Ride the crest of the wave

Nanotechnological tools are starting to have a positive impact in healthcare applications

Over the past decade, there has been significant interest in the promise that nanotechnology holds for the international life science industries. An estimated 40 per cent of US nanotechnology venture capital has been allocated to life science start-ups and the Engineering and Physical Sciences Research Council (EPSRC) in the UK has dedicated over £180m (€216m) to nanotechnology alone.

The biopharmaceutical industry is one sector guaranteed to see the benefits nanotechnology has to offer, with the nanotechnology-enabled drug delivery market predicted to rise in value from $3.39bn to $26bn by 2012.

The biotechnology industry is maturing and has already seen a number of huge benefits from nanotechnology, particularly in the fields of nanodiagnostics, regenerative medicine and drug delivery and formulation.

In the UK, the biotechnology and pharmaceutical industry has seen exports of over £17.2bn (€20.6bn) and a balance of trade of £6bn (€7.2bn), making it a significant success story. These companies are looking for the next generation of products and technologies, and with an estimated 308 nano-life science companies worldwide, it is no surprise that nanotechnology has attracted a huge amount of attention from global media and governments.

Nanotechnology is beginning to penetrate the pharmaceutical industry in two main ways. The first is in tools for drug discovery, where nano-enabled systems allow faster analysis in high throughput screening, which also provides greater information about targets and potential drugs. This area is becoming more pervasive as the benefits are recognised.

The second area is formulation. Liposomes and colloids have been used for a number of years, but the second generation of targeted nanocarriers, which deliver drugs to specific tissues, is at the start of commercial development.

Drug delivery has recently come to dominate nanotechnology in pharmaceuticals, as new applications enhance the drug development process through improving bioavailability, reducing side effects and enabling oral availability through nanoencapsulation.

Challenges

A significant challenge in drug development is delivery of the drug to the right place in the body for it to be effective. Ideally, drugs should be targeted accurately to diseased cells, while not affecting those that are healthy. In reality, however, many systematically delivered drugs distribute throughout the body, often causing undesirable and unpleasant side effects. Nanotechnology can be applied to drug technology systems in order to increase delivery efficiency, protect labile groups, or target certain tissues or cells.

Nanotechnology also has applications in medical imaging systems. These systems are being used for diagnosis of diseases such as cancer and neurological disorders and in the drug development process. Modern technologies are capable of generating images showing where drugs are localising in the body. A drug may have a high potency *in vitro* but if it settles in an area away from the disease site, negative side effects can occur. Imaging systems can be used to track radioactive-labelled drugs and identify where they

have been absorbed and distributed in real time by producing three-dimensional images of drug localisation in the body.

Increasingly, drug delivery systems are being used alongside point-of-care diagnostic systems. In February 2010, Prof Tony Cass of Imperial College London delivered a presentation about the benefits of point-of-care diagnostics at the Nano4Life 2010 conference, organised by the Nanotechnology Knowledge Transfer Network (NanoKTN) in partnership with The Wellcome Trust.

The conference brought together leading medical technology and pharmaceutical companies, both to encourage networking and discuss the key issues in the bionano arena, looking for areas where nanotechnologies can be used to help solve the issues facing healthcare systems.

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Prof Cass discussed how these systems are changing the pharmaceutical industry and benefiting patients. He addressed the need for advanced point-of-care diagnostics, an area that has increased considerably in importance as the complex nature of diseases has become better understood. By moving testing from tertiary care to primary care, medical professionals aim to lower overheads and achieve better outcomes through regular testing.

Point-of-care diagnostics have already shown benefits in therapeutic drug monitoring, infectious disease detection, cancer therapy and diagnosis and in the treatment of chronic conditions.

By using technology to analyse samples of blood, interstitial fluid, urine and saliva, medics are able to use minimally invasive techniques to obtain results that are easily collected with minimal stress and discomfort to patients.

Using nanotechnology in diagnostics means that by reducing the size and cost of equipment, biosensors can be made available at the point of care, whether that is in a healthcare setting or in the patient's home. In many cases, providing a diagnosis while the patient is with the doctor can ensure the right treatment is received early, avoiding complications caused by delays.

The same micro and nanotechnology diagnostics devices can also provide closed-loop systems, which continuously monitor patients and immediately respond to changes in physiological conditions. This is particularly important in intensive care units where simple parameters, such as oxygen levels, can be critical in ensuring drug concentrations are within the therapeutic range.

There are significant numbers of companies developing these 'lab-on-chip' technologies that function using biosensors. However, not all will make it to market, as ultimately they need the acceptance and support of patients and clinicians to succeed.

Nanoparticles

Nanoparticles are being developed to detect physiological changes in the body and can release drugs at certain times depending on these changes. These applications run alongside emerging new technologies for developing customised solutions for drug delivery systems. Nanoparticles enable these drug delivery systems to affect the rate of absorption, distribution, metabolism and excretion of the drug or other related chemical substances in the body positively.

Conclusion

Nanotechnology has a lot to offer and early adopters will reap the rewards. It is still in its first phase of development and industry leaders believe major growth will occur between 2015 and 2035, providing the public, academia and research facilities support it now.

The field of bionanotechnology is resolving some significant problems. It has enabled new formulations for drugs that are commercially available and there are a number of drugs and drug-delivery systems in the R&D pipeline and at the regulatory approval stage.

Several commentators have speculated that nanotechnology is the wave of the future in biotechnology and pharmaceuticals. Predictions suggest that the market could rise steeply after 2012, potentially reaching $220bn by 2015 for nano-enabled compounds. However, there is a large disparity between these predictions and the actions of the very companies that are in a position to make them come true. For example, the 2005 Lux Research survey, 'Why Big Pharma Is Missing the Nanotech Opportunity', concluded that the pharmaceutical industry was spending less than 0.5 per cent of its research budget on nanotechnology and that only a sixth of them had any nanotechnology strategy in place. Indications are that this position is changing, but not at a significant rate.

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Nanotech has a lot to offer, but it faces a number of hurdles, such as a clear regulatory pathway and a demonstration of value above and beyond current technologies, before it can become mainstream. However, efforts are being made by industry and governments to help it to jump the technology adoption gap quickly and ensure it can assist in developing the next generation of products for significant unmet medical needs.

With numerous life sciences applications at the early stages of development and entering the market, it is important that patient safety and needs are central.

It is clear that, with so many companies involved in this area, partnering is vital. Biological science requires thorough fundamental research and for this to be carried out, governments must allocate grants and support academic research. As long as research institutions, developers and manufacturers have access to the necessary funding and finance, the success of nanotechnology will continue to grow in the pharmaceutical industry.

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