoparticle-based therapeutics currently in use, with many more in various phases of clinical trials. The major road block to developing nanoparticle-based therapeutics remains to be the removal of these nanoparticles from the body.

Apart from these applications, nanoparticles are being increasingly looked upon in the field of medical imaging. Dr Rinti Banerjee, professor, Center for Research in Nanotechnology and Science, IIT Bombay, explains, â€œCurrently, advanced research is being carried out where iron nanoparticles are being used for phase contrast imaging. For example, on injection, most cells allow the entry of these nanoparticles except the tumor cells. This can help pinpoint the site of the tumor in an MRI scan. This technology is already in use in many parts of the world for phase contrast imaging.â€?

Combining imaging with therapy, Dr Banerjee elaborated about theranostic nanomedicines, saying, â€œNanoparticlecarriers can be made heat responsive. Hence, when they reach the location of the injury, application of heat to that particular area can cause the carrier to release the nanoparticle drug at the precise location. This form of targeted therapy holds a lot of promise for use in cancer. The carriers can also be made sensitive to stimuli that are commonly observed in diseased conditions. This principle can also be applied for release of growth factors.â€?

Stem cells have always held great promise in the field of regenerative medicine. But for stem cells to be effectively used for regenerating damaged tissue, there is a crucial need for a suitable scaffold. Explaining how nanoparticles can be a solution to this issue, Dr Swaminathan Sethuraman, director, Center for Nanotechnology and Advanced Biomaterials, SASTRA University, says, â€œThere is a need to prepare biocompatible scaffolds or matrices that can act as extracellular matrices. Nanofibres made of biodegradeable material, such as chitin or fibrin, hold the key for use in tissue regeneration. Human fibroblasts or stem cells can, in this manner, be allowed to proliferate in the area of injury for wound healing and wound contraction. These nanofibres can also be loaded with growth factors to accelerate the process. We have already applied for a patent regarding the technology on similar lines.â€?

Other futuristic technologies include nanoarrays where probes in nanomolar quantities are linked on a chip for the detection of disease pathogens, akin to microarrays. The minute quantities of the probes would require smaller volumes of samples and also allow a large number of samples to be screened at the same time.

The Indian perspective

Keeping in line with the growing need, the Government of Karnataka has recently planned to build a new Nano park near Bangalore under the aegis of the nationwide Nano mission. This park hopes to incorporate an incubation center for early-stage entrepreneurs in nanotechnology. It also hopes to further higher education in nanotechnology in order to prepare a large group of skilled individuals in nanotechnology.

Speaking at Bangalore Nano 2011, Mr Anand Vasant Asnotikar, Minister for Science and Technology and Fisheries, Government of Karnataka, said, â€œExpression of Interest has already been called for development of Nano Park on a public-private partnership mode. This initiative will give a major fillip to the nanotechnology industry to blossom in the state in the coming years.â€?

The Karnataka government is providing an acre of land for setting up a â€œNano Labâ€? by the Jawaharlal Nehru Centerfor Advanced Scientific Research in Bangalore. Also, the Indian Institute of Nano Science and Technology is being established with funding from the Government of India under the Nano Mission at an estimated cost of 100 crore, for which the state has already allocated 14 acres on Tumkur Road. A similar park is also going to come up in Chandigarh.

The great promise of nanomedicine is evident, but clinical translation and commercialization of most of these therapies remain difficult. Extensive research is required to be able to capitalize on the advantages of nanomedicine.

Manasi Vaidya in Bangalore