MATERIAL WITNESS

PRINTING ON THE BRAIN

Living tissues and organs typically consist of several cell types, and their arrangement — the histoarchitecture — is critical to functionality. That's a big challenge for tissue engineering. It's one thing to seed a shaped, three-dimensional biodegradable polymer scaffold with cells and let them colonize the structure. But achieving this for heterogeneous cell types that are intricately interwoven, often at a microscopic scale, is tough.

Cells can do some of the work for us, because they possess an innate capacity to self-organize, particularly if the scaffold is made from the harvested extracellular matrix (ECM) of the original tissue[1]. And micro-manipulation techniques such as dielectrophoresis and optical tweezers have been used to organize cells in liquid solutions of such a matrix before letting it gel. It has even proved to be possible to remove cardiac and endothelial cells from a rat heart while leaving the ECM intact, reseed it with the cells, and regrow a functional heart[2].

But there is a different approach to making three-dimensional organs, which involves 'printing' them layer-by-layer. This is a form of rapid prototyping, in which solid objects are constructed by deposition of cross-sectional slices under computer guidance. Traditionally it has been used to make complexly shaped components from 'inks' of small metal, ceramic or polymeric particles. But the technique will also work for living cells.

Needless to say, cells need to be treated gently if they are to survive the process. One technique uses a pulsed laser to gently evaporate a thin layer of cell-laden 'ink' and deposit them at high resolution into a biopolymer matrix[3]. Because it is gentle and doesn't require ultraclean conditions, one possible application of this type of bioprinting could be to repair wounds and build up tissues *in vivo*. This has now been demonstrated in a preliminary study by Fabien Guillemot and co-workers in France[4]. For their pilot study, they chose a less daunting challenge than the deposition of living cells, instead aiming to assist bone repair *in vivo* by computer-assisted bioprinting of hydroxyapatite nanoparticles (nHA).

The researchers removed a 4-mm-wide section of the upper skull of anaesthetized mice, and used laser-assisted bioprinting at near-infrared wavelengths to deposit nanoparticles onto the cavity in a prescribed pattern from a slurry film held on a quartz ribbon just above the head. The laser itself seemed to inflict no lasting damage on brain tissue.

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Does it work? Sort of. Although untreated cavities never healed spontaneously, only some of the treated cavities were closed over with real bone after three months. In those cases, a cap of nHA initiated regrowth of healthy bone, and the mice seemed to fully recover. But in other test cases, the skull wounds failed to heal. This was partly because of a trivial problem of misdirected nHA deposition, but in other instances it may have been caused by movement of the deposited particles, suggesting that they might need to be immobilized to ensure proper healing. All the same, the results suggest that bioprinting has a future in surgery. ❐

References

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STRUCTURE PREDICTIONS

The genetics of grain boundaries

The prediction of interface structures is an uncertain and time-consuming task. A technique merging *ab initio* calculations with a genetic algorithm simplifies the process and provides suitable solutions of the atomic structures that would be hard to envisage *a priori*.

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Interfaces may have a very strong influence on the macroscopic behaviour of a wide range of materials. Sometimes they are detrimental, as in the case of materials fracture and creep; sometimes they are beneficial as in the case of activated sintering[1]. Grain boundaries are a special type of interface that form when grains of the same phase but different crystallographic orientations abut. The geometry can be rather complicated because each grain boundary depends on three crystalline misorientation parameters and two extra parameters for the normal of the grain-boundary plane.

Predicting the structures of grain boundaries is a complex task. The crystalline structure of the abutting grains plays an