S2

EVOLUTION OF TWO LIGHT REACTIONS. COOPERATION AND INTER-DEPENDENCY IN PHOTOSYNTHESIS, SCIENCE, AND SOCIETY

John F. ALLEN

Research Department of Genetics, Evolution and Environment, University College London, Gower Street. London WC1E 6BT, U.K. E-mail: j.f.allen@ucl.ac.uk

The "Z-scheme" describes the electrical connection, in series, of two pigment systems each of which contains its own photochemical reaction centre and attendant light-harvesting antenna. The two photosystems are complementary, and inter-dependent: photosystem I and photosystem II cooperate in the conversion of absorbed excitation energy into electrochemical potential. Competition between the photosystems leads to inefficiency, and, if uncorrected, to their inactivation. In state transitions, absorbed excitation energy becomes optimally distributed between the two photosystems. The sensor that initiates redistribution is a departure from equal rates of electron transport into and out of the intermediary electron carrier, plastoquinone. The response is a redox-regulated reversible protein phosphorylation that serves to re-allocate a mobile antenna to the otherwise rate-limiting photosystem. In photosystem stoichiometry adjustment the rates of transcription of the genes for apoproteins of the two photochemical reaction centres are adjusted in response to the same sensor of imbalance that initiates state transitions. In eukaryotes, reaction centre genes are universally retained in chloroplast DNA where they are placed under redox regulatory control by components that have been inherited with little modification from the cyanobacterial endosymbionts from which chloroplasts evolved. While biochemistry and biophysics are satisfyingly immune to the naturalistic fallacy of inferring what ought to be from what is, it is clear that excitation energy, supplied in parallel to the two light-harvesting antennae, becomes equitably re-distributed by both post-translational and transcriptional mechanisms. Neither photosystem is allowed to remain in excess of the other in its capacity to contribute to overall quantum yield. By analogy, I shall argue that the yield of research – new knowledge and understanding – is increased by optimal distribution of resources between laboratories that cooperate by sharing their findings. In contrast to this view, a current trend is to sever cooperative links, placing researchers in competition with each other. At the boundary of existing knowledge there is neither competition nor scope for restriction on freedom of enquiry. All scientific progress is initiated by unique and unpredictable events.