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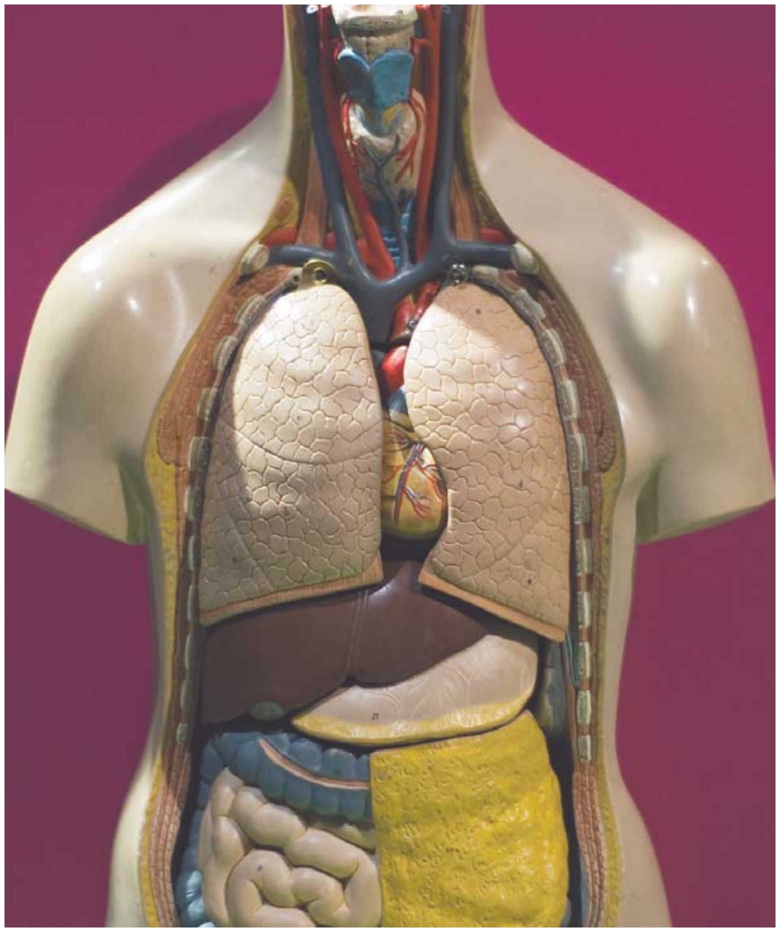

The use of nanotechnology in medicine can only grow

Dr Kostas Kostaleros reports on the use of nanotechnology in the delivery of pharmaceuticals

The image of a minuscule vessel navigating the blood stream, crossing organs, surveying the whole body for unwanted pathogens or malignancies and obliterating them on demand by use of a laser or tweezers is a truly fascinating concept that has become a cinematographic reality on numerous occasions since the 1950s.

The close relationship between scientific paradigm and science fiction illustrations has been tantalising for both sides. There have also been many examples where science fiction illustrations have found their graceful place in science laboratories and publications based on limited, if any, justification, but simply because the concepts described or professed as realities are so appealing.

This is the case for the nano-submarine imagery and all its nanometer-scale components that have appeared in cinema, which graphically illustrates the ultimate goal in the development of medicines: the ability to monitor, survey, treat and eliminate diseases with complete absence of complications, side effects to healthy organs, and minimal pain and suffering inflicted on the patient.

Can nanotechnology assist with its tools and knowledge to achieve such a challenging goal for medicine? This is precisely the role of nanomedicine and everyone involved in this captivating yet onerous effort.

Nanomedicine is emerging as an independent field of research and technology. As our knowledge of physical properties at the nanoscale becomes more profound and novel nanometer-size materials are developed, their use in biomedical applications will increase.

Similar to the rest of nanotechnology, the novelty and significance of nanomedicine is in the new perspective and focus that it offers: the utilisation of nanometer-scale materials to monitor, diagnose and cure diseases.

One can argue that all drug molecules can be considered as nanomedicines since they act at the molecular level.

Nanomedicine researchers will respond that their discipline is focusing at the nanoscale, namely above the molecular level and within the 100 nanometer scale.

Whatever the argument, the fact is that nanometer-sized drug delivery systems have been developed for a number of years, having an established role in clinical practice today.

This does not mean that nanomedicine has no further potential to improve clinical practice.

On the contrary, consolidation of previously acquired knowledge on how nanoparticles act in the body with novel nanoscale materials (such as carbon nanostructures, quantum dots) and tools (for example, sensors, high resolution imaging) give promise to a very exciting future for nanomedicine (Table 1).

Nanomaterial Name & Type	Pharmacological Function	Disease
Nanomedicines in the Clinic		
liposome (30 - 100 nm)	targeted drug delivery	cancer
nanoparticle (iron oxide) (5 - 50 nm)	contrast agent for magnetic resonance imaging (MRI)	hepatic (liver)
Nanomedicines under Development		
dendrimer (5 - 50 nm)	contrast agent for magnetic resonance imaging (MRI)	cardiovascular (Phase III clinical trial)
fullerene (carbon buckyball) (2 - 20 nm)	antioxidant	neurodegenerative cardiovascular (preclinical)
nanoshells (gold-coated silica) (60 nm)	hyperthermia	cancer

As with many aspects of nanotechnology, the UK boasts traditionally strong institutions and centres of excellence in nanomedicine. The Centre for Drug Delivery Research at The School of Pharmacy, University of London, has maintained a particular strength over the last 20 years in translating knowledge and materials at the nanoscale from fundamental basic research to advanced pharmaceuticals.

Liposomes, nanometer-sized water-containing spherules of fat, have a long history in our centre and, most importantly, have been the exemplary nanomedicines used in cancer treatment centres around the world for almost a decade.

Liposomes are currently developed in our laboratories as nanomedicines for the more effective and less toxic delivery of drugs, genes and radionuclides against cancer (Image 1). Moreover, carbon nanotubes (minuscule cylinders of a rolled-up carbon atom net) first discovered in the 1990s and made biocompatible only a few years ago, are also being developed as delivery systems of therapeutic and diagnostic agents in an early-stage exploration exercise (Image 2).

These are just two examples of a wide variety of nanomaterials that are increasingly explored in our laboratories and others around the world for a diverse number of biomedical applications. Such systems, and their combinations (for delivery systems of both imaging and therapeutic modalities) constitute the nanomedicine technologies and tools that are expected to reach the clinic and contribute to more effective treatment of disease.

So what are the shortcomings of nanomedicine? In my opinion, these lie in the 'eye of the beholder'. The most dangerous shortcomings from which a promising field like nanomedicine can suffer are a detachment from reality and overhyped expectations.

Nanomedicine should be encouraged to develop as a discipline based on scientifically proven realities rather than alluring science fiction-based prospects and illustrations.

Safety considerations, public awareness of what is feasibly possible, and very close contact with the reality and needs of the clinician, who will ultimately use the nanomedicine tools and knowledge, will guarantee valuable contributions and benefits to patients.

Nanomedicine and the construction of a comprehensive delivery system for surveillance, monitoring, treatment and elimination of disease may be an elusive goal to achieve, but provides great motivation for a creative process that can serve and benefit medical practice.

Pharmaceutical Bioengineering & Nanotechnology Group
cddr.pharmacy.ac.uk/main3.html

Centre for Drug Delivery Research
cddr.pharmacy.ac.uk/

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