MATERIAL WITNESS

MATERIAL COMPUTATION

"Rather than taking raw materials, sending them through a machine or process that is inherently fighting tolerances, errors and energy consumption to arrive at a desired product, we should be directly embedding assembly information into raw materials, then watching as the materials assemble themselves." This claim from architect Skylar Tibbits of MIT will sound familiar to anyone engaged in nanoscale and molecular engineering these days, but it is new and challenging to architects themselves. Equally so is Tibbits's exhortation to look to biology for inspiration. He sets out his case in a special issue of the journal *Architectural Design* (vol. 216, March–April 2012).

Tibbits argues that, to make self-assembly work in contexts from the microscopic to the truly architectural, one needs four components: (1) simple assembly sequences; (2) programmable parts; (3) force or energy of activation; and (4) error correction and redundancy. As for DNA, he says, so for buildings. Tibbits has demonstrated the principles with reconfigurable robots called the Decibot and Macrobot, made from rotating units that, like proteins, can form three-dimensional shapes by folding of one-dimensional chains. The point is not just that the chains can be folded into particular structures, but that they will do so in a predictable way when activated by a 'random' input of energy, obviating the need to put each part in place 'by hand'. Thus, mere shaking of Tibbits's prototype Biased Chain devices enables them to adopt a pre-programmed configuration. Meanwhile, redundancy is the key to robustness, so that for example breakage of a single point of connection does not induce global failure.

Tibbits's work illustrates very nicely the issue's central theme of 'material computation': getting the material or the structure itself to do all the work. In general, this is a matter of good planning: you might instead say that the work is focused on design, freeing up the construction process to take care of itself. In biology it's often assumed that good design results from Darwinian selection — but as J. Scott Turner points out, that's only part of the answer. Optimization often depends on dynamic updating to the demands of the environment, not genetic pre-destiny. Bone, for example, acquires a good engineering form because it is constantly remodelled by osteocytes that respond to stresses in a homeostatic way. "Where modern evolution has gone wrong is in assuming that it is the specifiers — genes — that are responsible for good living design", Turner says. "In seeking to emulate living nature in their designs, architects would do well not to repeat our mistake." This sort of feedback and updating is precisely what some animal architects employ.

PHILIP BALL

The issue's guest editor Achim Menges explains where this 'trust in materials' can lead in architecture — for example, to 'force-driven design' in which form can evolve elastically in response to tension and compression (in fact, a feature unwittingly built into Gothic cathedrals), as well as to climate-responsive design, such as a pavilion in Stuttgart walled with hygroscopic scales that open up when dry, but close in the rain. There are no mechanical parts — the material structure itself is the machine. ❐

SUPERCOOLED LIQUIDS

Clearing the water

Evidence of a transition between two coexisting liquids of the same composition in a water–glycerol mixture, where glycerol prevents the crystallization of water, provides a unique link to an elusive liquid–liquid transition in pure water.

Austen Angell

The existence of two coexisting liquids having the same composition but different structural organization — an unambiguous (equilibrium) phenomenon in model liquid systems[1,2] — has been controversial in the laboratory. Indeed, most cases of liquid–liquid transitions (LLTs) that were initially considered clear-cut have been challenged later. The most famous case is that of pure water. In 1994 Mishima reported abrupt discontinuous switches between high- and low-density amorphous phases under pressure-cycling at different temperatures near water's glass transition temperature (T_g) (ref. 3). Although his observations mostly applied to glassy states, measurements at the highest temperature were performed on the liquid. Still, defining the states of amorphous water phases has been challenging[4,5], and has only recently been convincingly clarified[6]. In fact, the major problem hampering the study of supercooled water has been the ease with which it crystallizes. Now, writing in *Nature Materials*, Ken-ichiro Murata and Hajime Tanaka avoid this issue by adding glycerol, which prevents water crystallization, and report evidence for an isocompositional