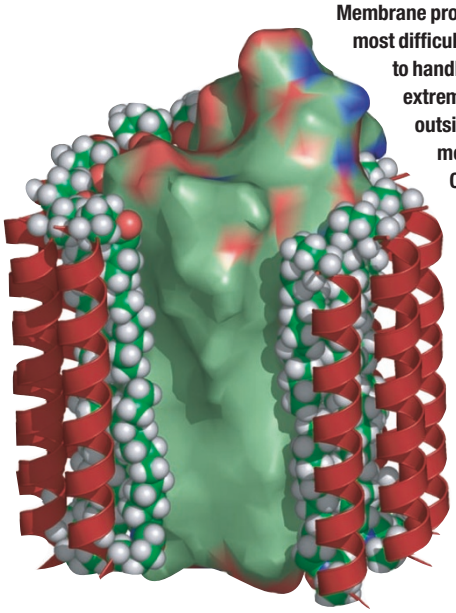
Protein mimics



Membrane proteins are by far the most difficult class of proteins to handle, owing to their extreme instability outside biological membranes. Consequently, structural information on these proteins is relatively limited. Surfactants are traditionally used in structural studies to stabilize the protein's hydrophobic surface, playing an analogous role to biological lipid bilayers. Inside the small spherical micelles formed by these surfactants, however, membrane proteins are not properly shielded from the solvent and tend to aggregate. The ideal surfactant – one that effectively mimics the biological lipid bilayers while forming small micelles – has now been designed by Gilbert Privé and colleagues (*Nature Biotechnology* 21, 171–176; 2003). They created a surfactant that has a helical peptide backbone with a hydrophilic side (exposed to the solvent) and a hydrophobic side (exposed to the protein), to which lipid chains are anchored. The lipo-peptide surfactants self-assemble into cylindrical micelles that are roughly as long as biological membranes (see image). These surfactants preserve membrane proteins for extended periods and form relatively small micelles, optimal for structural studies.

Concentrating on single molecules

Many biological processes, such as protein folding and enzyme dynamics, are controlled at the single-molecule level. Direct observation of the interactions between single molecules is crucial to understanding and directing these processes. Single-molecule fluorescence spectroscopy has proved a versatile tool in this respect. But most of the optical methods used to excite and detect the fluorescence are limited in resolution by the diffraction of light, so very dilute solutions are required to resolve the fluorescence from individual molecules. M. J. Levene and colleagues at Cornell University have now developed a technique that enables the detection of single-molecule fluorescence in solutions that are up to three orders of magnitude more concentrated than previously possible (*Science* 299, 682-686; 2003). They achieve this by using an array of small (~50 nm) holes in a thin metal film as parallel waveguides. These 'zero-mode' waveguides are too small to sustain propagating light modes, so any light incident on the entrance of the waveguides decays very rapidly. The excitation and detection region is therefore limited to very small volumes of solution within each waveguide, enabling parallel observation of single-molecule events within each detection volume. This technique allows single-molecule detection in solutions at biologically relevant, micromolar concentrations.

Recyclable zeolites

When chemists talk of ships in bottles, they may be referring to a process in which synthesis is carried out within a porous zeolite (the bottle) to create a product (the ship) that can only be removed by breaking the bottle. The usual means of destroying the zeolite involves concentrated acids or bases that may also harm the product. Now, Jing Li and colleagues (*Angew. Chem. Int. Edn* 42, 542–546; 2003) have created the first fully recyclable nanoporous material whose organometallic open framework can be readily dissolved and rebuilt using only mild reagents. Porous organometallic materials are zeolite mimics whose structure and function can be optimized by careful selection of the organic ligands and metal ions that make up the framework. The compound designed by Li and colleagues was constructed from identical 1D building blocks, to yield a porous structure containing two interpenetrating 3D networks with large open channels. When this framework is immersed in water, the structure rapidly dissolves, and is converted back into 1D units. The authors show that their organometallic material makes an efficient 'bottle' for high-yield photochemical reactions, and will fully release any reaction products when dissolved in water. Unlike most ship-in-a-bottle situations, this structural breakdown is completely reversible, and the 3D framework can be reconstructed from its 1D components.

Moving away from silicon solar cells

Until now, research into photovoltaics — the conversion of sunlight to electrical power — has been dominated by solid-state junction devices, often made of silicon. But this dominance is being challenged by the emergence of a new generation of solar cells based, for example, on nanocrystalline materials and conducting polymer films, which offer the prospect of cheap fabrication together with other features, such as flexibility. Eric McFarland and colleagues (*Nature* 421, 616–618; 2003) report a new design for solar cells that uses an organic dye as its light-harvesting layer, and which could help reduce the present cost of producing electricity from sunlight. In contrast with the operation of conventional photovoltaics, they have developed a device that physically separates the processes of light absorption and charge-carrier transport, resulting in a total energy conversion efficiency of 1%. This is small compared with what can now be achieved with silicon-based photovoltaics (in excess of 20%), but the authors suggest ways in which their approach could achieve the same efficiency as a conventional cell.

For more discussion on this story see http://www.nature.com/materials

MOLECULAR MEMORIES

The first requirement of a useful molecular material for data processing, storage and communication is a means for exchanging signals between two independent molecular components. Francisco Raymo and colleagues at the University of Miami (*J. Am. Chem. Soc.*; http://dx.doi.org/10.1021/ja027977j) have developed a system in which a chemical signal communicated between two molecules can transform an optical input into an electrical output. Their system combines a photoactive component, which releases a proton when stimulated by light, with an electroactive component that captures the proton.

This molecular switch can be used to create the chemical equivalent of a digital memory element, by exploiting the time delay between the initial transformation and its decay. A 'bit' of information can be written optically into the system, and then read electrically in a non-destructive manner. The limited bit lifetime (~ 11 hours) means that this molecular memory is more akin to chemical signals stored and transmitted in the nervous system than data stored in electronic devices.