authors ascribe to CP47 and the first six helices of the PsaA/B subunits in PSI, because only a weak sequence homology has been noted between the PsaA/B helices and those predicted for CP47 and CP43 of PSII. This match is strong evidence that PsaA/B, which are essential subunits in the PSI reaction centre, have evolved from a gene fusion of a CP43/47-like protein with a five-helix prototype of a bacterial reaction centre.

Despite the limited resolution, the tetrapyrrole pigments can be detected in the PSII map by comparison with the bacterial reaction centre (Fig. 2). Two elongated densities that partially overlap with the tetrapyrroles of the bacterial special pair probably represent the two chlorophylls of the primary electron donor, P680. Interestingly, these densities are slightly further apart than in the bacterial reaction centre — 11 Å instead of 7.6 Å — consistent with spectroscopic analyses[6]. Further densities in the D1/D2 complexes could tentatively be assigned to the pheophytins, and densities corresponding to chlorophylls have been identified in the CP47 map.

Rhee and colleagues' three-dimensional map of the sub-core of the PSII reaction centre not only gives us a framework on which to model this enzyme from the related structural elements of the bacterial and PSI reaction centres, but also shows how the pigment–protein complexes that convert sunlight into chemical energy have evolved. To understand the structure and function of these amazing enzymes is increasingly important in view of the urgent need to find a regenerative replacement for fossil fuels. □

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Atmospheric chemistry

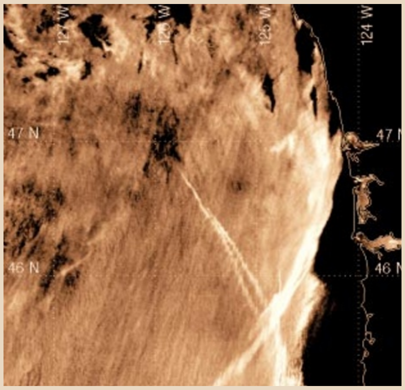
Shipping forecast is partly cloudy

Aircraft contrails are a familiar feature of modern life, but ships too can leave traces of their passage in the sky. As this satellite image shows (R. J. Ferek *et al.*, in *J. Geophys. Res.* 103, 23199–23206; 1998), diesel-powered vessels leave behind 'ship tracks' — narrow lines of perturbed regions in the marine atmosphere resembling bright bands of cloud.

Ship tracks were first reported more than 30 years ago. They are caused by the interaction of particles emitted from ships with ambient air, which results in a higher cloud droplet concentration and lower average droplet size. The consequence is increased cloud radiance at 3.7 μm, as detected by the advanced very-high-resolution radiometers (AVHRR) on satellites of the US National Oceanic and Atmospheric Adminstration.

On 26 August 1992, the region off the coast of Washington state was covered by a uniform layer of low-lying stratus clouds — the perfect weather to look for ship tracks on satellite images, and direct an aircraft to collect microphysical and chemical data in and around them. The two tracks spottedby Ferek *et al.*, seen in this picture as a narrow, inverted V, are caused by plumes from the *Forest Wave* and *Al Alamira* on their way northwest across the North Pacific Ocean.

The data collected during repeated aircraft crossings of the tracks, at about 210 m above the sea surface, show the expected strong perturbation of microphysical cloud properties: the initially very high total concentration of particles in the tracks



decreases over time, while the cloud droplets (which form in the presence of activated particles known as cloud-condensation nuclei) are about six times more abundant and half as large as those in the surrounding unperturbed clouds. Surprisingly, the higher droplet concentrations persist for a long time.

The radiative properties of clouds influence the global radiation budget, and depend sensitively on droplet size and concentration. Anthropogenic pollutants such as sulphur dioxide, volatile organic compounds and particulates can initiate the formation of cloud-condensation nuclei, and thereby perturb these radiative properties. Ship tracks seem an ideal setting for tackling the challenge of quantifying the correlation between emissions and cloud perturbations, and so may help to improve understanding of Earth's radiation budget and the factors affecting it.

Magdalena Helmer

Daedalus

Fossil knowledge

What we know of ancient societies comes largely from written records — paper and vellum documents and baked clay tablets. Clay tablets are by far the most enduring. Organic documents have mainly survived by preservation and repeated copying over the centuries. What does this imply for our own torrent of data?

The obvious conclusion is that it is all doomed. Magnetic and optical tapes and disks will delaminate and embrittle; paper and film will bleach and crumble. Worse, respect for the past is now dead. Modern short-term businesses, election-driven governments and fashion-crazed media have no use for archives; a future Dark Age might not bother with copying at all. Only a few 'clay tablets', in the form of commemorative statuary and crockery, will survive to puzzle future historians.

But Daedalus is more optimistic. He points out that fossilization can preserve animal remains over millions of years. Their organic content is replaced by stable mineral, and with amazing fidelity. So DREADCO chemists are trying to fossilize books, film, CDs, magnetic tapes and disks and so on. They are immersing them in pressurized carbonated or silicated water, and studying the rate and fidelity with which their organic content is replaced by the mineral. Daedalus argues that their information content will be unchanged. It is either held as a spatial pattern (as in CDs and gramophone records) or as a stable mineral itself: metallated carbon ink in printed paper, silver grains in monochrome film, magnetic oxide particles in tape and disks. Fossilized information media would faithfully carry their message down the millennia.

Reading them, however, will be tricky. A carbonate disk would be too brittle to be played; a silica reel of tape or film could not be unwound. The DREADCO team are studying their data-rich fossils by X-ray and magnetic-resonance tomography, trying to read them directly as three-dimensional solid objects. They hope to define the optimum procedure for recovering data from the mineralized remains of our time.

But how to inform future historians of this crucial work? Daedalus plans to encode his findings on the glass fibre read-only memory, or FROM, he devised last week. Fully mineral already, it is the only truly future-proof data format. FROMs will be the key by which our descendants will unlock the copious fossilized glories and absurdities of our civilization.

David Jones