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# Healthy challenges

Medical applications of nanotechnology are growing, but a number of outstanding issues need to be resolved before nanomedicine moves from the lab to the bedside.

Ten years from now, a visit to the hospital or health clinic might be quite different from today. Imagine doctors using carbon nanotubes to shrink cancerous tumours[1], or deploying peptide-based nanofibres to stop bleeding[2] or to regenerate severed nerves[3]. Indeed, as the list of nanobased medical products compiled by the Project on Emerging Nanotechnologies[4] continues to grow, and as more and more nano-enabled products enter pharmaceutical 'pipelines'[5], it is clear that nanomedicine will see significant progress in a few key areas: drug delivery, imaging, the detection of disease, and regenerative medicine.

It is in drug delivery and imaging that nanotechnology is likely to have the biggest impact, largely because it will be possible to target only those regions where drugs are needed, leaving the surrounding healthy tissue intact. On page 495, for instance, Carsten Rudolph and co-workers report the use of magnetic nanoparticles to direct aerosols into mice lungs to treat localized lung diseases (see also page 467). Moreover, multifunctional drug delivery systems in which the nanoparticles carry both targeting agents and therapeutic payloads may also double up to act as contrast agents for MRI, CT and other imaging techniques. Detection tools made from nanowires and nanocantilever arrays[6] allow faster diagnosis and, therefore, earlier prevention of disease. It is foreseeable that these and other advances will offer personalized diagnostic tools and treatment (theranostics) in the future, especially for treating cancer[7].

By virtue of their small size, nanobased platforms have several advantages when treating diseases, which are largely caused by damage at the cellular or molecular level. Nanotechnology allows cells, proteins and genes to be manipulated with precision, a feat impossible with existing surgical tools, which are large and crude from the viewpoint of a cell. Equally dramatic is the ability of these nanomaterials to move through our bodies and deliver therapeutics to previously unreachable places. This, of course, creates a new set of concerns related to toxicity and biodistribution. On page 469, Marina Dobrovolskaia and Scott McNeil review the interaction of nanoparticles with the immune system, and call for further research in this area.

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Elsewhere research into stem cells continues to gather pace, despite opposition in some quarters. One of the critical problems in this field is the need to grow and expand stem cells to the scale required for useful therapies. Because nanomaterials can be made to resemble living systems, materials scientists and stem-cell researchers have now come together to use nanotube-based materials as scaffolds to grow cells in large numbers while keeping other contaminating cells at bay (see page 459).

With so much research being carried out, what will *Nature Nanotechnology* publish? We are interested in ground-breaking papers from all areas of nanomedicine, but it is important to show that the control of materials and phenomena on the nanoscale is central to the discovery. Papers demonstrating the possible application of new materials in the body must, at the very least, include detailed material characterization and compelling evidence that they have the potential to compete with existing approaches. And ideally, these papers should also present preliminary toxicity and biodistribution data. For papers on nanotoxicology, it is essential to have at least two quantitative and two qualitative assessments. And whenever possible, a careful validation of each technique is critical to ensure that the nanomaterial does not interfere with the assays used in traditional toxicology studies.

Last but not least, although many of these concepts work on cell cultures and animal models in the lab, one of the biggest challenges in nanomedicine is translating proof-of-principle studies into approved therapies that can benefit society. This is, of course, not easy because so many things can happen between the cell, mouse, rabbit, dog and human. A cautious and stepwise approach is necessary because being sure and being safe are just as important as being first.

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