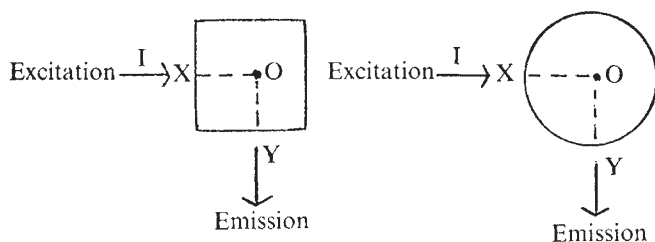


Fig. 1 Quenching of the fluorescence, and fluorescence lifetimes of chlorophyll *a* by β -carotene. \blacktriangle , τ_0/τ (— best fit K_{SV} 22.5); \bullet , Φ_{F_0}/Φ_F (square cells, — best fit K_{SV} 26 ± 5); \blacksquare , Φ_{F_0}/Φ_F (cylindrical cuvette - - - best fit K_{SV} 37 ± 5), τ and τ_0 , Chlorophyll *a* lifetime in presence and absence of β -carotene. Φ_F and Φ_{F_0} , Chlorophyll *a* fluorescence quantum yields in presence and absence of β -carotene. $[Q]$, Quencher concentration; K_{SV} , Stern-Volmer quenching constant. Φ_{F_0}/Φ_F was calculated by the following procedure: consider the fluorescence from the centre O of a cell, illuminated at X by light of intensity I , and observed at right angles at Y.



In the absence of a quencher let the transmittance of the solution over XO and OY be x and y respectively. Then the fluorescence intensity at Y, $F_o = Ixy\Phi_{F_0}$. If the transmittance of a solution of pure quencher over XO and OY is α and β respectively, then the new observed fluorescence intensity of quenched chlorophyll solution, $F_{obs} = Ixy\alpha\beta\Phi_F$. Hence the observed Stern-Volmer quenching $F_o/F_{obs} = \Phi_{F_0}/\alpha\beta\Phi_F$. $\alpha = 10^{-\epsilon_1 cl}$ and $\beta = 10^{-\epsilon_2 cl}$; ϵ_1, ϵ_2 are extinction coefficients of β -carotene at excitation and monitored emission wavelength respectively; c is quencher concentration; l is distance from centre of cuvette to X and Y (normally equal).

because of their design, show whether the quenching process occurs.

We propose that the role of carotenoids in photosynthesis is wider than originally envisaged. On interaction of the excited singlet state of β -carotene with chlorophyll the energy can be partitioned between energy transfer and an electron transfer process. The relative importance of the two processes will be determined by the orientation and the distance separating the two molecules. Since energy transfer occurs by a resonance process^{20–22}, it should be favoured relative to the redox process by an increase in the distance separating the two molecules. The environment of carotenoids in the antennae is known to be different from that in the reaction centre^{24,25}. In the antennae resonance transfer from carotene to chlorophyll and rapid resonance transfer from one chlorophyll molecule to another may compete successfully against the electron transfer reaction such that only resonance transfer is occurring. At the reaction

centre, resonance energy transfer from the centre to a chlorophyll molecule outside the centre becomes inefficient because of the lower energy of the excited singlet state of the chlorophyll in the centres. Consequently, the electron transfer should be favoured and a chlorophyll radical anion and a carotene radical cation formed. This latter species will undergo a rapid ground state reaction with a neighbouring chlorophyll molecule^{22,26} to generate a chlorophyll radical cation²⁷ and thus the overall effect of the electron transfer reaction is to produce a charge separated pair Chl^-Chl^+ . It has been proposed that such a dimer species is involved in photosystem II (ref. 25).

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GODFREY S. BEDDARD

The Davy Faraday Laboratory,
The Royal Institution,
London W1, UK

R. STEPHEN DAVIDSON
KENNETH R. TRETHERWEY

Department of Chemistry,
The University,
Leicester, UK

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Corrigendum

In the article 'Economics of alternative energy sources' by Martin Ryle, *Nature* **267**, 111–117, the figures given in Table 1 under Present Gas Turbine Generators should have included two entries: *a*, the contribution from oil-fired steam stations, showing an annual variation and *b*, the contribution from gas turbines used for peak boosting. These figures were inadvertently combined and used with the gas turbine time variations. The correct figures lead to a reduction in the final peak value in the Table from 187 to 163 GW and a reduction in the installed capacity needed from 266 to 233 GW; these figures are still some 50 times those of the present nuclear capacity.