MATERIAL WITNESS

NANO CONTRACEPTION

Among the potential uses of nanomaterials in medicine, one of the most appealing is to deploy metallic nanoparticles as antennae for sub-optical electromagnetic signals, enabling highly localized heating by wireless means. Such particles have already been used to induce melting (unpairing) of individual molecules of double-stranded DNA[1] and thermal gating of ion channels[2]. In the latter case, manganese ferrite nanoparticles 6 nm across, fixed next to calcium ion channels *in vivo* in the nematode worm *Caenorhabditis elegans*, were used to trigger firing of neurons in response to a radiofrequency magnetic field, altering the direction of motion of the entire organism. Using the same techniques, Stanley *et al.* were able to control calcium-triggered insulin release in mice[3]. Even more impressively, the mice were genetically modified to produce the iron oxide nanoparticles biologically *in situ*.

Such achievements have led to predictions of an emerging new field of biomedicine based on radio or infrared signalling to nanoparticles[4]. One particularly attractive avenue is the selective targeting and thermal destruction of cancer cells[5]. That vision gains yet more traction from a report by Li *et al.* of induced sterility in male mice by means of gold nanorods injected into the testicle and heated by absorption of near-infrared radiation[6].

The researchers adduce the need for a contraceptive method for household pets such as cats and dogs that is cheap, controllable (perhaps non-permanent) and does not involve surgery. Because heat will inhibit sperm production, it seemed natural to extend earlier work on nanoparticle-based photothermal treatment of cancer cells[5] to this application.

Gold nanoparticles are generally considered non-toxic, being excreted via the liver and kidneys, and have already been approved by the US Food and Drugs Administration for some medical uses in humans[7]. Coating them in polyethylene glycol (PEG) enables them to evade the immune system. Li *et al.* found that PEG-coated gold nanorods about 40 nm long, injected into the testes of male mice, could raise the temperature up to 45 °C when irradiated with an infrared (808 nm) laser.

That degree of heating, although not unduly uncomfortable, essentially destroyed the testes and suppressed spermatogenesis permanently. But milder heating (lower irradiation intensity) impaired sperm production only temporarily. When mice treated this way later mated with females, the pups that resulted showed no morphological defects — a necessary but not sufficient indication of a lack of long-term damage to the spermatogenic function. The male mice showed no changes in eating, aggression or sexual activity after treatment.

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All this bodes well for the efficacy and safety of the procedure, but inevitably there is more to be done before pronouncing with certainty. It's not yet clear, for example, if the nanorods are voided from the body: the concentration in the testes and epididymis declined over time, but the particles seemed to accumulate in the spleen and liver.

One obviously wonders about an extension to humans. That's certainly the authors' long-term goal, and they are confident that it should work in theory. ❐

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FERROELECTRIC TUNNEL JUNCTIONS

Beyond the barrier

Employing a semiconducting electrode in a ferroelectric tunnel junction boosts the resistance switching effect.

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Non-volatile memories, as opposed to volatile ones, allow data to be retained even when not powered. This prominent advantage has made non-volatile memory technologies one of the fastest growing markets with applications ranging from smart phones to industrial robots. A continuing quest for higher storage density, higher write and read speeds, and lower power consumption drives vigorous exploration of new materials, physical principles and operation schemes that can be exploited in non-volatile memories. One of the promising candidates for the new technology is a ferroelectric tunnel junction (FTJ)[1] .

An FTJ consists of two electrodes separated by a nanometre-thick