throughout the hydrophobic interior of the bilayer. Release of Ca^{2+} inside the vesicle occurs when the shuttle complex meets the carotinoid radical cation, which oxidizes the complex to form the stable quinone and supply free Ca^{2+} at the inner membrane surface. The Ca^{2+} pumping circuit is completed by recycling of the quinone to the semiquinone form at the outer membrane surface. This reduction reaction is driven by the naphthoquinone radical anion, formed in the initial electron transfer process.

There remain several limitations to this approach. The observed photochemical efficiency of Ca^{2+} pumping, estimated to be ~ 0.01 , is low. The low value may be a consequence of relying on quinone shuttle diffusion within the bilayer to move ions and cycle redox species; if diffusion of these species is slow relative to competing, non-productive secondary reactions, the efficiency of the system will suffer. Long-term stability of the Ca^{2+} -binding shuttle quinones may also be an issue under conditions in which many catalytic cycles are required. In addition, Ca^{2+} transport kinetics in the absence of an internal trapping agent were found to be nonlinear as a function of irradiation time, indicating that progressive charge accumulation in the inner vesicle compartment impedes further Ca^{2+} transport. This will limit the magnitude of the transmembrane potential that can be developed in the absence of reactions that consume the transported Ca^{2+} .

It is clear, nonetheless, that the use of light-transducing and ion-transporting agents that can generate a chemical gradient, and lipid membranes that can maintain them, are successful in driving a thermodynamically unfavourable process. Such design features may be exploited in future systems aimed at photochemically regulating calcium homeostasis, cell proliferation, calcium mineralization within enclosed compartments, and a myriad of other processes that are strongly Ca^{2+} dependent.

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MATERIAL WITNESS

The stuff of youth

There's scarcely any scientist, with the possible exception of geneticists and cosmologists, who feels that his or her discipline gets its fair share of the limelight. But materials scientists have the added disadvantage that their science runs perilously close to engineering—and when was the last time you saw a popular TV programme on engineering?

So it is good news that this year's Christmas Lectures for children at the UK's Royal Institution in London, entitled *Smart Stuff*, will have a heavy focus on materials. Not only that, but they will show something of the grand sweep and diversity of today's materials science, ranging from photonics to biomedical materials to food science.

The lecturer is Tony Ryan of Sheffield University, who is especially well-situated to explain the importance of polymers in modern science and technology—illustrated in this case with reference to that icon of youthful cool, the training shoe.

If there is an older tradition of communicating science to the public, I do not know of it. The Christmas Lectures at the Royal Institution begun in 1825, and became legendary through the pedagogical genius of Michael Faraday, who delivered them regularly until 1860.

Faraday established the model that Tony Ryan will adopt this Christmas: to illustrate the unfamiliar by means of the familiar. For Faraday, the famous leitmotif was the candle; now mobile phones and ice creams are likely to capture the attention of a young audience more effectively.

The Christmas Lectures have always reflected the Royal Institution's strong tradition in the chemical and practical sciences, with recurring themes such as electricity, light, photography and radio communications. The glittering array of speakers has included John Tyndall, James Dewar, William Bragg, D'Arcy Thompson and the late George Porter. The more recent decades have been delightfully egalitarian, embracing geology, music and mathematics, alongside more familiar topics.

Because the Christmas Lectures are televised, they reach out to more than a few hundred school children: there were 1.5 million viewers last year. And one must suspect that it is not just children who watch. The appeal of the lectures is that, by having to address themselves to a young audience, they are highly visual, participatory and free from earnestness: qualities just as attractive to adults.

This need not mean that fun eclipses any real instruction. There is little, if anything, that we might wish the adult public to understand about science that cannot be readily assimilated by a ten-year-old child. It's just that, to communicate to the latter, we are forced to say what we mean in simple words and short phrases, knowing that attempts to impress will fall on deaf ears. This is a principle that could be usefully employed more widely than in lectures for children. Peter Goodhew of the UK Centre for Materials Education has asked why undergraduate lecture courses or book chapters have to be called 'Metallurgical thermodynamics' or 'Microstructure 1', rather than 'Why reactions work' or 'How far can we bend a beam?' Can anyone see a reason?

PHILIP BALL