Australian Academy of Science

RUDI LEMBERG LECTURE

The redox switch hypothesis for the first cyanobacterium: the origin of two light reactions in photosynthesis

Professor John F Allen
20009 Rudi Lemberg Travelling Fellow
Professor of Biochemistry, Queen Mary, University of London

4.00pm, Tuesday24th February, 2009
Rountree Room (3rd Floor, Bioscience Bldg.)
School of Biotechnology and Biomolecular Science
The University of New South Wales

Photosynthesis provides energy in the Earth's biosphere and oxygen in its atmosphere. For oxygen to be produced, two different light reactions must operate simultaneously, and in series. Known anaerobic, photosynthetic bacteria contain one or other of these photosystems, but never both. I propose that the two photosystems diverged, in structure and function, from a common ancestor, within a single, continuous anaerobic lineage. In such cells, the two photosystems are isoenzymes encoded by orthologous genes under co-ordinated, redox regulatory control. A redox switch responds to defined environmental conditions and selects which set of genes is expressed. In these cells, the two photosystems are thus synthesized at different times. It is further proposed that the origin of oxygen-evolving photosynthesis was a simple mutation that disabled the redox switch, permitting simultaneous expression of the two sets of genes. The two, newly co-existing photosystems became connected by shared electron carriers, allowing generation of electrochemical potential high enough to oxidize water; an inexhaustible supply of reductant; and the selective advantages, and pressures, of an aerobic world. The redox switch hypothesis predicts specific, sulphide-responsive redox regulatory control in a Heteronuclear, Anoxygenic Phototroph – "HAP". "Heteronuclear" denotes the possession of genes for both type I and type II reaction centres, a property previously thought to be restricted to oxygenic phototrophs. The predicted organism will share some of the characteristics of *Chloroflexus* and *Oscillatoria* spp. It is possible to imagine that all such lineages have died out, but this seems unlikely, since suitable habitats still exist. It is therefore to be expected that this bacterium is either undiscovered, or a known species, as yet incompletely described. "HAP" is also a good candidate for the organism that built ancient stromatolites and other microbialites in the early Archaean, up to 1 Gyr before the origin of oxygenic photosynthesis at 2.5 to 2.6 Gyr before the present day.

Allen JF: **A redox switch hypothesis for the origin of two light reactions in photosynthesis**. *FEBS Letters* 2005, 579: 963-968

Allen JF and Martin W: **Evolution: Out of thin air.** *Nature* 2008 (in press)