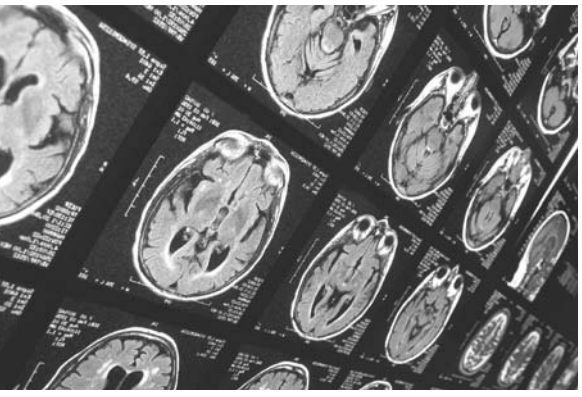
Nanotechnology can lead the battle against cancer

Advances in nanotechnology will have the greatest and most socially-sensitive impact in the field of biomedicine.

BY KOSTAS KOSTARELOS, LEADER, NANOMEDICINE LABORATORY AND DEPUTY HEAD, CENTRE FOR DRUG DELIVERY RESEARCH, THE SCHOOL OF PHARMACY, UNIVERSITY OF LONDON



For several decades now, scientific discoveries and engineering at the nanoscale have directly influenced the way therapeutics and diagnostics are delivered to us today. Although for biomedical and pharmaceutical researchers the close relationship of nanoscience and nanotechnology with medical practice is not new, many of the available tools that the recent booming developments in nanotechnology offer are. The scope for these new technologies is vast, but perhaps the most marked is the potential for the diagnosis and treatment of cancer.

Despite advances in cancer patient care, surgical techniques and anti-cancer medicines, dramatic improvement in long-term survival is still far from satisfactory. It is true that some types of malignancies can be treated much more effectively today than just a few years ago; however the overall result is still associated with intensely traumatic experiences for both the patients and their families in addition to the considerable investment for treatments that have still fallen short of a therapeutic outcome that clinicians and patients are content with. Nanotechnology has the potential to change that by offering the tools to impact every single stage of cancer intervention: exploratory, preventive, diagnostic, therapeutic and monitoring.

Cancer research

Exploratory cancer intervention relates to all the new clinically-focused cancer research that nanotechnology and its tools enables. From nanocrystals to nanotubes and nanovessels, cancer research will be influenced more than ever by an increasing number of studies and technologies. The financial support from governments in Europe, the US and Japan guarantees that advances in exploratory cancer intervention will be made.

Preventive cancer intervention will be in the form of a vaccine or other prophylactic treatment prescribed by a doctor to 'high risk' individuals. Nanotechnology will contribute both in terms of delivery of the preventative cancer drug and the identification of individuals who are suitable for treatment.

Diagnostic cancer intervention is the area that will critically determine improvements in overall long-term survival. Early diagnosis is now widely accepted as contributing to the best possible outcome for the patient. Nanotechnology based, ultra-sensitive detectors will be key tools in order to achieve such early detection. Currently, there are various prototypes of such detectors being manufactured.

Drug delivery

Therapeutic cancer intervention refers to the active drugs that are used to eradicate cancer cells and has already benefited from nanoscale drug delivery systems.

As these delivery systems become more sophisticated they will feature nanotechnology-generated components that can be incorporated early on in the development of all new anti-cancer drug molecules to enhance their efficacy and, more importantly reduce the psychologically distressing side effects such as hair and nail loss, nausea and weakness nowadays characteristic of such treatment options. Moreover, nanotechnology will enable the manufacture of more accurate and sophisticated surgical tools minimising invasiveness during procedures.

Monitoring cancer intervention is the way in which the oncologists will follow their patients after treatment. Nanotechnology is again a rich source of materials and devices that in combination with information and wireless technologies will benefit the patient, the clinician and the overall health care system.

Nanotechnology is the product of science at the miniscule dimension with the power and potential to reduce suffering caused by one of the biggest disease challenges to humankind today. This formidable task can be accomplished only if we succeed in transferring nanotechnology from the bench in an affordable and effective way to clinical oncology centres around the world.

Medical nanotechnology – the way to a healthier future?

In the past, medical treatments have been, rather like medieval architecture, the result of adopting those techniques that worked and discarding those that did not. In today's world, an improved knowledge of how the body functions at the cellular level is leading to many new and effective medical techniques, which can be described under the umbrella term of 'nanomedicine'.

BY RICHARD MOORE, MANAGER, NANOMEDICINE AND LIFE SCIENCES, INSTITUTE OF NANOTECHNOLOGY

Firstly, the earlier a disease can be detected, the easier it is to remedy. Many of us are acquainted with scanners that can provide an image of the extent of disease in a given organ. Unfortunately, by the time most diseases can be detected this way, they are often at an advanced stage.

However, a revolution is underway in the ability to detect the very early signs of disease. This is achieved by introducing into the body specially designed nanoparticles, often comprising tiny fluorescent 'quantum dots' bound to targeting antibodies. The antibodies bind to the diseased cells, causing the quantum dots to fluoresce brightly. This fluorescence can then be picked up by new, specially developed, advanced imaging systems, accurately pinpointing the site and extent of the disease.

> "A revolution is underway in the ability to detect the very early signs of disease"

Fast and early

Even with today's technologies, diagnosis tends to be a lengthy and stressful business, often with a test sample having to be sent away for analysis, with the results taking several days or even weeks.

Nanotechnology is enabling much faster and more precise diagnosis, and many diagnostic tests can be built into a single, often palm-sized device that only requires tiny quantities of sample. This is often termed a 'lab-on-a-chip'. It can process and analyse samples so rapidly that the results can be read out almost instantaneously.

Often the cure for a disease can feel almost as bad as the disease itself, as therapeutic drugs may have unpleasant (and if we are very unlucky, sometimes even fatal!) side effects. This is because the body is flooded with very high doses in order to ensure that a sufficient volume reaches the site of the disease.

Accurate targeting, using drug-carrying nanoparticles, means that a much smaller quantities of an active drug are needed. The drug is activated by light or other means when the carrier nanoparticle reaches a specific disease site, such as a tumour.

Sight and sound

Until now, retinal and cochlear implants have been quite crude offering relatively poor performance.

The further miniaturisation of medical devices and implants, combined with nanoscale electronics developed for advanced computers, is leading to new and much improved cochlear and retinal prosthetics that are cheap to produce and capable of making a real difference to maintaining the faculties of ageing patients or those who have received damage through illness or war.

> "Nanotechnology is enabling much faster and more precise diagnosis"

Exciting future

A further, very fruitful area of work has been in the nanoengineering of implant surfaces. Cells in the body are very fussy about the kind of surface they will attach to and may eventually reject an implant that is not engineered to be 'body friendly'.

The acceptance of hip implants by the surrounding tissue has been much improved by etching a topography at the nanoscale onto the implant and then coating it with a bone-like nanocomposite material.

So, the future for nanomedicine looks very exciting, with many more applications than there is space to list here, including ways of regenerating failing organs. Getting these technologies to market requires the help of enlightened and knowledgeable investors.