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What is glass?

Things aren't as clear as you might think. Glass is a weird kind of solid liquid – and how it comes to be like that defies all explanation

(Image: Peter Marlow/Magnum)

FORGET the hoary myths peddled by tour guides at old European churches and cathedrals. Medieval window panes are sometimes thicker at the bottom not because of the slow flow of glass over centuries, but because of the uneven way molten glass was originally rolled into sheets in the Middle Ages.

Glass is not a slow-moving liquid. It is a solid, albeit an odd one. It is called an amorphous solid because it lacks the ordered molecular structure of true solids, and yet its irregular structure is too rigid for it to qualify as a liquid. In fact, it would take a billion years for just a few of the atoms in a pane of glass to shift at all.

But not everything about glass is quite so clear. How it achieves the switch from liquid to amorphous solid, for one thing, has remained stubbornly opaque.

When most materials go through this transition between liquid and solid states, their molecules instantly rearrange. In a liquid the molecules are moving around freely, then snap! – they are more or less locked into a tightly knit pattern.

But the transition from the glassblower's red-hot liquid to the transparent solids we drink from and peer through doesn't work like that. Instead of a sudden change, the movement of molecules gradually slows as the temperature drops, retaining all the structural disorder of a liquid but acquiring the distinctive physical properties of a solid. In other words, in all forms of glass we see something unusual: the chaotic molecular arrangement of a liquid locked in place.

The process underlying this strange behaviour remains an open question. "The number of explanations almost matches the number of researchers," says Hajime Tanaka at the University of Tokyo in Japan.

One possibility is that it's all down to energy use. According to the laws of thermodynamics, which govern how energy is transferred within a system, every collection of molecules is driven to find an arrangement with the lowest possible energy. But within any given system some patches do better than others, meaning different groups of molecules settle into different configurations – and, overall, into an irreconcilably chaotic arrangement.

But even if we put it down to thermodynamic laws, it's not clear what exactly drives glass's strange behaviour. The push for low energy might be the prime mover. Then again, it could be the irrepressible tendency towards a maximum state of disorder. That's a perfectly plausible proposal, though it raises the troubling question of how ordered solids manage to survive.

Tanaka is not giving up just yet. "So far crystallisation and glass transition have been studied independently," he says. But Tanaka believes that glass may form in a manner not all that different from crystals, which have proved an easy target for analysis thanks to their repeating geometric structures. If he's right, maybe glass will finally become crystal clear.

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