## 100 years ago

*PERSONAL IDENTIFICATION AND DESCRIPTION*

The thumb-mark has been used . . . in preventing personation, and in putting an end to disputes about the authenticity of deeds.

The question arises whether fingermarks remain unaltered throughout the life of the same person. I am enabled to submit a most interesting piece of evidence, which thus far is unique, through the kindness of Sir Wm. Herschel. It consists of the imprints of the fingers of his own hand, made in 1860 (left) and in 1888; that is, at periods separated by twenty-eight years. There is an obvious amount of wearing and of coarseness in the latter, but the main features in both are the same.

From *Nature* **38,** 201; 28 June 1888.

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whole-cell recording through noise analysis to single-channel recording. The analogy illustrates the enormous potential of techniques which allow functional studies of single protein molecules.

The new approach to molecular mechanics is not limited to the study of myosin. On the contrary, the microneedle method of force measurement was used some years ago to estimate the force on a single moving chromosome in anaphase[7] (about 50 pN per kinetochore microtubule) and the force responsible for microtubules sliding in flagella[8] (about 1 pN per dynein arm). Any motor protein which is driven by ATP hydrolysis is limited to a maximum energy input of 50 kJ mole$^{-1}$, or about $10^{-19}$ J per ATP hydrolysed. If its efficiency were, say, 10 per cent, it could exert a force of 1 pN over a distance of 10 nm. It has already been shown that myosin and dynein operate in this range of force and displacement, and it seems likely on thermodynamic grounds that kinesin and other ATP-driven motor proteins will also do so. The new high-resolution methods have great potential for investigating these mechanisms of biological motility at the molecular level. □

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**Photosynthesis**

# Roofs and ceilings of light-response curves

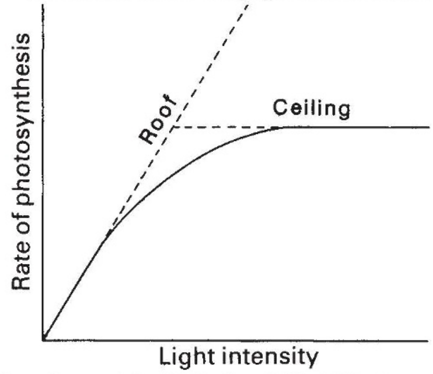
*D.S. Bendall and J.C. Gray*

Photosynthesis, a highly complex metabolic system, can adapt to a wide range of environmental conditions. But it is only half the story. Textbooks usually neglect to mention the almost equally important process of photodissipation — the controlled conversion of excess light energy into heat. This is surprising because almost everyone is aware of the great instability of chlorophyll exposed to light, once it has been removed from the organized structure of the chloroplast. New insights into some of the many control mechanisms involved in photosynthesis and photodissipation were the subject of two recent, associated meetings*.

The classical description of photosynthesis is due to Blackman[1] and the central concept that of limiting factors. At low light intensities, for example, the limiting factor is the rate of absorption of photons (see figure). The rate of $CO_2$ fixation is proportional to intensity and the slope of the line (the 'roof' of Rabinowitch[2]) is a measure of the quantum efficiency. The rate increases linearly until other factors, such as temperature or $CO_2$ concentration, become limiting and determine a maximum rate or 'ceiling' — the underlying limitation is the catalytic capacity of the dark reactions of $CO_2$ assimilation.

The development of a computerized leaf electrode by D.A. Walker (University of Sheffield) has so simplified the determination of light curves that our knowledge of the varied responses of leaves to light under different physiological conditions is likely to be transformed. The intersection region of the roof and ceiling is particularly important. Biochemists brought up with Michaelis–Menten kinetics have difficulty in accepting that a true description might involve a discontinuity rather than a gradual transition from an initial slope to a ceiling approached asymptotically. Walker suggests that the most meaningful measure of the curvature is the area underneath the curve expressed as a percentage of the area under the ideal Blackman roof and ceiling. The value of this 'light-utilization capacity' depends on the sharpness of response of the control mechanisms as the chloroplast adjusts to photodissipation; in practice it can be well over 90 per cent. As shown by S.P. Long (University of Essex), the observation of low values is often the result of self-shading, of the lower half of a leaf by the upper, for example. The point was made most dramatically at the second meeting, when T. Vogelmann (University of Wyoming) reported that with the aid of glass fibres of diameter 1–5 μm inserted into a leaf, the chloroplasts in upper layers of cells could be seen to filter out nearly all the red and blue of the incident light.

Variations in chlorophyll fluorescence provide a powerful method for probing energy flows in photosystem 2 because fluorescence is in competition with photochemistry (photochemical quenching, $q_Q$) and acts as an indicator of non-radiative dissipative mechanisms (energy-dependent quenching, $q_E$). The latter process comes into play in the transition from roof to ceiling. E. Weis (University of Düsseldorf) proposed a model for $q_E$ in which protonation of reaction centres by the low *p*H of the thylakoid lumen converts them to an energy-dissipating form which generates heat with high efficiency. This raises the intriguing possibility that this process involves a reduced phaeophytin molecule of the photochemically inactive arm of the reaction-centre dimer.




Experimental (solid line) and ideal Blackman (dashed lines) light response curves (based on Fig. 26.6 of ref. 2).

P. Horton (University of Sheffield) put forward an alternative model (based on the observation that antimycin specifically inhibits $q_E$ with little effect on the intrathylakoid *p*H) in which energy dissipation is the result of wasteful cycling of electrons via cytochrome *b*-559. Not only would this provide a function for the cytochrome, which is closely associated with the photosynthetic reaction centre, but it also raises a further question about the nature of the switch (could this be a function of one of the extrinsic regulatory polypeptides associated with the water oxidation

*New Vistas in Measurement of Photosynthesis*, The Royal Society, London, 25–26 May 1988; and *Physical and Biological Techniques in Photosynthesis Research*, CIBA Foundation, London, 27 May 1988.