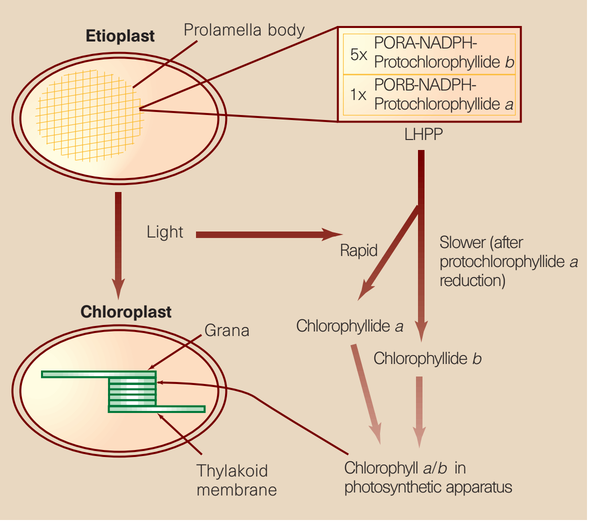

Figure 1 **Conversion of an etioplast to a chloroplast. The interaction of a protochlorophyllide oxidoreductase (POR)–NADPH–protochlorophyllide complex with membranes results in the formation of prolamella bodies in the developing chloroplast (etioplast). Reinbothe *et al.*[1] have reconstituted this complex *in vitro*, and call it the light-harvesting POR–protochlorophyllide complex (LHPP).**

spectral properties from the complex *in vivo*. However, by adding galactolipids and sulpholipids from etioplasts to the mixture, they were able to obtain LHPP with spectral characteristics similar to those of etioplast membrane preparations. They found that protochlorophyllide *b* in the LHPP initially has a light-harvesting function. It then transfers light energy to protochlorophyllide *a* for photoreduction to chlorophyllide *a* by PORB. By this transfer, protochlorophyllide *a* is rapidly photoreduced — even under low light intensities — so that the seedling can assemble its photosynthetic apparatus quickly.

Although protochlorophyllide *a* is reduced quickly, the protochlorophyllide *b* is not immediately photoreduced at the light-harvesting stage. Any excess light energy that is not transferred to protochlorophyllide *a* is then emitted as fluorescence. Only when the complex between protochlorophyllide *b* and PORA is separated from the LHPP can this protochlorophyllide be efficiently photoreduced; this means that, under a high light intensity, protochlorophyllide *b* has a photoprotective function. This ties in with the fact that there is five times as much protochlorophyllide *b* as *a* in the LHPP. Once enough chlorophyll has been made and assembled into a functional photosynthetic apparatus, PORA is no longer needed, explaining why this enzyme is negatively regulated by light.

Protochlorophyllide *b* has been identified in many fully green plants[4] but, despite numerous spectroscopic studies[5], it has never before been reported in etiolated tissue. So, the implication of Reinbothe and colleagues' study — that most of the protochlorophyllide in barley etioplasts is protochlorophyllide *b* — is not yet supported experimentally. However, some characteristics of chlorophyll-*b*-deficient mutants (which, presumably, cannot make protochlorophyllide *b*) may be explained by the requirement for protochlorophyllide *b* in the LHPP. These mutants almost universally cannot green rapidly when exposed to light[6], and they do not develop well when greened under high light conditions. These are the phenotypes that would be expected if PORA could not carry out its function in the LHPP.

Expression of PORA can be suppressed in the dicotyledon *Arabidopsis thaliana* if the plant is grown under continuous far-red light. These plants do not make prolamella bodies (etioplast precursors of the grana) and they cannot green rapidly[7]. However, when either PORA or PORB is overexpressed in these *Arabidopsis* seedlings[8] (or in *Arabidopsis* mutants that lack prolamella bodies[9]), the prolamella bodies form and the seedlings green normally. These experiments[8,9] indicate that the quantity of POR is important for formation of the prolamella body and greening in *Arabidopsis*, and they do not exclude the possibility that an LHPP containing a PORA–protochlorophyllide-*b* complex occurs in this plant. However, they do contradict the suggestion by Reinbothe *et al.*[1] that formation of the prolamella body requires both PORA and PORB in an LHPP.

The specificity of protochlorophyllide *b* for the highly expressed PORA in etiolated seedlings is important for formation of the LHPP, with its interesting photochemical properties. The next challenge will be to see whether the PORs of other plant species have similar substrate specificities, or whether the LHPP is unique to barley. □

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Daedalus

Highly pointed remarks

The new global telephone systems, with their multitude of orbiting satellites, worry radioastronomers. The Iridium system now entering service uses 66 satellites; at least one, and usually several, are above the horizon at any time anywhere on Earth. The radio glare of their transmitters blots out the feeble radiation from cosmic sources. Daedalus now points out that radioastronomy itself has pioneered a solution to the problem.

The satellites are all in communication with one another; but only one (the nearest) communicates with any given client station on the ground. But suppose all the satellites in sight of that station joined in the communication. They would collectively form a 'very long baseline interferometer' aerial in the sky, spread over millions of square kilometres of orbital space. With the right phasings between its elements, such an aerial is wonderfully directional. It could transmit to, and receive from, a mere few square metres around a specific ground station. Receivers elsewhere, such as radio telescopes, would detect nothing.

Not only would this system eliminate interference, it would drastically reduce the power needed for its transmitters. For instead of broadcasting wastefully to whole regions, the satellite array could target each ground station exactly. Its sensitivity as a receiving array would be equally enhanced. Properly phased, the collective satellite aerial would have a very high 'gain' for signals from that station. So the satellites could be put into higher orbits, their horizons would broaden, and fewer of them would be needed to cover the globe. The only snag is that their positions are constantly changing. And to compute the correct phasings needed to target each ground station, and keep them properly updated, those positions would have to be accurately known all the time.

No problem, says Daedalus. The most accurately located satellites of them all are, of course, those of the Global Positioning System. Several of those must also be in the sky over any point at any time. So combine the two systems in one set of satellites. Fewer satellites would crowd the heavens, transmitter power and radio spectrum space would be saved, and radioastronomers everywhere could relax. They would merely have to avoid using the satellite telephone while at the telescope. Otherwise their cosmic gaze would be disrupted by a sudden accurately targeted blast of chatter from the sky.

David Jones