

Nanotechnology: Big Things in Small Packages

Guest Editorial

In simple terms, nanotechnology is the engineering of functional systems at the molecular scale. Within this realm, there is an enormous variety of structures, devices and applications. A key technology of the 21st century, nanotechnology in diagnostics and therapeutics is an interdisciplinary scientific field focusing on methods, materials, tools, biology and medicine. The field is broad and this Special Technical Feature aims to provide a snapshot of some of the exciting potential and advances for the use of nanotechnology in therapeutics.

Chemotherapy remains the most widely used cancer treatment. Cytotoxic chemotherapeutics are given systemically to patients with haematologic or solid cancers. Dose-limiting toxicity to normal tissues is frequently a problem in the clinic and can lead to dose reduction and survival of tumour cells. Sharon Sagnella and Calum Drummond describe the development and use of nanoparticles for drug delivery. The impact on size and shape of particles and the tumour microenvironment are all factors that influence retention and uptake of particles by tumours. Nanoparticles are being developed for use in passive targeting where trapping and delivery of drug-loaded nanoparticles relies on the 'leaky' vasculature of tumours. In tumours that are less vascular, or where more specific targeting is required, the use of targeting moieties on nanoparticles can facilitate uptake of the drug-loaded nanoparticles by specific cell types.

RNA interference (RNAi) is a naturally occurring gene silencing mechanism which holds great promise for the treatment of human disease. There is intense effort to overcome the many challenges associated with the therapeutic targeting of RNAi in the clinic. Josh McCarroll and I discuss the challenges and opportunities associated with therapeutic delivery of RNAi. A number of delivery vehicles that are being developed for diverse disease

states such as infections and cancer are presented. The best characterised of these delivery vehicles are the lipid-based particles such as liposomes and lipid nanoparticles. Biocompatible particles such as chitosan are non-toxic and have been exploited as delivery vehicles for gene therapy. Dendrimers are another promising approach for RNAi delivery and have shown promise in HIV and cholesterol therapy. Progress in clinical trials of RNAi therapeutics is also outlined in this review.

Non-invasive imaging techniques are important to detect cancer and cardiovascular disease. There has been an enormous effort to improve the resolution and the sensitivity of imaging techniques using nanotechnology. Cyrille Boyer and Tom Davis describe the development of nanoparticle-based imaging enhancement for diverse methods including positron emission tomography, optical imaging (fluorescence), magnetic resonance imaging and computer tomography imaging. There are both challenges, such as the delivery and stability of the imaging nanoparticles, and opportunities, such as the dual imaging and drug delivery particles. This is a rapidly expanding field that has the potential to increase the resolution of imaging technologies.

Switching gears to nanodevices, Simon Corrie, Alexandra Depelsenaire and Mark Kendall introduce the Nanopatch, a needle-free delivery system. Infectious diseases kill 13 million people worldwide each year. Formulating, packaging, distributing and administering these vaccines poses many challenges, particularly in the developing world. The authors describe the development and design of the Nanopatch, engineered to overcome many of these challenges. The Nanopatch delivers the vaccine to the epidermis, which is rich in immune cells, in order to immunise against disease. For all of you with a needle phobia – help is on its way!

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Cover Illustration

Uptake of nanoparticles containing doxorubicin following 1 hour incubation with SKNBE2 neuroblastoma cells. Red: doxorubicin particles; blue: nucleus (Hoechst 33342). *Image courtesy of Dr Sharon Sagnella, ACN and CCIA.*