MATERIAL WITNESS

THE ROMAN MELTING POT

Recycling of materials is generally good for the planet, but it makes life hard for archaeologists. Analysis of ancient materials, for example by studying element or isotope compositions, can provide clues about the provenance of the raw materials and thus about the trade routes and economies of past cultures. But that business becomes complex, even indecipherable, if materials were reused and perhaps reprocessed in piecemeal fashion.

This, however, does seem to have been the way of the world. Extracting metals from ores and minerals from quarries and mines, and making glass and ceramics, were labour-intensive and often costly affairs, so that a great deal of the materials inventory was repurposed. Besides, the knowledge was sometimes lacking to make a particular material from scratch *in situ*. The glorious cobalt-blue glass in the windows of medieval French churches and cathedrals is often rich in sodium, characteristic of glass from the Mediterranean region. It was probably made from shards imported from the south using techniques that the northern Europeans didn't possess, and perhaps dating back to Roman or Byzantine times. The twelfth-century monk Theophilus records that the French collected such glass and remelted it to make their windows[1].

In that instance, composition does say something about provenance. But if glass was recycled en masse, the chemical signature of its origin may get scrambled. It's not surprising that such reuse was very common, for making glass from scratch was hugely burdensome: by one estimate, 100 kg of wood was needed to produce the ash for making 2 kg of glass, and collecting it took a whole day[2].

Just how extensively glass was recycled in large batches in Roman times is made clear in a new study by Jackson and Paynter[3]. Their analysis of glass fragments from a Roman site in York, England, shows that a lot of it came out of "a great big melting pot": a jumble of recycled items melted together. The fragments can be broadly divided into classes differentiated by their antimony and manganese compositions. It was common for both of these elements to be added purposely during the Roman glass-making process because they could remove the colour (typically a blue-green tint) imparted by the impurities, such as iron, in the sand or ash[4]. Manganese was known in medieval Europe as 'glassmaker's soap'.

It's the difficulty of making it that meant colourless glass was highly prized — and so particularly likely to be recycled. The results of Jackson and Paynter's investigation confirm how common this was. The largest category of glass samples that they analysed — around 40 percent of the total — contained high levels of both Sb and Mn, implying that glass rendered colourless by either additive would be separated from the rest and then recycled by melting.

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But most of those samples aren't colourless. That's because remelting tends to incorporate other impurities, such as aluminium, titanium and iron, from the crucibles, furnaces or blowing irons. The recycled glass may then end up as tinted and undistinguished as that made with only low amounts of Mn. As a result, although it is derived from once valuable, colourless glass reserved for fine tableware, this high Sb–Mn glass becomes devalued and used for mundane, material-intensive items such as windows and bottles. Eventually it just disappears into the melting pot. ❐

References

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STEM CELL REPROGRAMMING

A 3D boost

Biophysical factors in an optimized three-dimensional microenvironment enhance the reprogramming efficiency of human somatic cells into pluripotent stem cells when compared to traditional cell-culture substrates.

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Following Shinya Yamanaka and colleagues' description in 2007 of how human somatic cells could be reprogrammed into induced pluripotent stem cells (iPSCs) by using just four embryonic transcription factors[1], iPSCs have provided autologous cells as a powerful tool for disease modelling, pharmaceutical screening, therapeutic regeneration and precision medicine[2]. Since then, numerous approaches have attempted to improve yields compared to the original protocol that was based on a 2D cell-culture system. Yet the role of a 3D environment has, surprisingly, remained unexplored. Reporting in *Nature Materials*, Matthias Lutolf and colleagues now describe a 3D culture system that promotes iPSC generation by modulating