Comment by Sir George Porter, F.R.S.

The Royal Society

Phil. Trans. R. Soc. Lond. A 1980 **295**, 471-472
doi: 10.1098/rsta.1980.0142

Phil. Trans. R. Soc. Lond. A **295**, 471–472 (1980)
Printed in Great Britain

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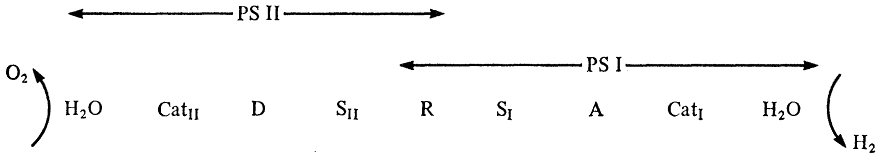
At this point in our discussion we turn from solid state devices to biological systems and although this may seem to be a somewhat discontinuous transition there is in fact an almost complete line of connection between the two. This has already been indicated by Dr Nozik, whose photoelectrochemical cells resemble photovoltaic devices when used for the generation of electricity and also bear some similarity to the natural photosynthetic process when used for the photoelectrolysis of water.

If electrodes are dispensed with and replaced by a donor or acceptor molecule, we enter the realm of ordinary photochemistry in homogeneous solution. Although homogeneous photochemical methods for the dissociation of water into hydrogen and oxygen have not yet been fully developed, this is at present a very active area of research where progress is rapid and promising. If it can be perfected it has many advantages over photoelectrochemical methods, not the least of which are economic ones.

The dissociation of water into its elements requires the transfer of four electrons for each molecule of oxygen produced and is thermodynamically possible by using one photon of red light for each electron transfer (1.23 eV ≡ 1000 nm). When activation and other losses are taken into account, however, the single photon process appears less promising and has not, in practice, been achieved. Most effort is therefore centred on analogy with the natural photosynthetic process where two photons operate two photochemical systems (PS I and PS II) in series to effect the transfer of a single electron.

The two photosystems are connected by a common redox component (R), which is reduced by PS II and oxidized by PS I. Each photosystem has its own sensitizer (S) and the overall electron transfer chain may be represented as follows:



Here D is an electron donor, A is an electron acceptor and $\mathrm{Cat_{II}}$ and $\mathrm{Cat_{I}}$ are catalysts for the accumulation of electrons and the liberation of oxygen and hydrogen respectively.

Photosystem I has now been achieved, with quite high efficiency, in a number of laboratories (for a recent review see Harriman & Barber 1979). A wide variety of components have been used successfully; some of the most important of them are as follows:

donor	sensitizer	acceptor	catalyst
ascorbate	chlorophyll *a*	methyl viologen	hydrogenase
triethanolamine	acridines	$\mathrm{Eu^{3+}}$	Pt
EDTA	flavins	$\mathrm{V^{3+}}$	Au
cysteine	$\mathrm{Ru(bipy)_3^{2+}}$	$\mathrm{Rh(bipy)_3^{3+}}$	

In all cases the donor is oxidized and hydrogen is liberated, the other components being unchanged. To complete the process it is necessary to liberate gaseous oxygen and restore the donor to its reduced form, and this problem has not yet been solved. It is almost certain that green plants involve a complex of manganese in this process and work which attempts to model these reactions *in vitro* (Porter 1978) has been reviewed recently.

Intermediate between these purely chemical processes and the production of biomass by natural photosynthesis comes the possibility of using systems which are partly composed of plant materials and partly of synthetic components. The paper that follows (from Professor Hall and his group) summarizes work in that area.

References

Harriman, A. & Barber, J. 1979 *Topics in photosynthesis*, vol. 3. Amsterdam: Elsevier.
Porter, G. 1978 *Proc. R. Soc. Lond.* A **362**, 281.