energy-transfer ‘ratchets’ caused by the interplay of coherence and decoherence. But we do not know if photosynthetic light harvesting is, or needs to be, optimized to make use of coherence. Moreover, are there other roles that could be played by quantum effects in sensing, regulation or photoprotection? Can quantum coherence be helpful in the rugged energy landscape of an organic polymer film for exciton diffusion? Can it help charge separation in organic photovoltaics? How can coherent effects found in some supramolecular structures be beneficial on the longer length-scales of assembled systems? Can quantum effects in crowded molecular systems be used as a quantum resource?

The next step seems to be elucidating how we can write a blueprint to ‘make something’ based on what we have learned from photosynthetic complexes and multichromophoric synthetic systems. To do this we need to address a number of outstanding issues. These include working out how to increase the length scale over which quantum effects influence dynamics. At present this issue is challenged by the complexity of information obtained by experimental studies of large systems. Similarly, there are challenges for theory, though not only in regards to treating large systems. We may also need to consider more carefully the molecules that comprise the electronic system. Given their intrinsic complexity compared with notional ‘two-level systems’, we should give some thought to what attributes those components contribute to the system. Similarly, realizing the importance of the environment, we should elucidate design principles for the structural scaffold or matrix. To aid advances in this direction, we need experiments to probe the relevant environmental response more directly. The meeting showed that theoretical models for energy transfer are converging, but there remain opportunities for theories that make predictions that change how we think about energy-transfer dynamics. Especially for synthetic solar fuel production or more speculative technologies, it is desirable to harness quantum coherence to help more than light harvesting — for example, to aid the interplay between energy transfer and charge separation. Interestingly, photosystem II, the enzyme responsible for photosynthetic oxygen production, may provide clues for this challenge.

Clearly this is a rich field. Incisive experiments have reinvigorated energy-transfer research. The resulting accelerated development of theories has been breathtaking. The stage is set for young researchers to solve the new challenges now in sight.

Gregory D. Scholes is in the Department of Chemistry and Centre for Quantum Information and Quantum Control, University of Toronto, 80 St George street, Toronto, Ontario M5S 3H6, Canada.
e-mail: gscholes@chem.utoronto.ca

BUBBLE NUCLEATION

Stout fizz-ics

It has long been known that nucleation sites are essential to give carbonated drinks their fizz. Spontaneous bubble formation at a smooth surface only occurs in liquids that are supersaturated with dissolved gas. Without nucleation, a glass of champagne would seem lifeless and still, and a pint of lager poured from a can or bottle wouldn’t form much of a head. In practice this isn’t a problem, as preparing a glass that it is free from the impurities that generate bubbles — such as cellulose fibres from the environment — is actually quite difficult.

But for stout beer, which is infused with a mixture of carbon dioxide and nitrogen gas, this isn’t enough. To try to figure out why, William Lee and colleagues have extended a mathematical model that successfully describes the formation of bubbles in a purely carbonated liquid to one that describes a liquid containing a mixture of dissolved gases (W. T. Lee *et al.*, http://arxiv.org/abs/1103.0508; 2011).

© 2011 GUINNESS & CO

There are many reasons for using nitrogen in place of some of the carbon dioxide in stout. The lower concentration of carbon dioxide lowers the beer’s acidity. And bubbles of nitrogen tend to be smaller and more numerous than those of carbon dioxide, giving stout its characteristic creamy texture. This doesn’t present any problems for draught stout served in a pub, which is forced through a perforated metal plate that agitates the beer to produce the requisite bubbles.

But when delivered from a can or bottle, the agitation is much less vigorous, producing fewer bubbles and a less fulsome head. To compensate for this, many canned stouts use a hollow ball — commonly referred to as a widget — containing pressurized nitrogen that rushes out when that can is opened, to break up into hundreds of millions of tiny bubbles in the resulting turbulent flow.

Lee and colleagues wondered whether nitrogen bubbles simply don’t nucleate by the same process that carbon dioxide bubbles do, and whether it might be possible to promote their formation by some other mechanism. The model they subsequently developed suggests that nitrogen bubbles can in fact form by nucleation, but they do so at a rate that is much slower than carbon dioxide.

As a test, they immersed a cellulose fibre drawn from a coffee filter in a glass of canned stout and observed it under a microscope. They found that bubbles did indeed grow slowly, but regularly, from the fibre. This prompted them to speculate that coating the inside of a can with such fibres might produce enough bubbles quickly enough to remove the need for pressurized widgets. But whether that is economically viable, they leave for a more sober head to decide.

ED GERSTNER