Five big ideas for nanotechnology

New drug-delivery approaches based on nanotechnology offer promise, but designing tiny particles that can efficiently target disease presents more than just a small challenge. Here are five ways that scientists have taken unconventional inspiration to overcome drug-delivery hurdles for nanoparticles.

You're fired

Injecting drug-delivery nanoparticles into the human body is one thing, but getting them to move through thick tissue to the right part of the body is quite another. One approach being investigated by a team led by Stefaan De Smedt from Ghent University in Belgium is to fire them out of a microscopic 'cannon'. This cannon consists of a tiny bead of sugar-based gel covered with a thick semipermeable polymer membrane. Water diffusing through this membrane causes the gel to expand until the bead suddenly explodes, firing any nanoparticles in the gel over a large area. In tests, this led to 200 nanometer particles travelling almost 800 times faster than they normally would in solution (*J. Am. Chem. Soc.* **130**, 14480–14482; 2008).

Sticky seeds

It's not just a challenge getting nanoparticles to the right part of the body—it can also be quite tricky getting them to stay there. This is especially the case for mucus-covered surfaces found in regions like the nose and intestines, which are regularly washed with new mucus. So, a team led by Tejal Desai from the University of California–San Francisco decided to take inspiration from the plant seeds known as burrs that stick to clothing and fur. They mimicked burrs on a microscopic level by covering tiny glass beads with silicon nanowires and found that the beads would firmly bind cells, refusing to budge even when doused with mucus (*Nano Lett.* **9**, 716–720; 2009).

Propeller power

Ensuring that a drug is released from a nanoparticle at a specific time and place within the human body requires a much finer degree of control than is available with diffusion. One option is to trigger the release in some way, and this is what Jeffrey Zink and his colleagues at the University of California–Los Angeles have now achieved. They stored an anticancer drug within pore-covered silica nanoparticles, attaching a paddle-shaped molecule known as an azobenzene to the pore walls. Ordinarily, these molecules prevent the drug from escaping, but when exposed to a specific wavelength of light they rapidly alternate between two different configurations, generating a waving motion that propels the drug out of the pores (*Small* **4**, 421–426; 2008).

Liquid gold

Nanotechnology could offer promise as a means of delivering combination therapy, if scientists can develop a way to release numerous drugs at different times. Engineers led by Kimberly Hamad-Schifferli at Massachusetts Institute of Technology have shown that this can be achieved with nano-sized gold rods. When exposed to light of specific wavelengths, gold nanoparticles heat up and eventually melt, with differently shaped gold nanoparticles responding to different wavelengths. Hamad-Schifferli and her team created small, capsule-shaped gold rods and long, bone-shaped rods and then attached hundreds of DNA strands to their surfaces. Using light of different wavelengths, the engineers were able to melt first one type of rod and then the other, both of which released their cargo of DNA as they melted (*ACS Nano.* **3**, 80–86; 2009).

Landing craft

When traveling through the human body, nanoparticles are exposed to a whole raft of dangers, from enzymes that can degrade them to cells that can engulf them. To ensure safe passage, scientists led by Mauro Ferrari at the University of Texas have come up with a system in which nanoparticles are safely housed within biocompatible silicon particles that are able to travel through the body unhindered. The researchers say that the nanoparticles are released as the silicon particles degrade. Initially demonstrating that this system works with fluorescent nanoparticles and carbon nanotubes, Ferrari has since gone on to show that the silicone particles can house and release therapeutic nanoparticles and RNA strands (*Nat. Nanotechnol.* **3**, 151–157; 2008).

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