films[2]. In their system the nanoparticles are poorly wetted by the polymer in the absence of any surface treatment. Drawing on the two-layer model for thin films, one might conjecture that the reduction in T_g observed in these systems would scale with the ratio of the particle surface area to the polymer volume. By considering particle aggregates as single particles of larger diameter, the authors calculated this ratio from electron micrograph images and plotted T_g reduction as a function of the inverse ratio (volume/surface area). They find that, comparing nanocomposite systems to thin films of equal surface-to-volume ratio (such as the two systems depicted schematically in Fig. 1), the nanocomposites exhibit a greater T_g suppression.

Most strikingly, by equating the harmonic average (the reciprocal of the arithmetic mean of reciprocals) of the interparticle spacing to film thickness, the authors find that the nanocomposite and thin-film data completely superpose[2]. The remarkable agreement between the two geometries seems surprising, given the 3D nature of the confinement in nanocomposites, the presence of particle curvature, the broad range of particle sizes and so on. The equivalence between interparticle spacing and film thickness implies that a dynamic cross-talk exists between the interfaces of polymer thin-films, consistent with the results of Ellison and Torkelson[4]. These findings further beg the question: for a fixed interparticle spacing, what is the role of particle size? Is there a particle size below which no T_g suppression is expected, or does the effect hold down to molecular dimensions, connecting reductions in T_g arising from geometric constraints to those achieved by the addition of common plasticizers?

The precise origin of the T_g suppression in constrained geometries remains a subject of inquiry[3,5,6] along with the nature of the glass transition itself. Nevertheless, the intriguing work by Kumar, Schadler and co-workers reported in this issue offers new light in which to view the properties of polymer nanocomposites. Their results may explain, for instance, why silica nanoparticles added to a glassy polymer membrane imparts substantially enhanced permeability to organic molecules[7]. Their findings might also be used in designing new materials — the addition of weakly wetting particles to a conventional polymer electrolyte, for example, should suppress T_g and thereby raise ionic conductivity above that of the unfilled polymer[8]. Thus, these results promise further advancements in both fundamental and applied aspects of the thermomechanics of polymer nanocomposites.

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MATERIAL WITNESS

Taking lessons from the book

When the bicycle was voted by Britons last year as the greatest invention, some technology experts were dismayed. As a keen cyclist, I was reluctant to complain myself. More frustrating, however, was the time span considered: the past 250 years, perhaps on the basis that older inventions would be mere historical curiosities by now. On the contrary, this eliminated some of the most worthy candidates, of which the foremost is surely the book.

Just as literary critics love to discuss the 'death of the novel', so publishers obsess about the 'death of the book', if only to debunk the notion. In part, this is a question about the future of 100,000-word theses in the era of the word-bite and web page; but also at issue is the fate of the book as physical object, a series of printed paper sheets between covers.

This invention has its drawbacks. Libraries consume space. Books are heavy, combustible, edible (to some species), and they fall apart. Electronic media would eliminate these problems at a stroke.

And yet they have not done so. The impact of electronics on reading and writing has been hugely asymmetric. These words will not encounter paper until they are ready for the pages of *Nature Materials*. Many people barely pick up a pen now except to sign their name; but some newspapers can put virtually their entire content online without fear of losing paper sales.

Some commentators are convinced that this is only a matter of time; and they may be right. Electronic paper has improved remarkably, and will surely hit the mass market within a decade. Power sources for such devices are getting lighter and longer-lived; manufacturing of high-resolution screens becomes ever cheaper, largely as a result of inventive materials solutions.

In his new book *The Singularity is Near* (Viking, 2005), inventor Ray Kurzweil suggests that technologies evolve in series of S-shaped curves — slow initial growth followed by rapid expansion that eventually levels off — with exponentially decreasing 'cycle' times. He suggests that the false starts and fundamental shortcomings of early 'electronic books' are mirrored by those of electronic pianos (a technology Kurzweil pioneered), and that once these problems are overcome, books will be seen as no less susceptible to 'digital' replacement than the acoustic piano.

But even if this is true, the extraordinary resilience of the book has something to teach us about the nature of technology. The reasons for the book's current dominance over electronic alternatives are not purely technical but are bound up with the human interface. What seems like imperceptible flicker on a standard computer screen confuses the eye and slows reading speed, so that we still prefer to print out long texts. Electronic books are wonderful for text searches, but don't yet have a browse facility that compares with flicking through paper pages. And even if books are biodegradable, do we still trust that words are as safe in an electronic memory as they are in paper and ink?

Philip Ball