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Materials witness: Body painting

PHILIP BALL

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There is something curious about the concept of ‘bioprinting’. It is an exciting and potentially valuable approach to tissue engineering, but the prospect is akin to that of a sculptor taking a smooth block of stone and carving it into a shape indistinguishable from a natural boulder. It might precipitate new questions about our bodies’ dynamic architecture.

The most common technique for creating artificial tissues involves growing cells on a polymer scaffold. Artificial skin for grafts has been made this way for years from fibroblasts cultured within a biodegradable, porous scaffold of a material like collagen. Three-dimensional tissues – artificial organs – are more challenging, however, because of the issue of vascularization.

Without a blood supply, seed cells deep within a scaffold matrix will quickly die. One option is to first grow the vasculature on an appropriately shaped tubular scaffold, and then to grow the other cells around it – a slow process at best. And it is hard, with the scaffold approach, to reproduce complicated, three-dimensional mixtures of cell types of the sort found in real organs.

Bioprinting aims to address these problems. It is basically an extension of the rapid-prototyping technology developed for making complex shapes in polymers and ceramics by building them up as a series of two-dimensional slices. Ink-jet technology is used to deposit the material in the form of an ‘ink’ that can be cured or sintered into a solid form.

For bioprinting, the ink consists of clusters of living cells, which are printed onto thin sheets of soft polymer gel. A fresh sheet of this gel ‘paper’ is added for each successive layer, and the cells ultimately adhere to form cohesive, three-dimensional structures. Thomas Boland of Clemson University in South Carolina, for example, has produced tubes of contractile smooth muscle tissue from stacks of ring-shaped layers.

Viable cells can now be printed using nothing more sophisticated than commercial ink-jet printers. Multiple nozzles can create arbitrary structures of mixed cell types: Boland has demonstrated a nine-nozzle bioprinting system.

That bioprinting is approaching a true biomedical technology seemed clear at an international workshop on the topic at the Medical University of South Carolina, Charleston, in March. In June the university approved the establishment of a centre to develop the method.

Yet the strikingly materialistic idea of reproducing an organically grown 3D body part by the 2D positioning of cells would force the issue of how much (and in what way) shape matters to function. Is it enough simply for the vascular system to be hierarchically branched, for example? Or (as some believe) might the precise scaling behaviour of the network structure, and the exact branching geometry – that is, the generative rules and the topological outcome of growth – matter for getting the right flow properties and minimizing the pumping energy? There's no obvious reason why such a structure complex couldn't still be mimicked by bioprinting, yet it would highlight the fact that our bodies are not just arbitrary architectures of cells but frozen histories of the dynamic processes that made them.