MATERIAL WITNESS

NATURE VERSUS NATUROID

Can there be metameric devices in the same way that there are metameric colours? The latter are colours that look identical to the eye but have different spectra. Might we make devices that, although made up of different components, perform identically?

Of course we can, you might say. A vacuum tube performs the same function as a semiconductor diode. Clocks can be driven by springs or batteries. But the answer may depend on how much similarity you want. Semiconductor diodes will survive a fall on a hard floor. Battery-operated clocks don't need winding. And what about something considerably more ambitious, such as an artificial heart?

These thoughts are prompted by a recent article by methodologist Massimo Negrotti of the University of Urbino in Italy (*Design Issues* **24,** 26–36; 2008). Negrotti has for several years pondered the concept of what, in science and engineering, is commonly called biomimesis, aiming to develop a general framework for what this entails and what its limitations might be. His vision is informed less by the usual engineering concerns, evident in materials science, of learning from nature and imitating its clever solutions to design problems. Rather, Negrotti wants to develop something akin to a philosophy of the artificial, analogous to (but different from) that expounded by Herbert Simon in his 1969 book *The Sciences of the Artificial* (MIT Press, Massachusetts).

To this end, Negrotti has coined the term 'naturoid' to describe "all devices that are designed with natural objects in mind, by means of materials and building procedures that differ from those that nature adopts." A naturoid could be a robot, but also a synthetic-polymer-based enzyme, an artificial-intelligence program or even a simulant of a natural odour. This concept was explored in Negrotti's 2002 book *Naturoids: On the Nature of the Artificial* (World Scientific, New Jersey).

Can one say anything useful about such a broad category? That might remain a matter of taste. But Negrotti's systematic analysis of the issues has the virtue of stripping away some of the illusions and myths attached to attempts to 'copy nature'.

It won't surprise anyone that these attempts will always fall short of perfect mimicry; indeed, such replication is often explicitly not intended, with biomimetic materials generally imitating just one function of a biological material or structure, such as adhesion or toughness. Negrotti calls this the 'essential performance', which itself also implies a selected 'observation level' — we might make a comparison solely at the level of bulk mechanical behaviour, irrespective of, say, microstructure or chemical composition.

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This inevitably means that the mimicry breaks down at some other observational level, just as colour metamerism can fail depending on the observing conditions (daylight or artificial illumination, say, or different viewing angles).

This reasoning leads Negrotti to conclude that there is no reason to suppose the capacities of naturoids can ever converge on those of the natural models. In particular, the idea that robots and computers will become ever more humanoid in features and function, forecast by some prophets of AI, has no scientific foundation. ❐

DRUG DELIVERY

Stealth particles give mucus the slip

Mucus presents a formidable barrier to nanoparticle drug-delivery systems, but adding a coating of polymer molecules helps them sneak through the net.

Yen Cu and W. Mark Saltzman

Mucus, the amorphous, sticky substance that often invokes unpleasant images, may not be a favourite topic at the dinner table, but we all rely on it for a healthy life. The mucus barrier is essential in preventing viruses and bacteria from entering our tissues; but this function also poses a perennial problem for drug delivery (Fig. 1). Ying-Ying Wang and colleagues have now demonstrated a method that could help drug-loaded nanoparticles to slip through the mucus barrier[1]. Their coating of a non-degradable polymer opens opportunities for particles to be used in localized drug- and gene-delivery in mucus-coated areas. This could include treatment of diseases such as cancer and infections in the respiratory and female-reproductive tracts.

Mucus provides an essential barrier for humans that protects vulnerable surfaces in the lung, intestinal, eye and reproductive tissues from invasion by bacteria, viruses, allergens and irritants. Mucus is home to a wide range of microorganisms that exist in symbiosis with our body. It also acts as a lubricant, making possible everyday functions that we often take for granted, such as blinking and passing food through the digestive tract.

It was long thought that the mucus barrier prevents uptake of large molecules by hindering their ability to diffuse. We