



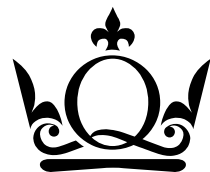
Cell Biology and Developmental Genetics

Lectures by

John F. Allen

School of Biological and Chemical Sciences, Queen Mary, University of London

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University of London

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Endosymbiosis and the origin of bioenergetic organelles. Some history

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Mitochondria, ageing, and sex – energy versus fidelity

Lecture 5

Co-location for redox regulation



Problem

Why Do Mitochondria and Chloroplasts Have Their Own Genetic Systems?

Hypothesis

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Co-location for Redox Regulation - CoRR

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Vectorial electron and proton transfer exerts regulatory control over expression of genes encoding proteins directly involved in, or affecting, redox poise.

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Allen, J. F. (1993) J.Theor. Biol. 165, 609-631

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Co-location for Redox Regulation - CoRR

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Prediction: Explanation of previous knowledge

Distribution of genes for components of oxidative phosphorylation between mitochondria and the cell nucleus

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Prediction: Explanation of previous knowledge

Distribution of genes for components of oxidative phosphorylation between mitochondria and the cell nucleus

Prediction: Experimental results

Redox control of mitochondrial and chloroplast gene expression

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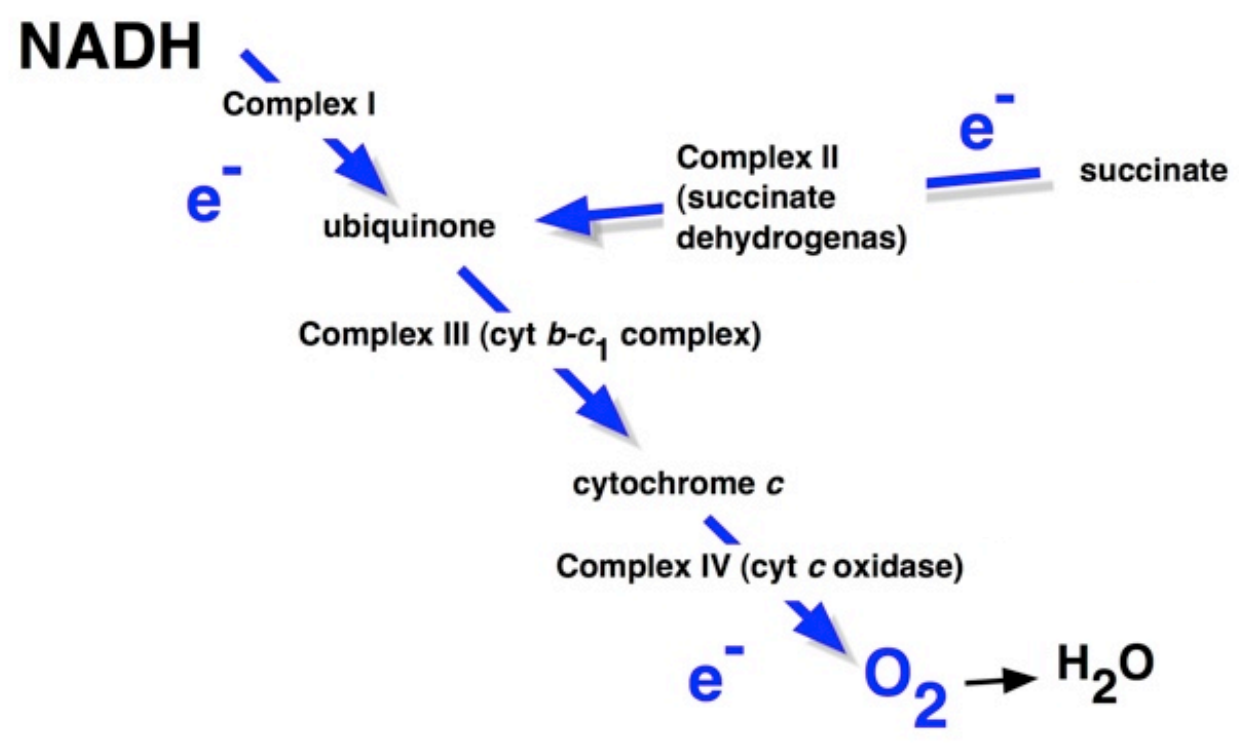
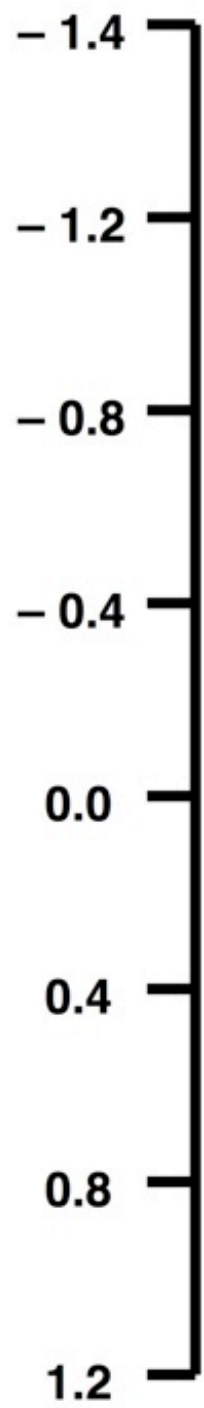
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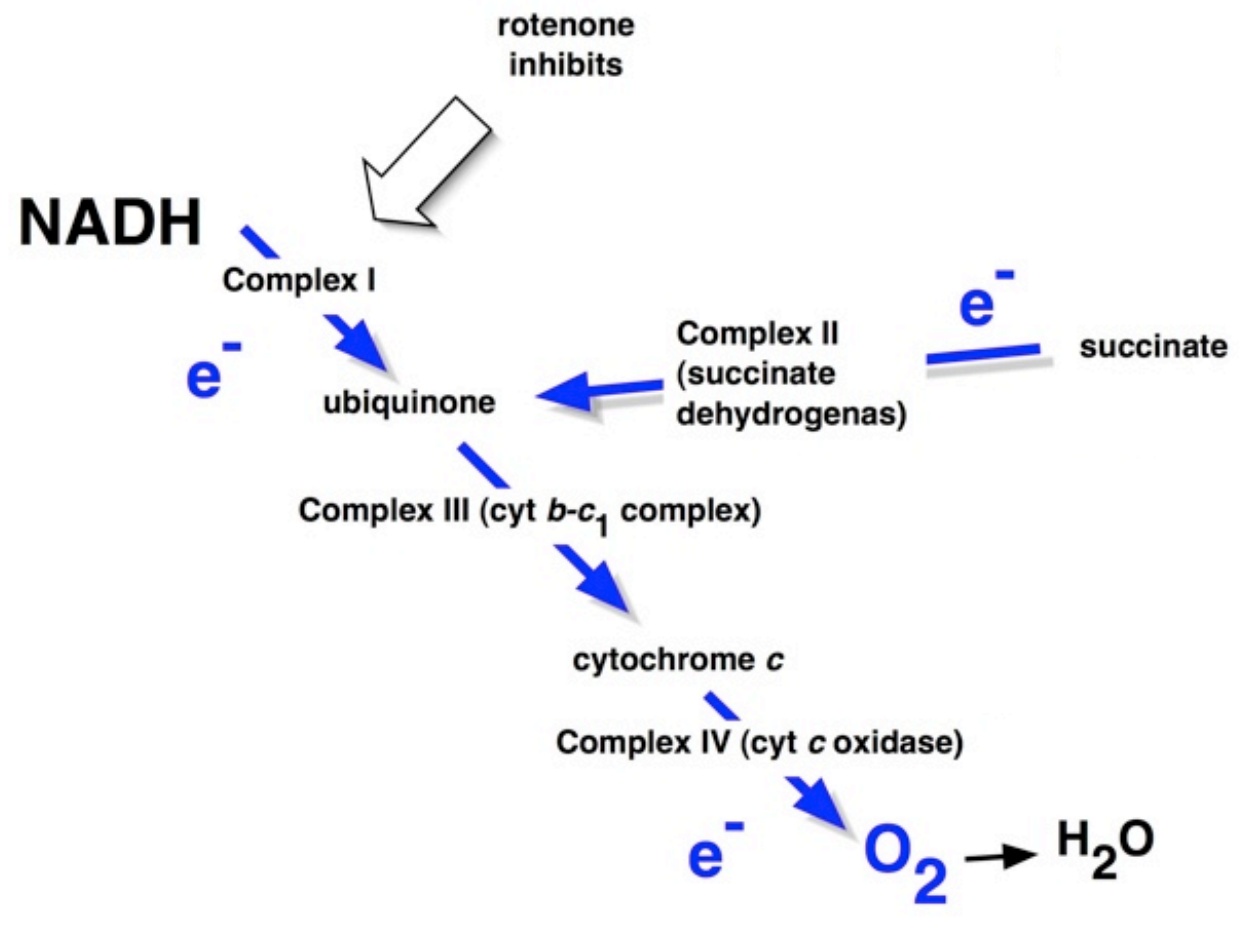
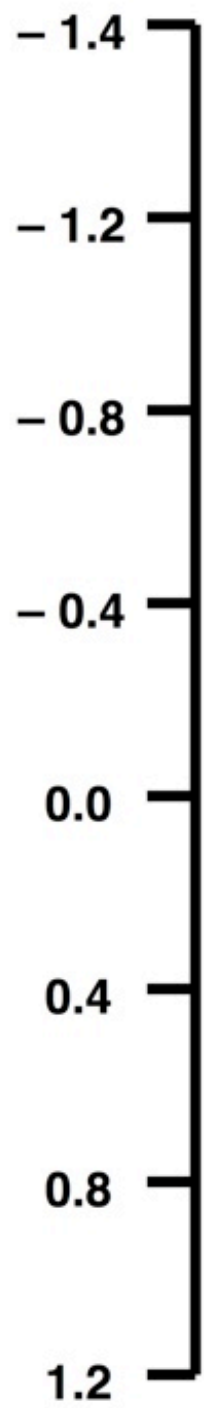
Prediction

Experimental results

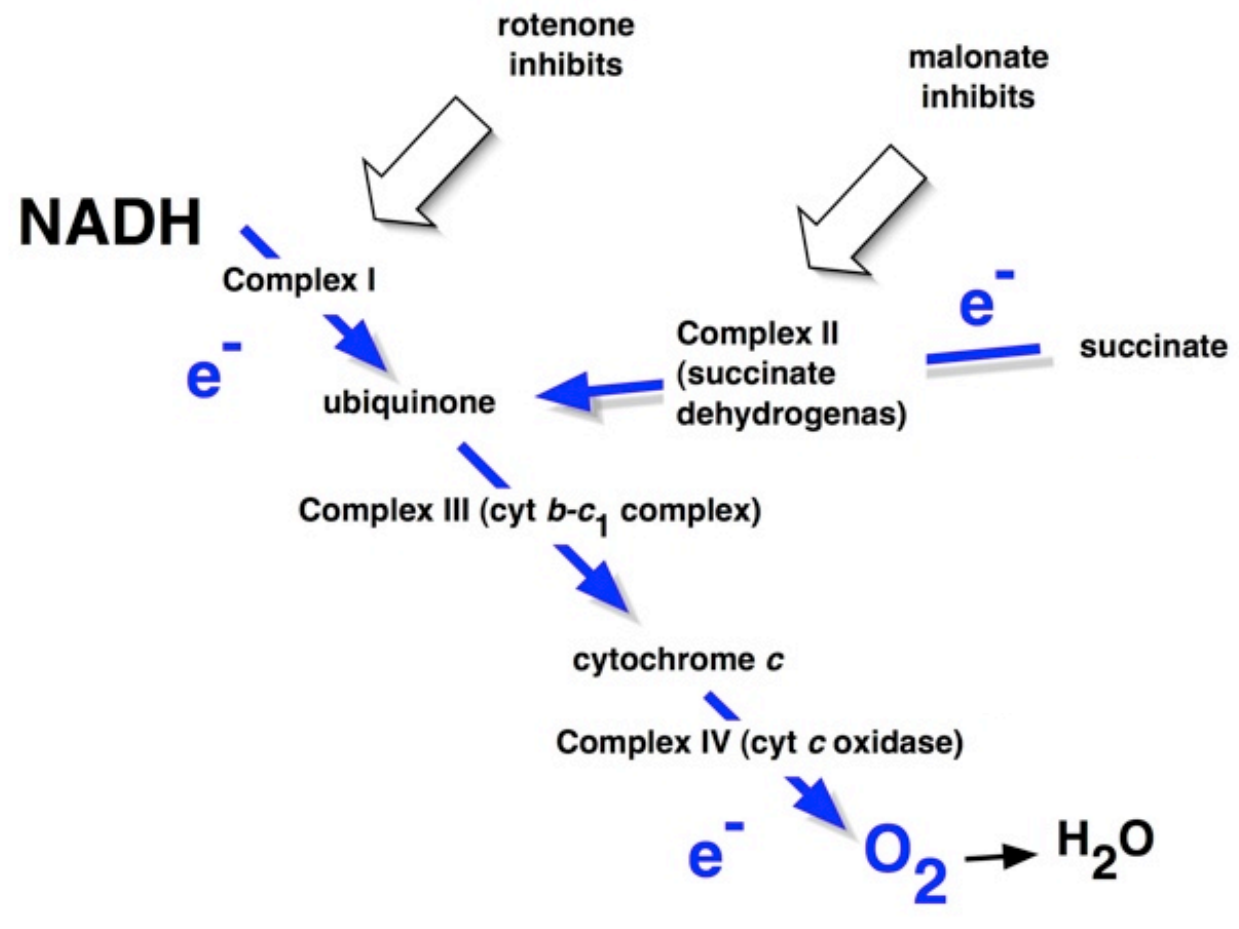
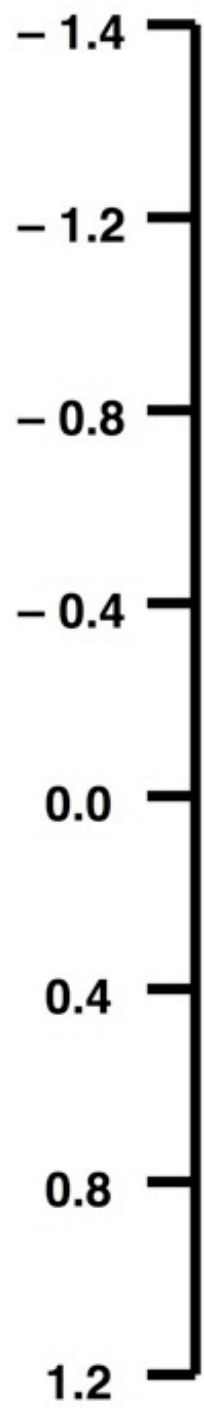
Redox control of mitochondrial and chloroplast gene expression



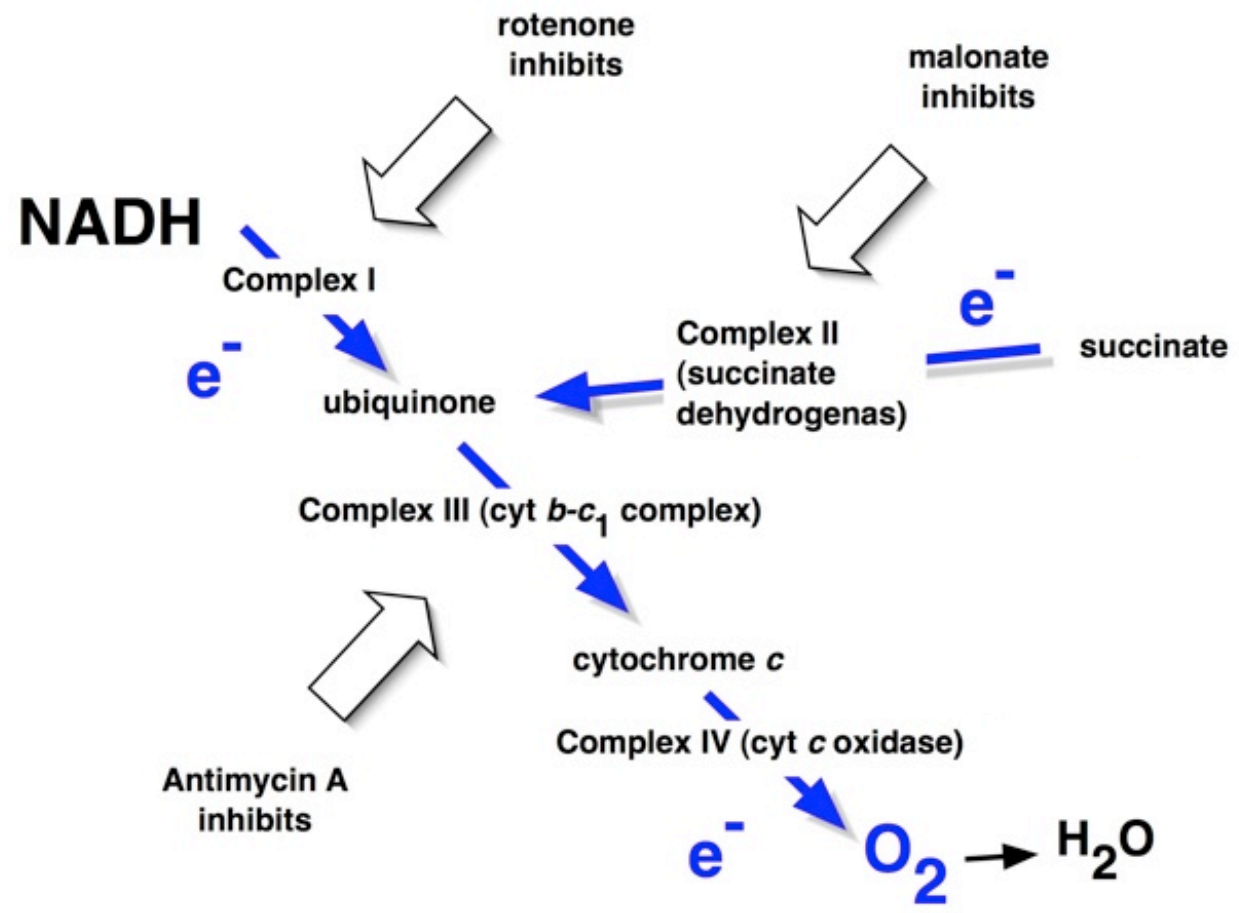
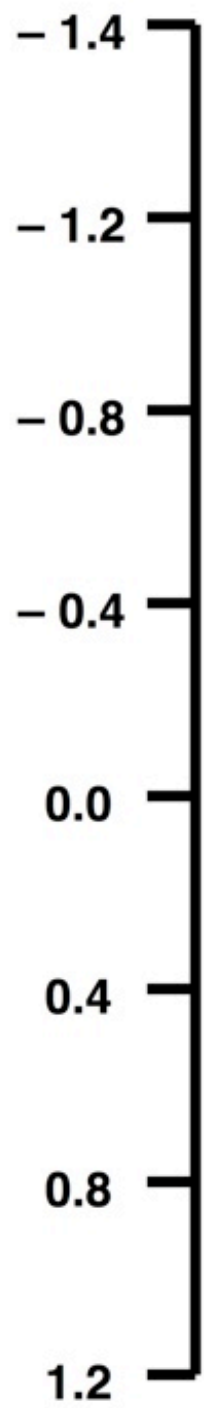
standard redox potential, volts



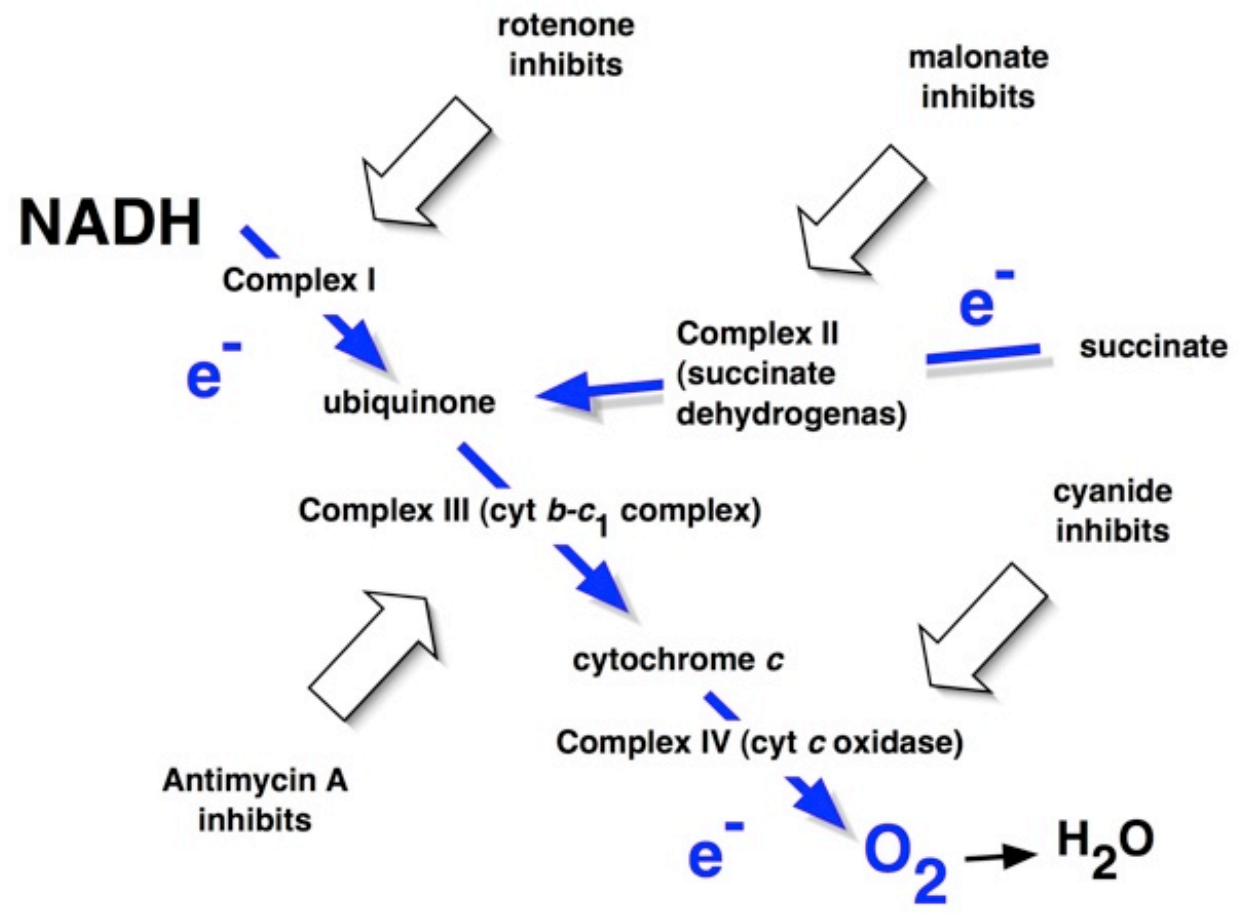
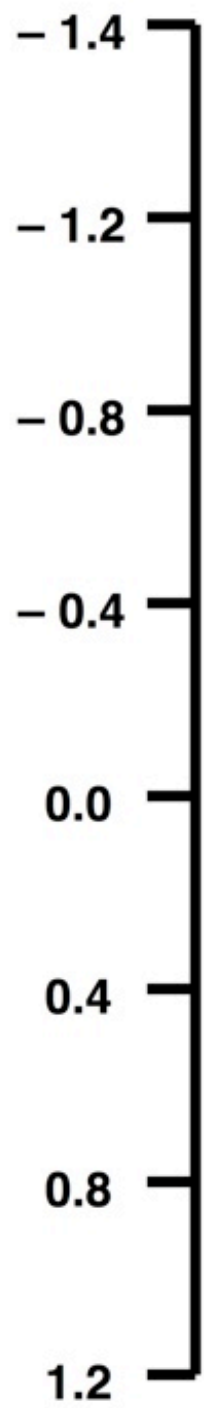
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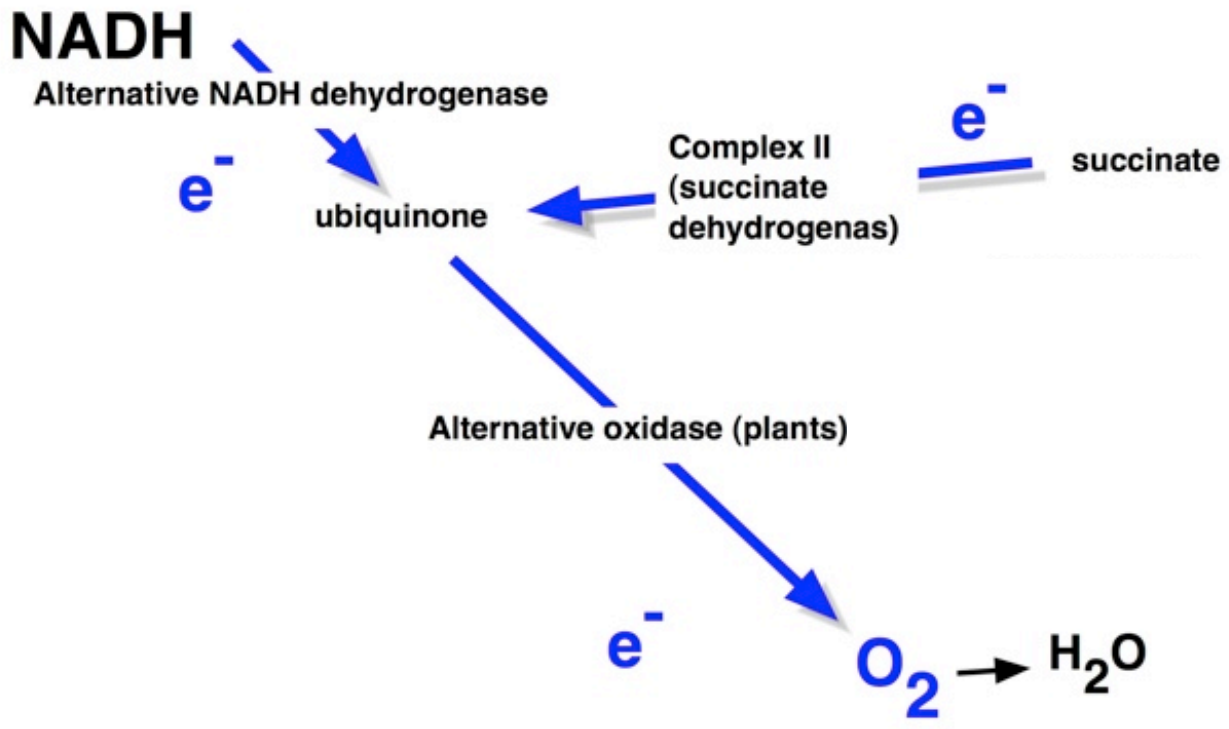
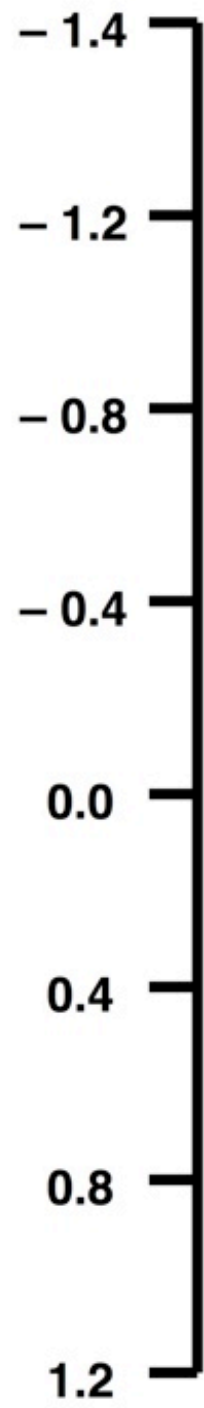
standard redox potential, volts



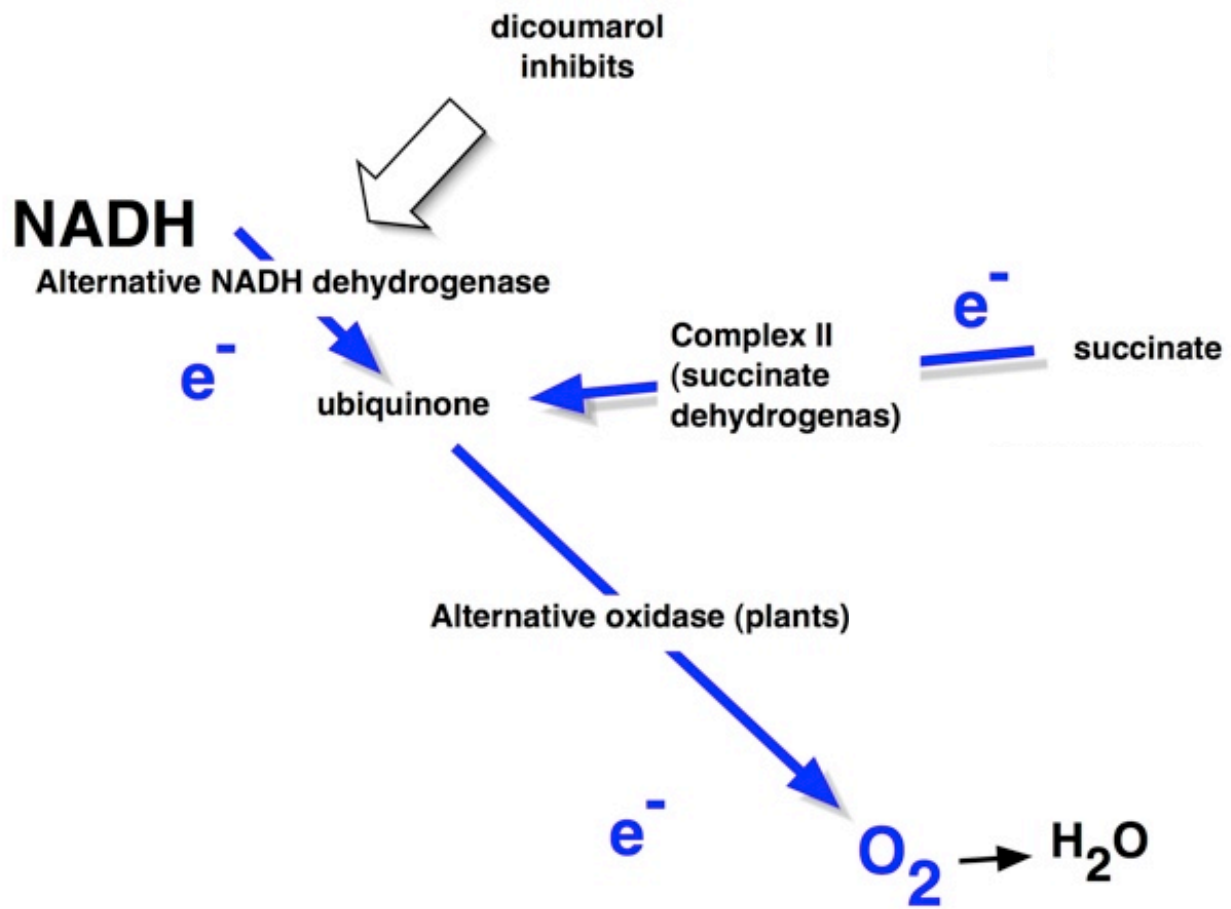
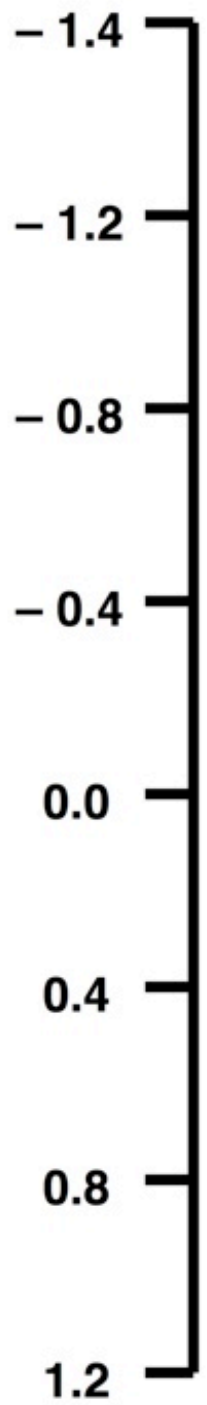
standard redox potential, volts



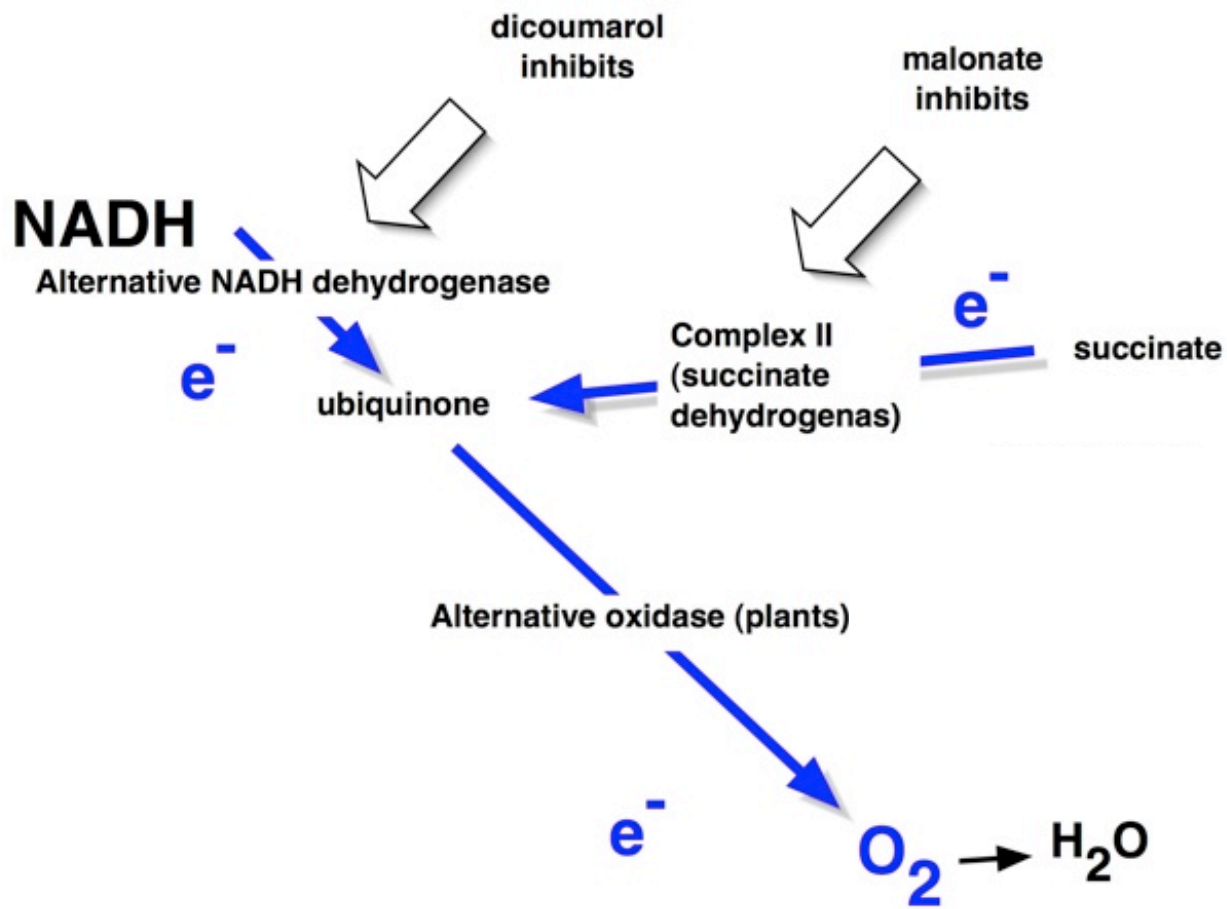
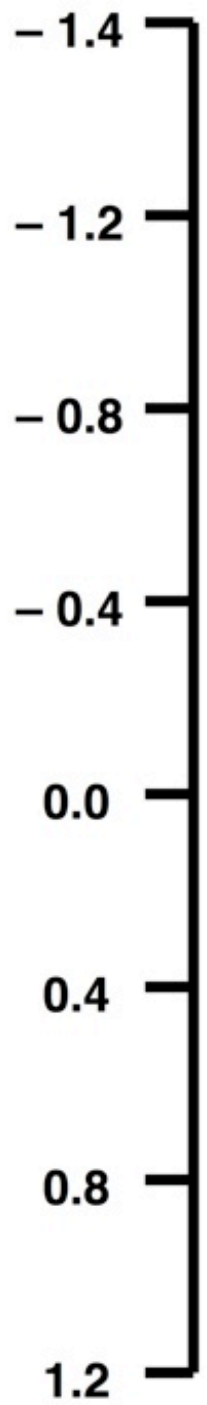
standard redox potential, volts



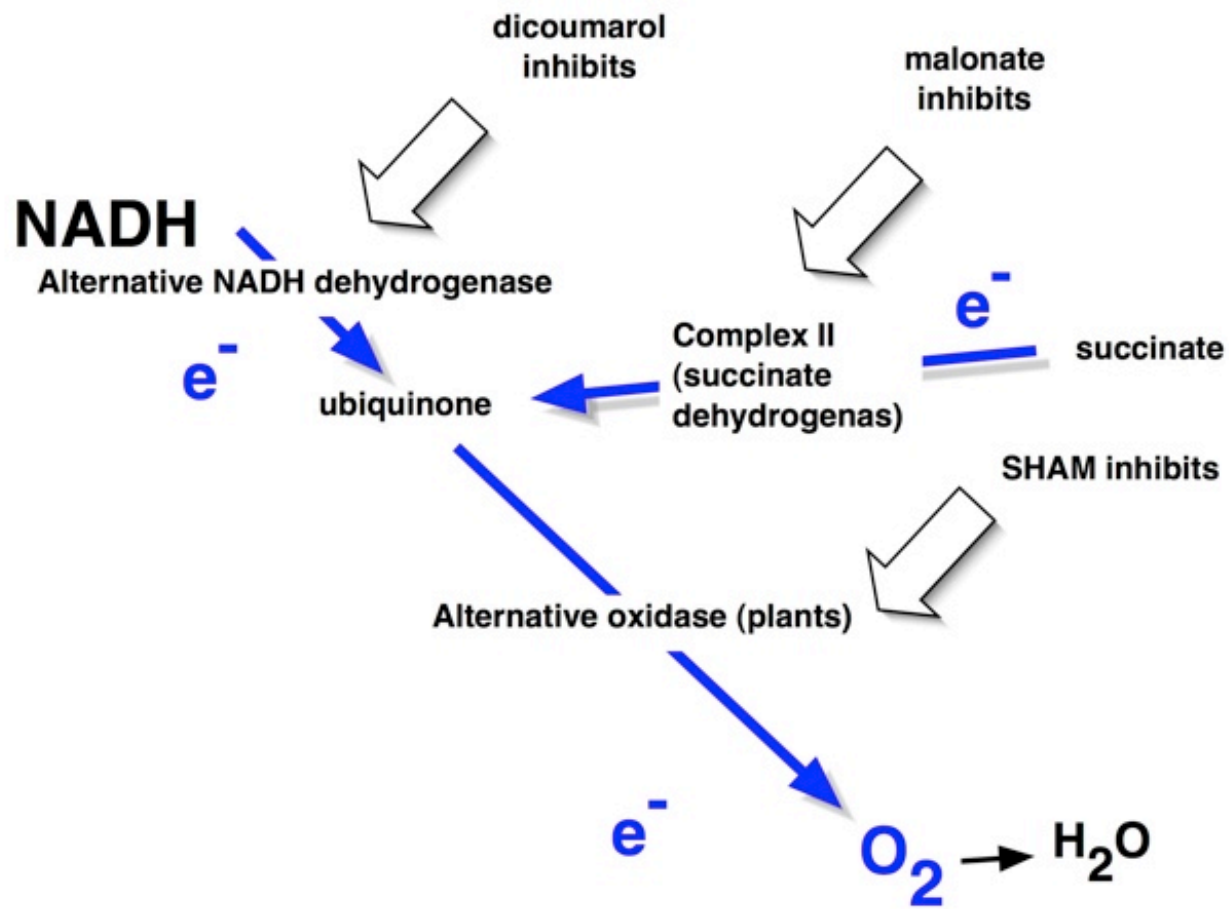
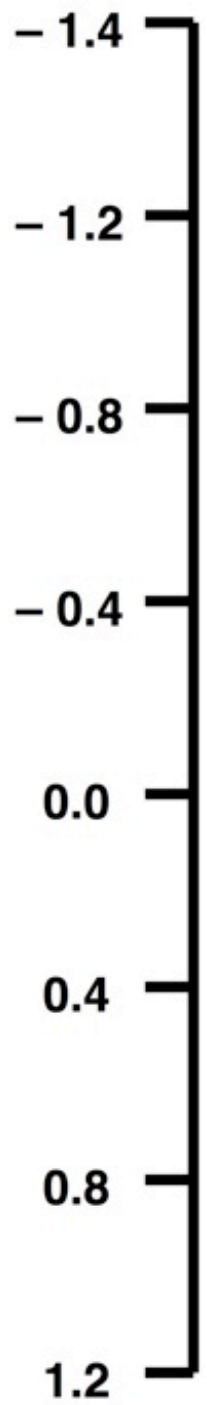
standard redox potential, volts



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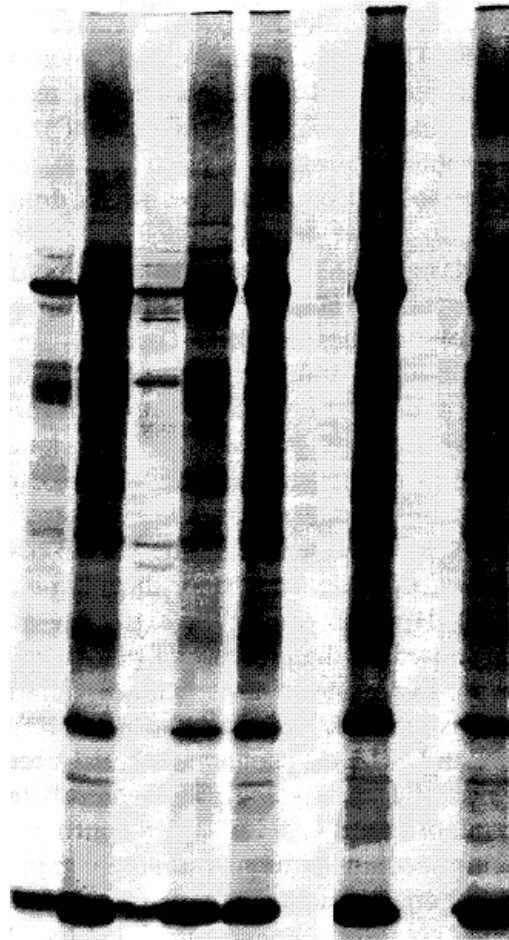


standard redox potential, volts



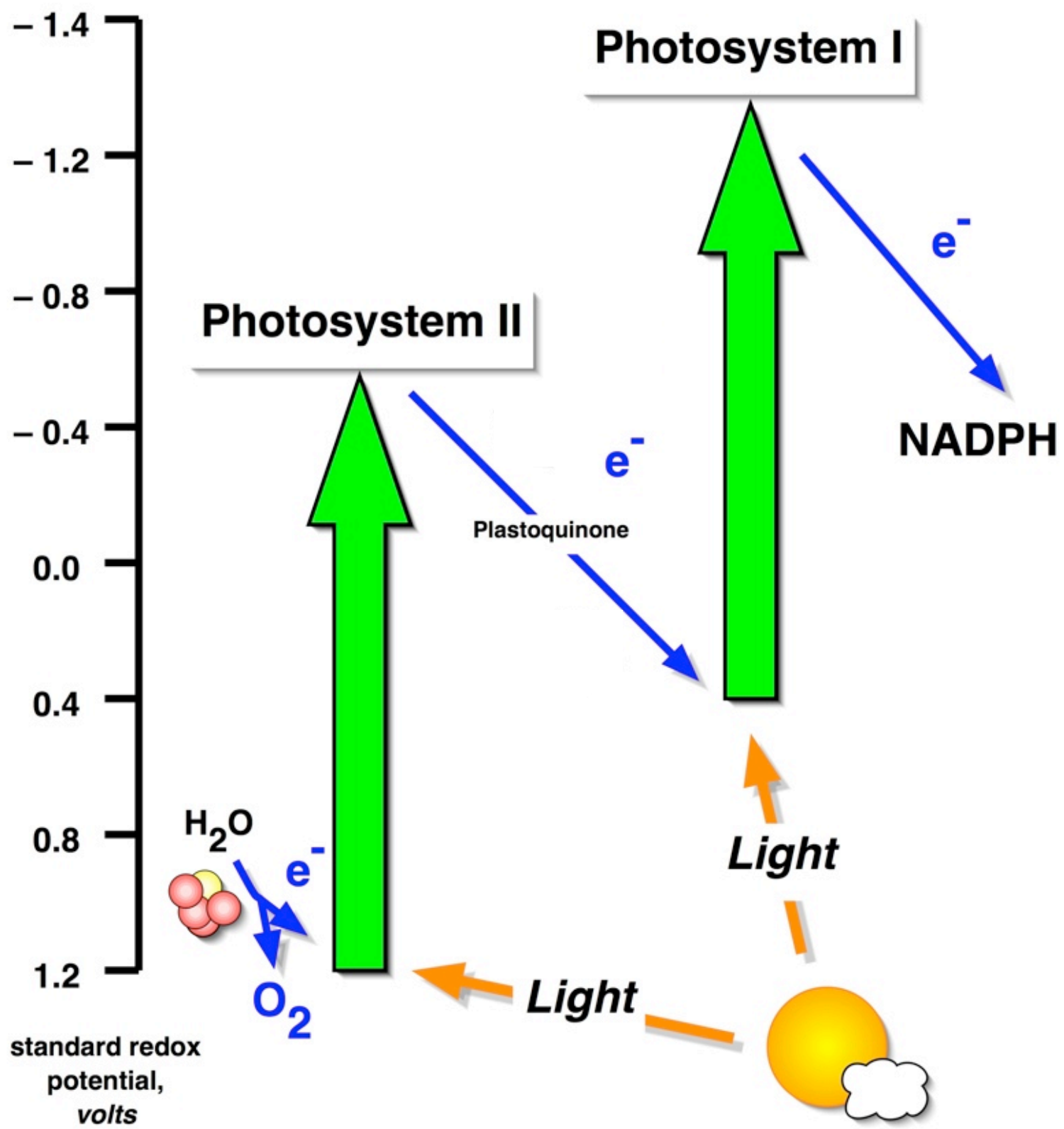
standard redox potential, volts

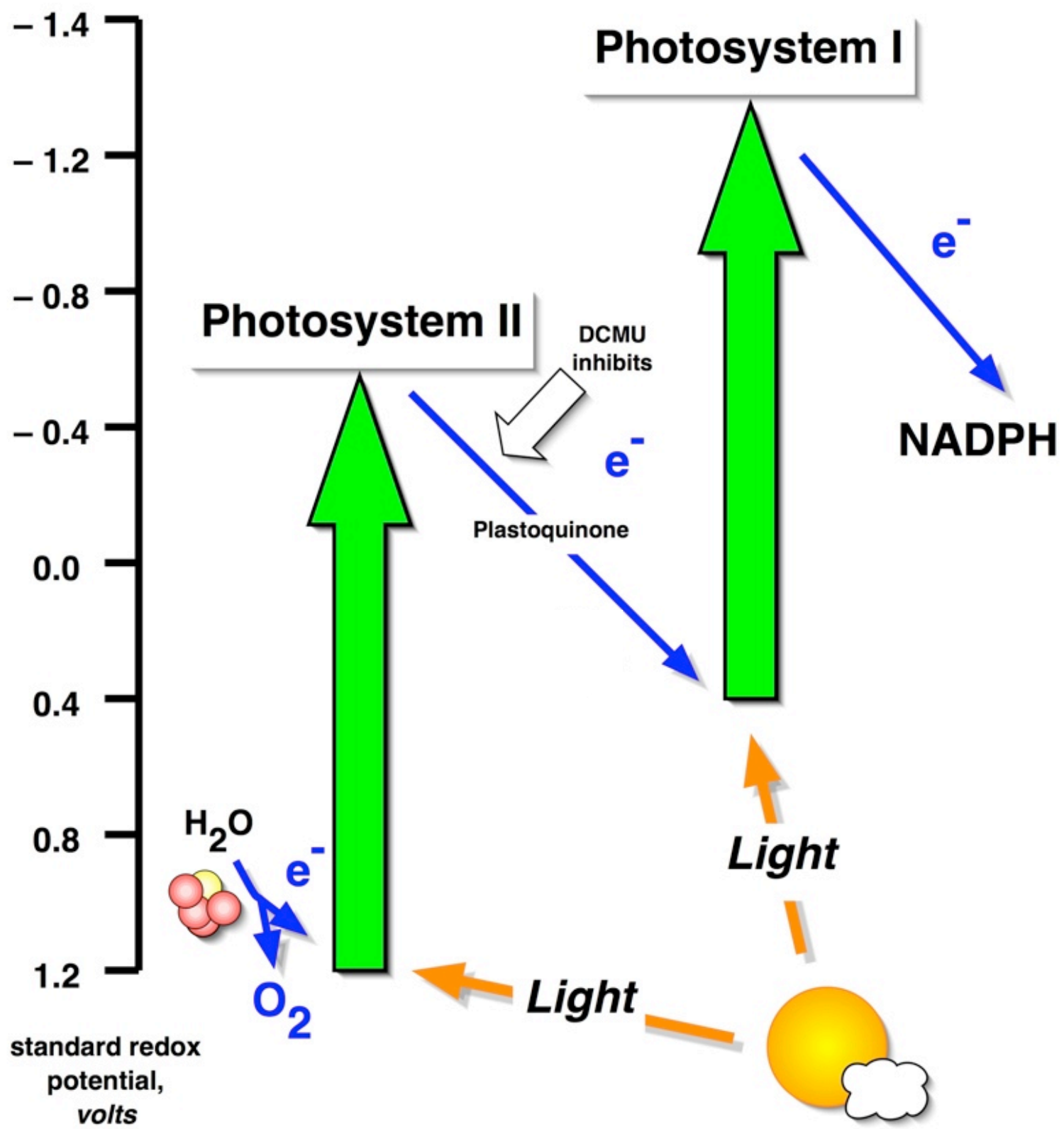
+ ferricyanide
 + ascorbate
 + dithiothreitol
 + dithionite
 + duroquinol
 + rotenone, malonate.,dicumarol
 + cyanide, SHAM

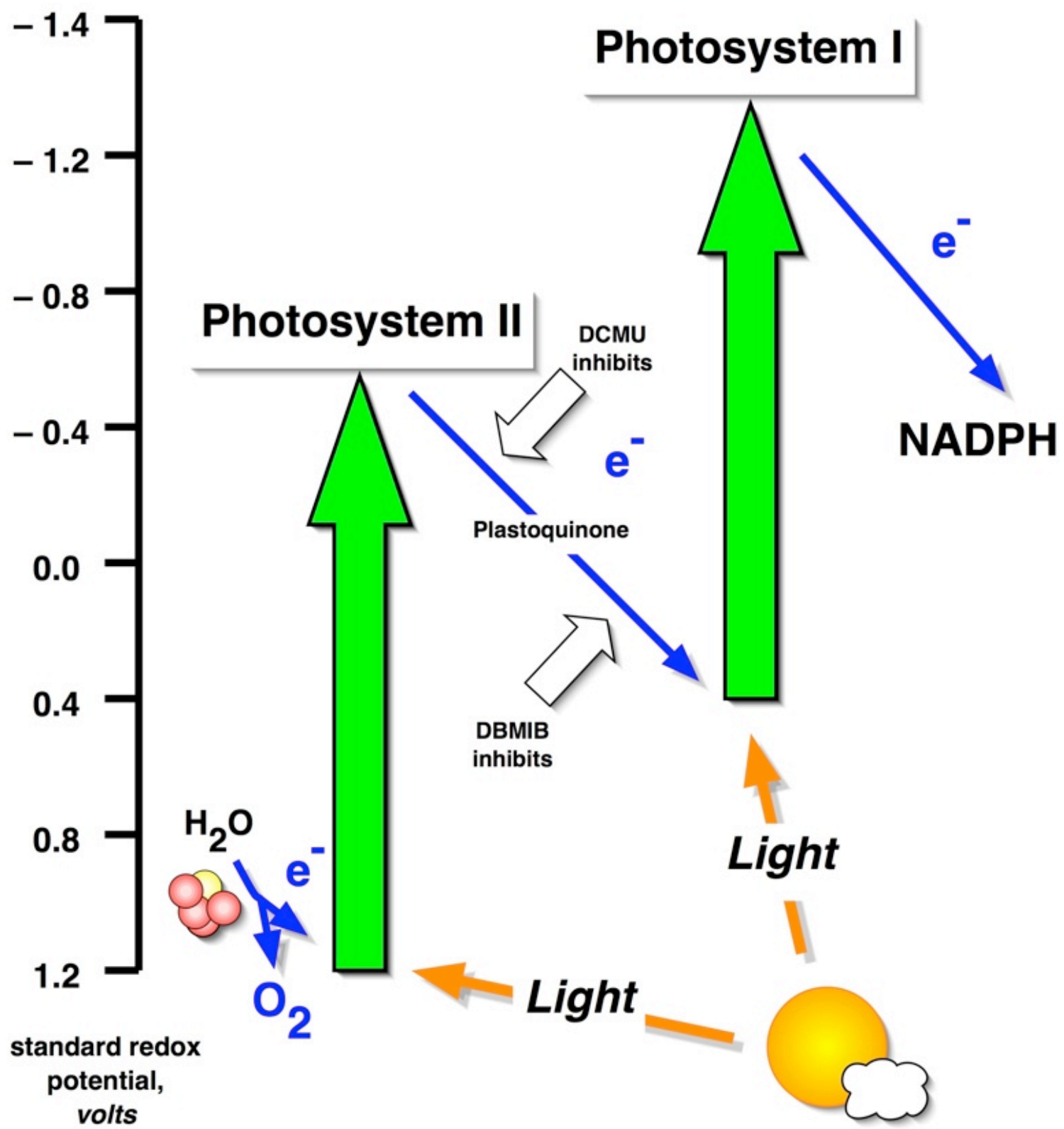


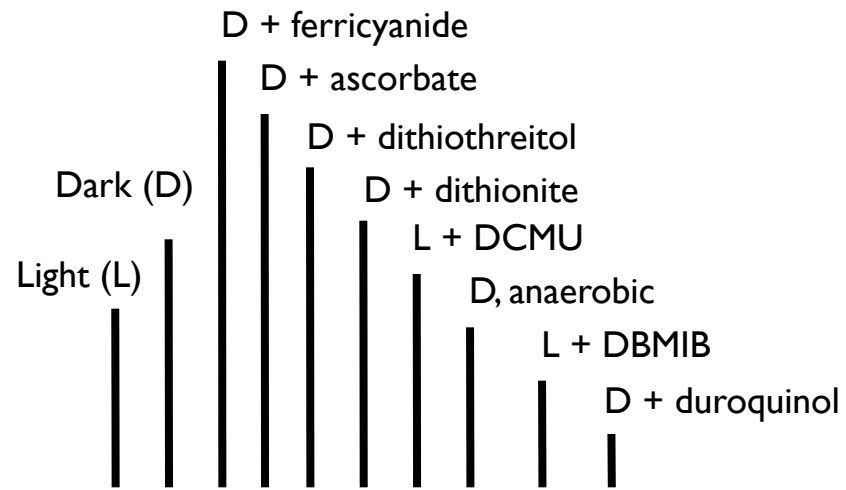
Allen, C.A. et al
 Redox Report 1, 119-123

³⁵S-methionine labelling of newly synthesised proteins in pea leaf mitochondria



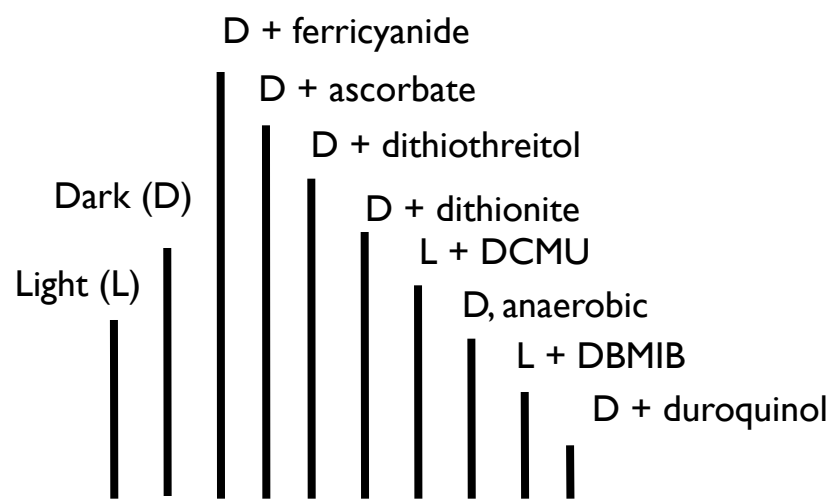






Allen, C.A. et al
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³⁵S-methionine labelling of newly synthesised proteins in pea leaf chloroplast stroma

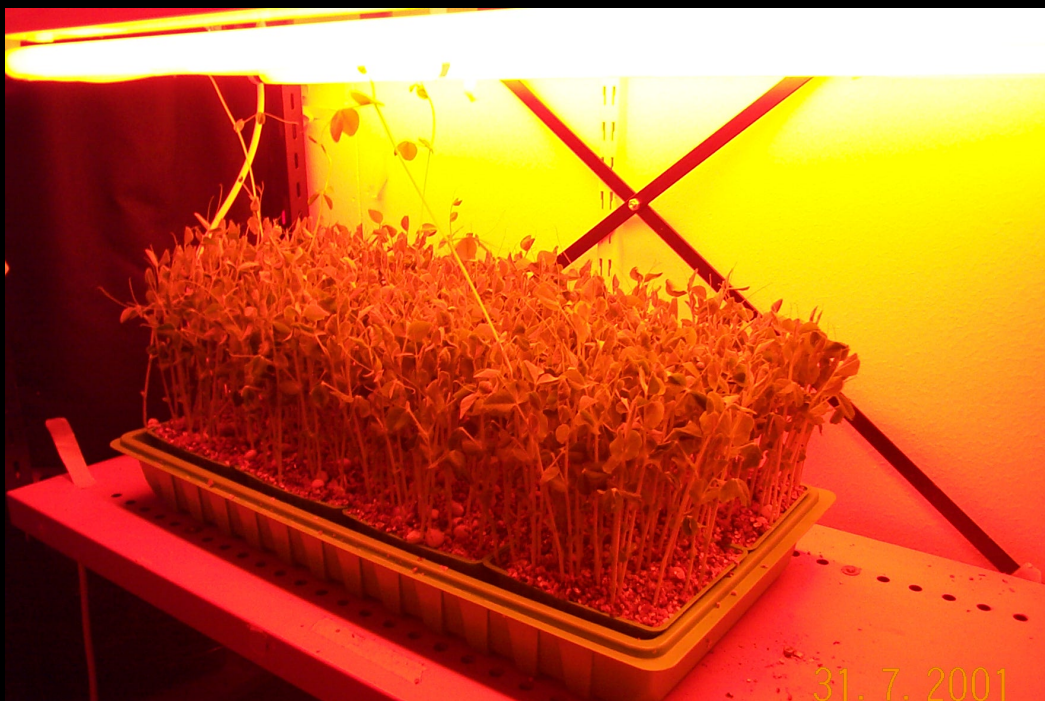
Co-location for Redox Regulation - CoRR

Prediction

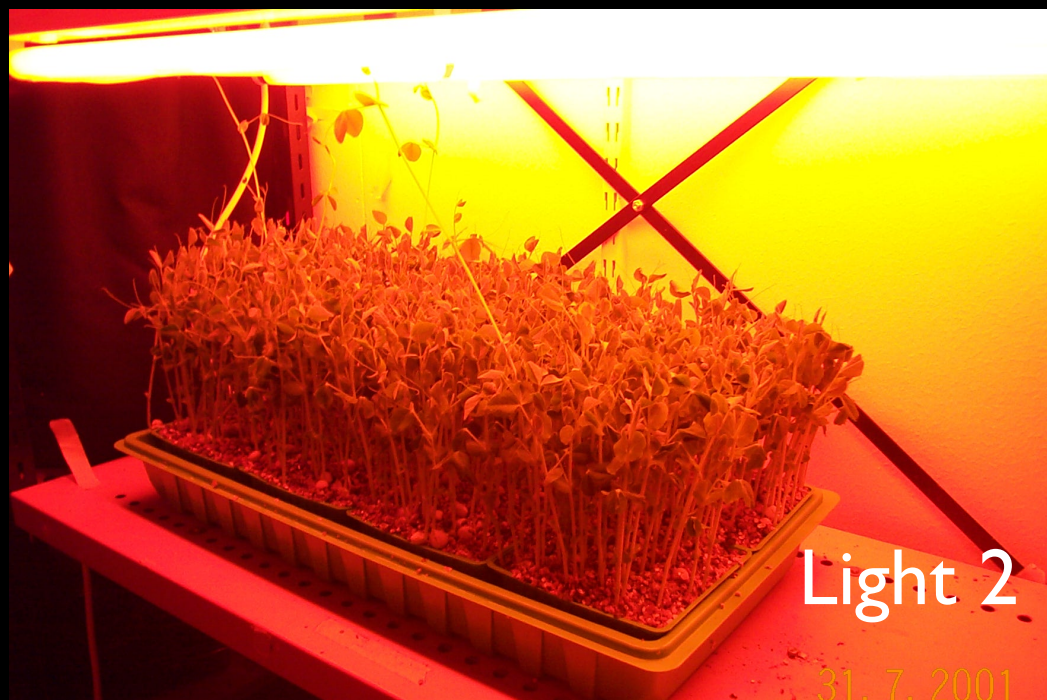
Experimental results

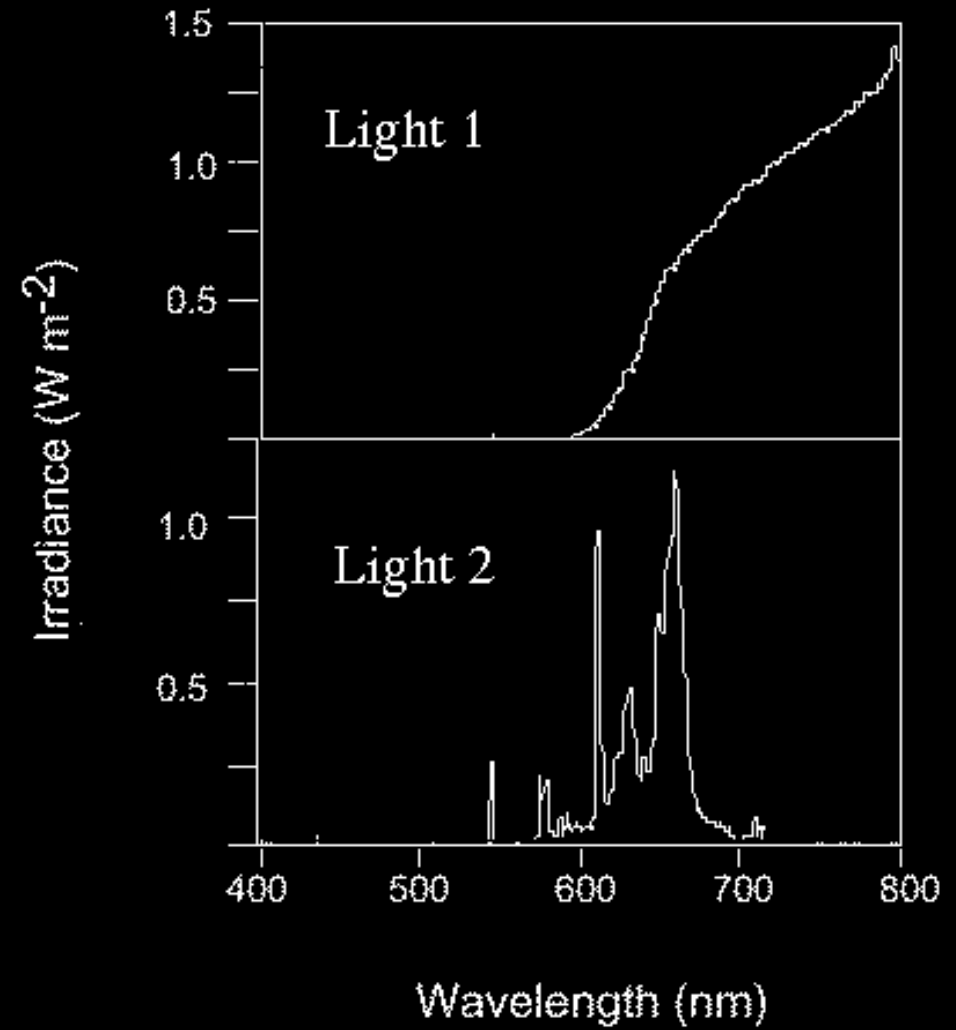
Redox control of chloroplast transcription

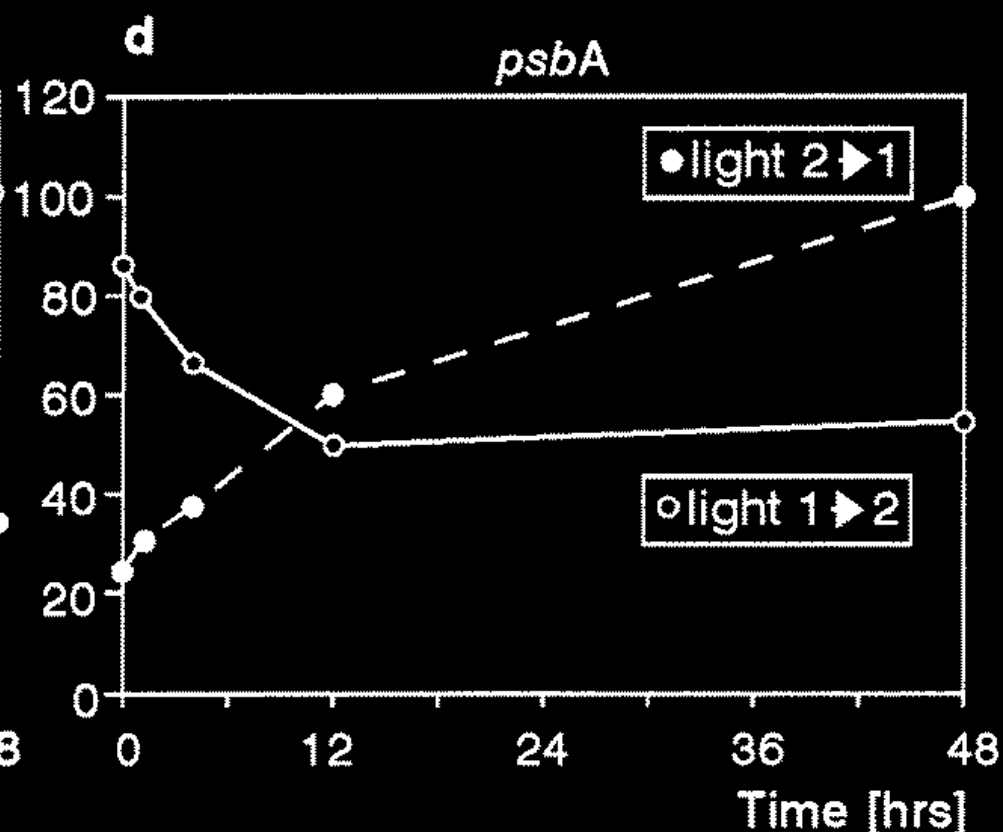
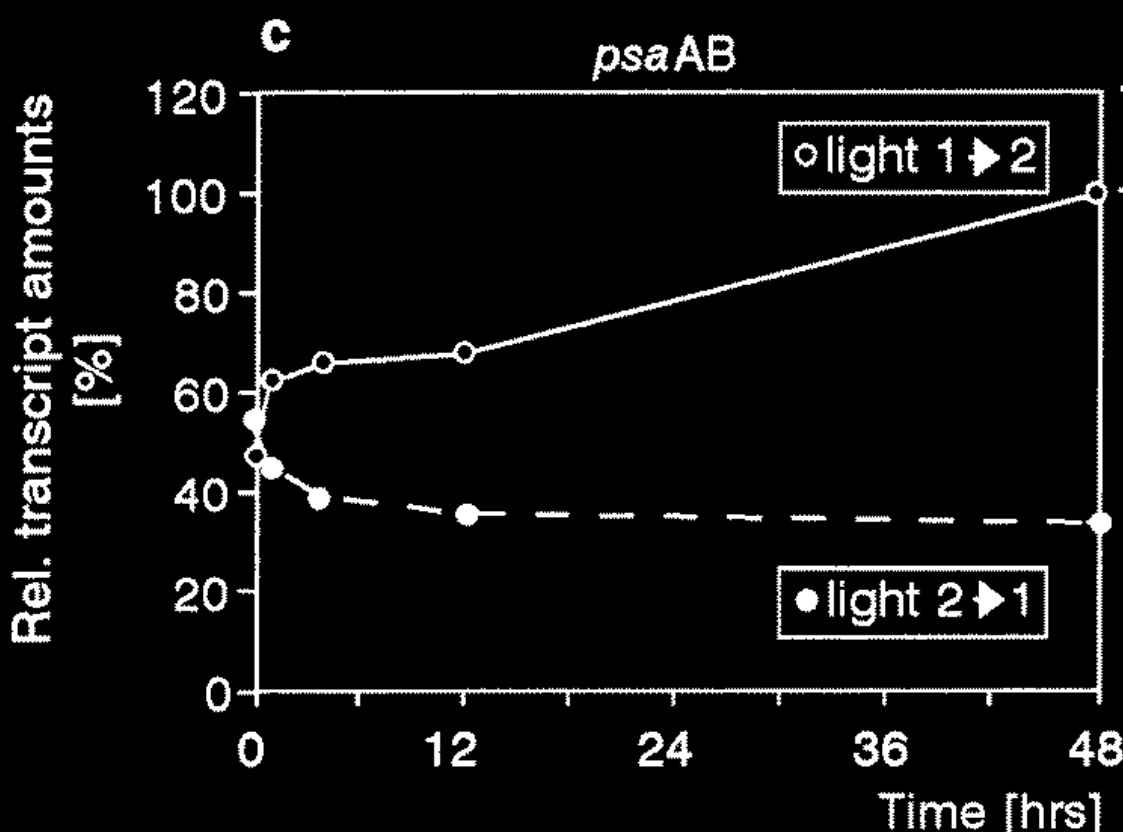
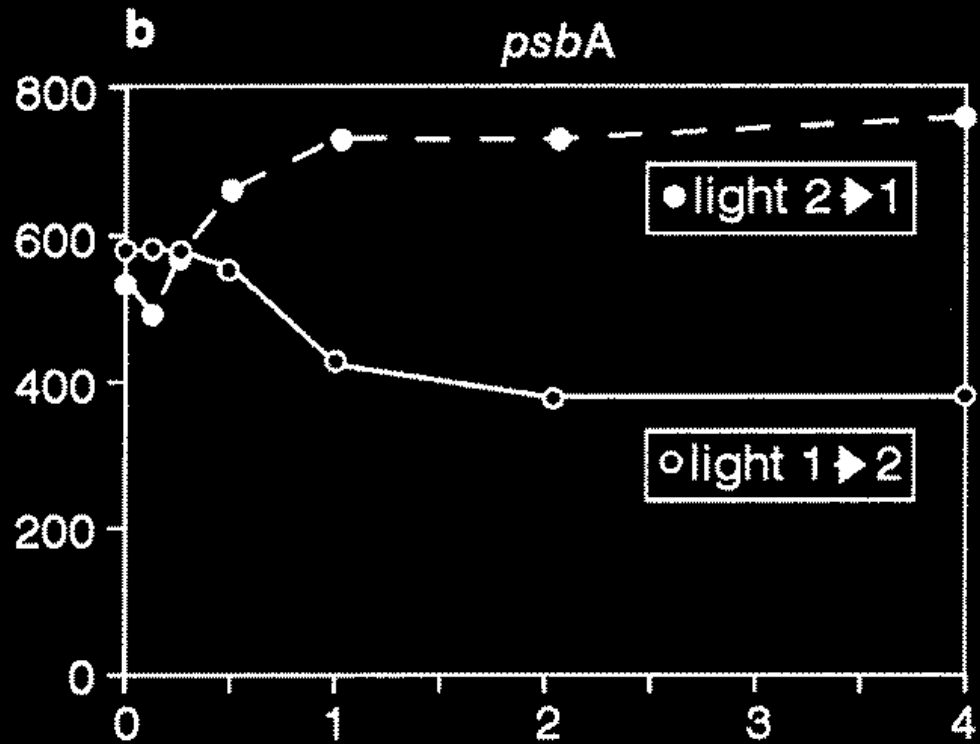
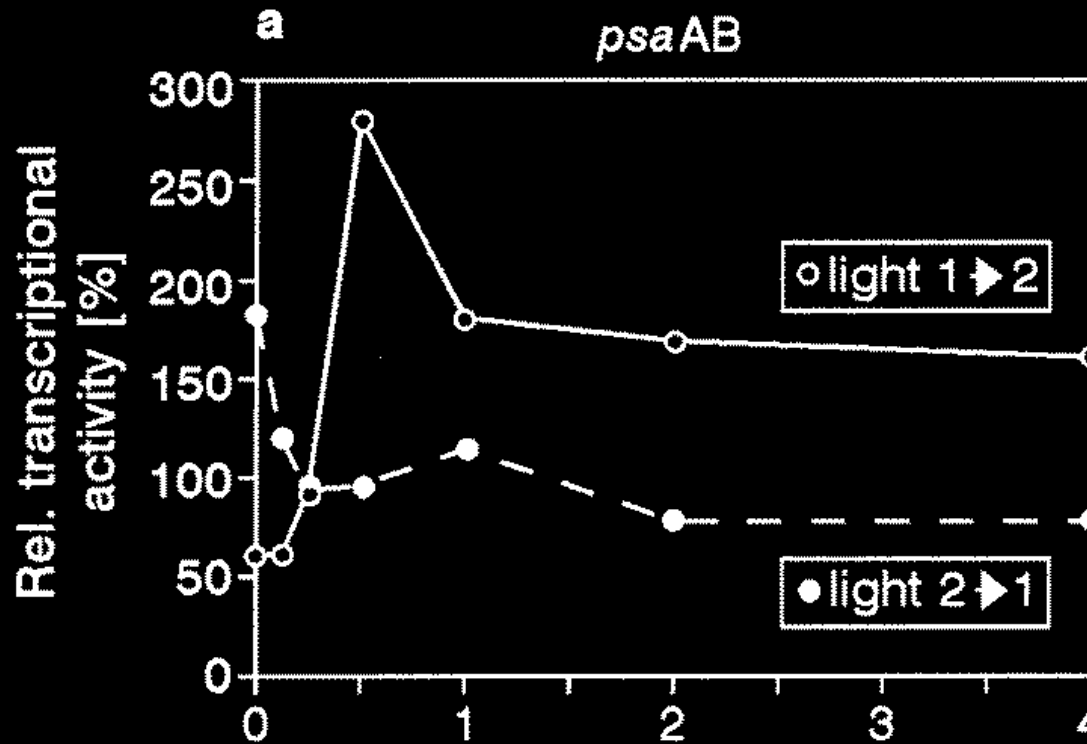










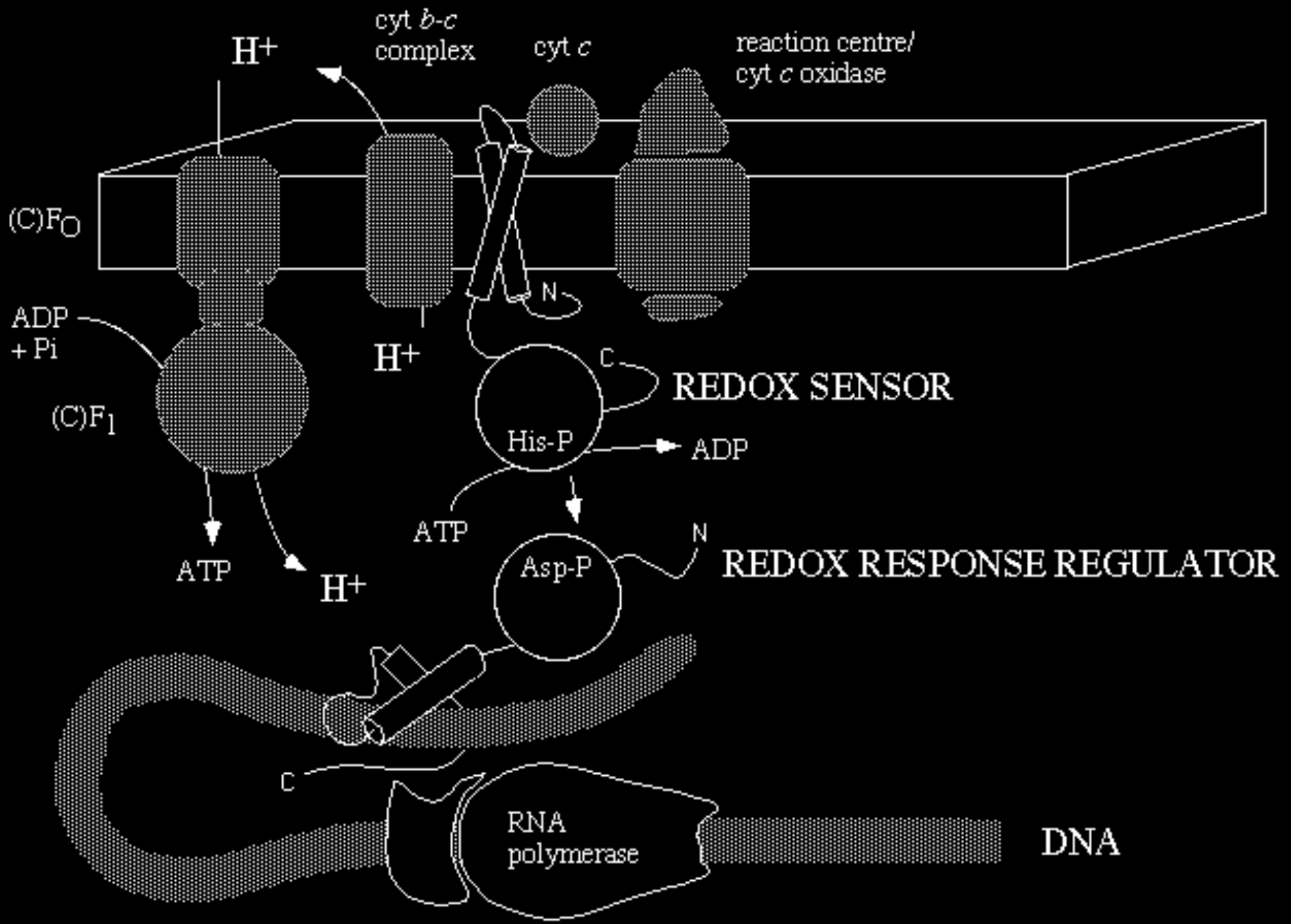


Co-location for Redox Regulation - CoRR

Prediction

Experimental results

Persistence of “bacterial” redox signalling components in chloroplasts and mitochondria



The ancestral symbiont sensor kinase CSK links photosynthesis with gene expression in chloroplasts

Sujith Puthiyaveetil*, T. Anthony Kavanagh[†], Peter Cain[‡], James A. Sullivan*, Christine A. Newell[§], John C. Gray[§], Colin Robinson[‡], Mark van der Giezen[¶], Matthew B. Rogers[¶], and John F. Allen*^{||}

*School of Biological and Chemical Sciences, Queen Mary, University of London, Mile End Road, London E1 4NS, United Kingdom; [†]Smurfit Institute of Genetics, Trinity College Dublin, Dublin 2, Ireland; [‡]Department of Biological Sciences, University of Warwick, Coventry CV4 7AL, United Kingdom; [§]Department of Plant Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EA, United Kingdom; and [¶]Centre for Eukaryotic Evolutionary Microbiology, School of Biosciences, University of Exeter, Exeter EX4 4QD, United Kingdom

Communicated by Elisabeth Gantt, University of Maryland, College Park, MD, April 25, 2008 (received for review February 15, 2008)

We describe a novel, typically prokaryotic, sensor kinase in chloroplasts of green plants. The gene for this chloroplast sensor kinase (CSK) is found in cyanobacteria, prokaryotes from which chloroplasts evolved. The CSK gene has moved, during evolution, from the ancestral chloroplast to the nuclear genomes of eukaryotic algae and green plants. The CSK protein is now synthesised in the cytosol of photosynthetic eukaryotes and imported into their chloroplasts as a protein precursor. In the model higher plant *Arabidopsis thaliana*, CSK is autophosphorylated and required for control of transcription of chloroplast genes by the redox state of an electron carrier connecting photosystems I and II. CSK therefore provides a redox regulatory mechanism that couples photosynthesis to gene expression. This mechanism is inherited directly from the cyanobacterial ancestor of chloroplasts, is intrinsic to chloroplasts, and is targeted to chloroplast genes.

limited to a few examples in certain nongreen algal groups, where there are just one or two two-component genes of uncertain function in the chloroplast genome itself (8).

Author contributions: S.P. and J.F.A. designed research; S.P., T.A.K., P.C., C.A.N., and J.F.A. performed research; S.P., T.A.K., J.A.S., and M.v.d.G. contributed new reagents/analytic tools; S.P., T.A.K., P.C., J.C.G., C.R., M.v.d.G., M.B.R., and J.F.A. analyzed data; and S.P. and J.F.A. wrote the paper.

The authors declare no conflict of interest.

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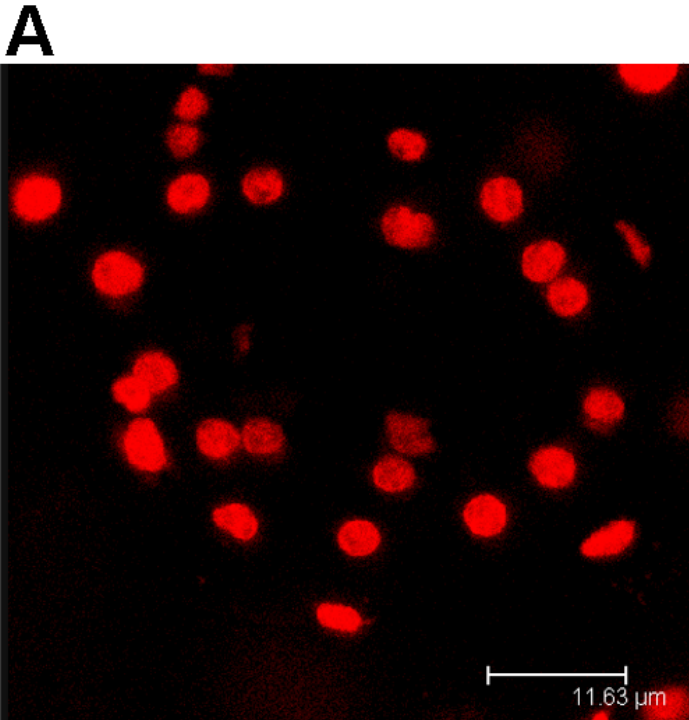
^{||}To whom correspondence should be addressed. E-mail: j.f.allen@qmul.ac.uk.

This article contains supporting information online at www.pnas.org/cgi/content/full/0803928105/DCSupplemental.

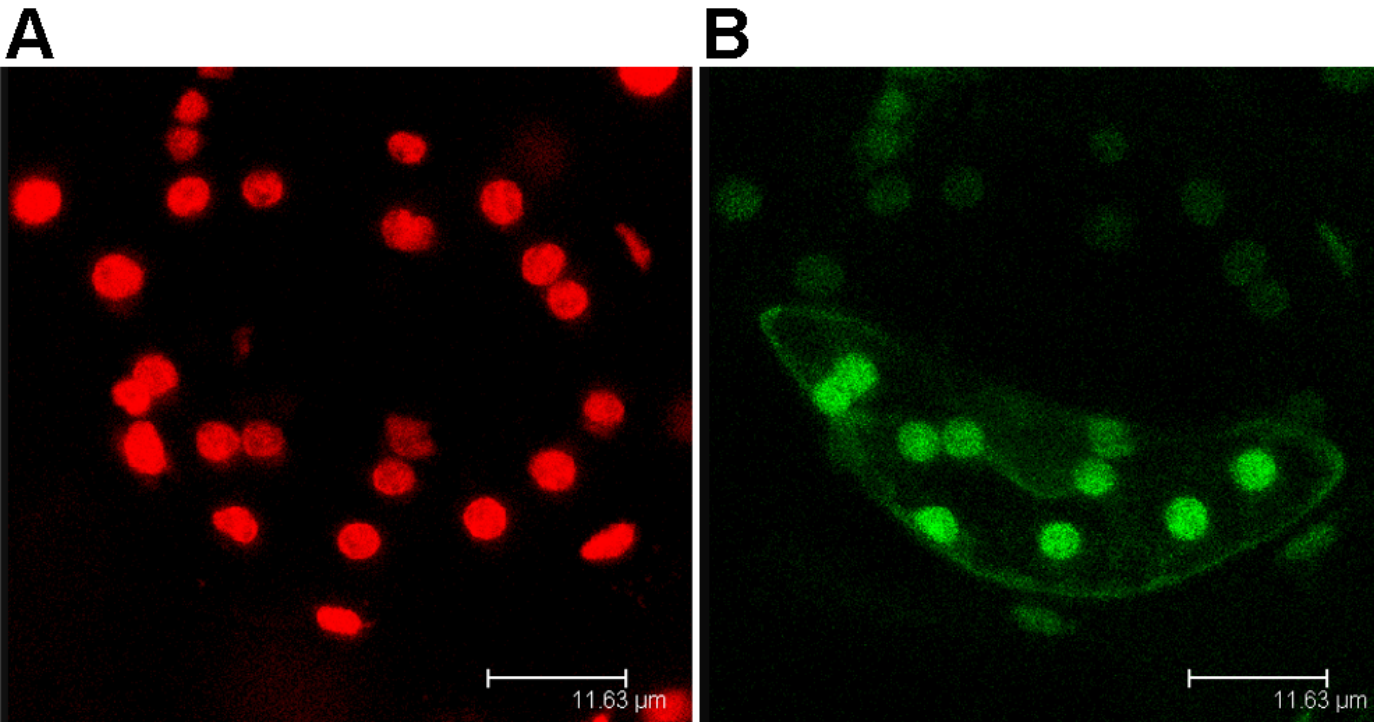
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CSK

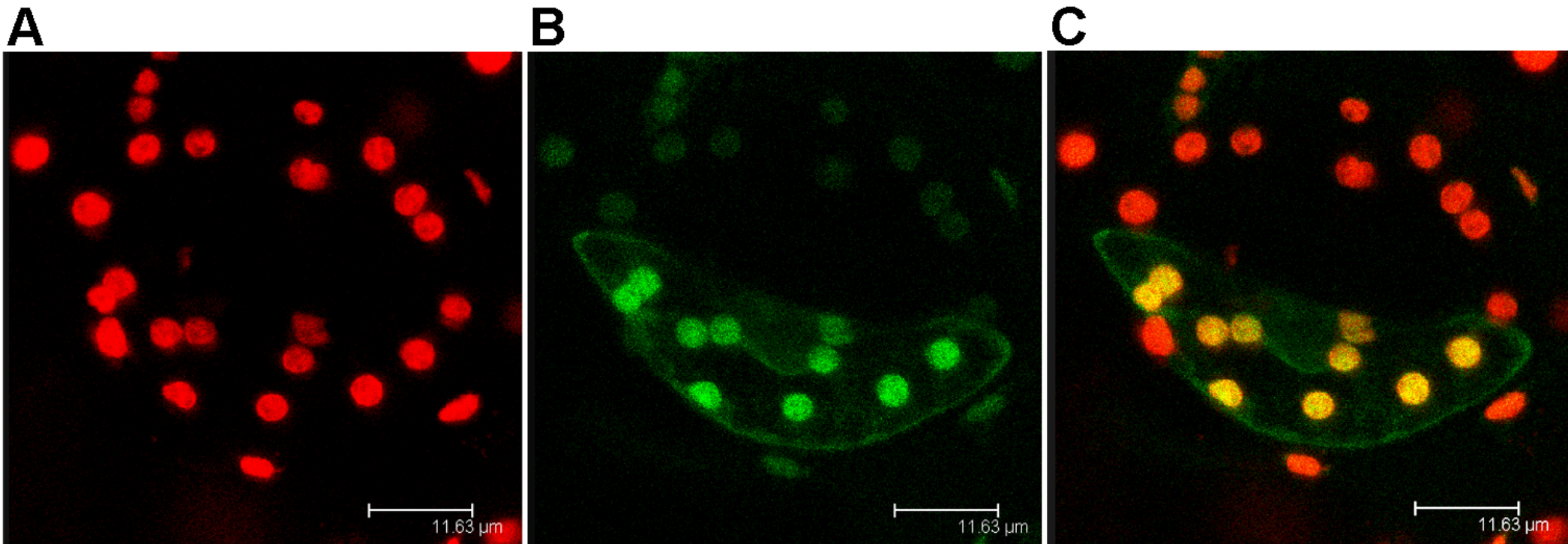
- **C**hloroplast **S**ensor **K**inase
- A Histidine sensor kinase homologous with Hik2 of cyanobacteria
- *A Redox Sensor*
- Sujith Puthiyaveetil



Puthiyaveetil S, Kavanagh TA, Cain P, Sullivan JA, Newell CA, Gray JC, Robinson C, van der Giezen M, Rogers MB, Allen JF (2008) The ancestral symbiont sensor kinase CSK links photosynthesis with gene expression in chloroplasts. *Proceedings of the National Academy of Sciences of the United States of America* 105: 10061-10066.

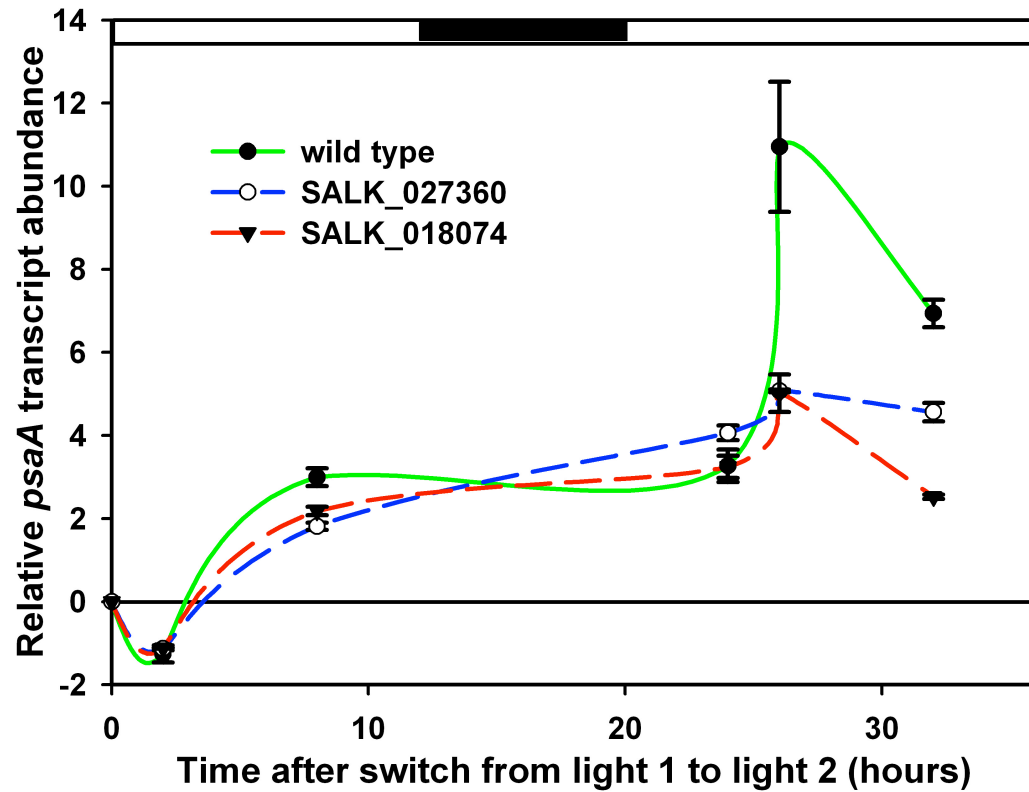


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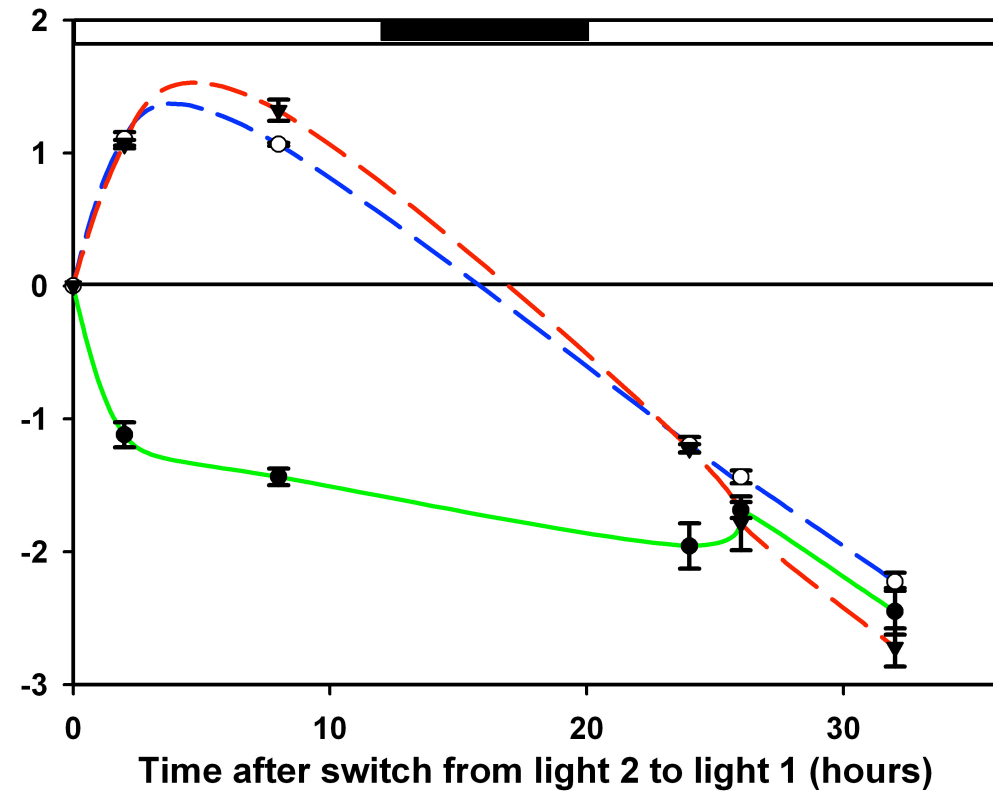


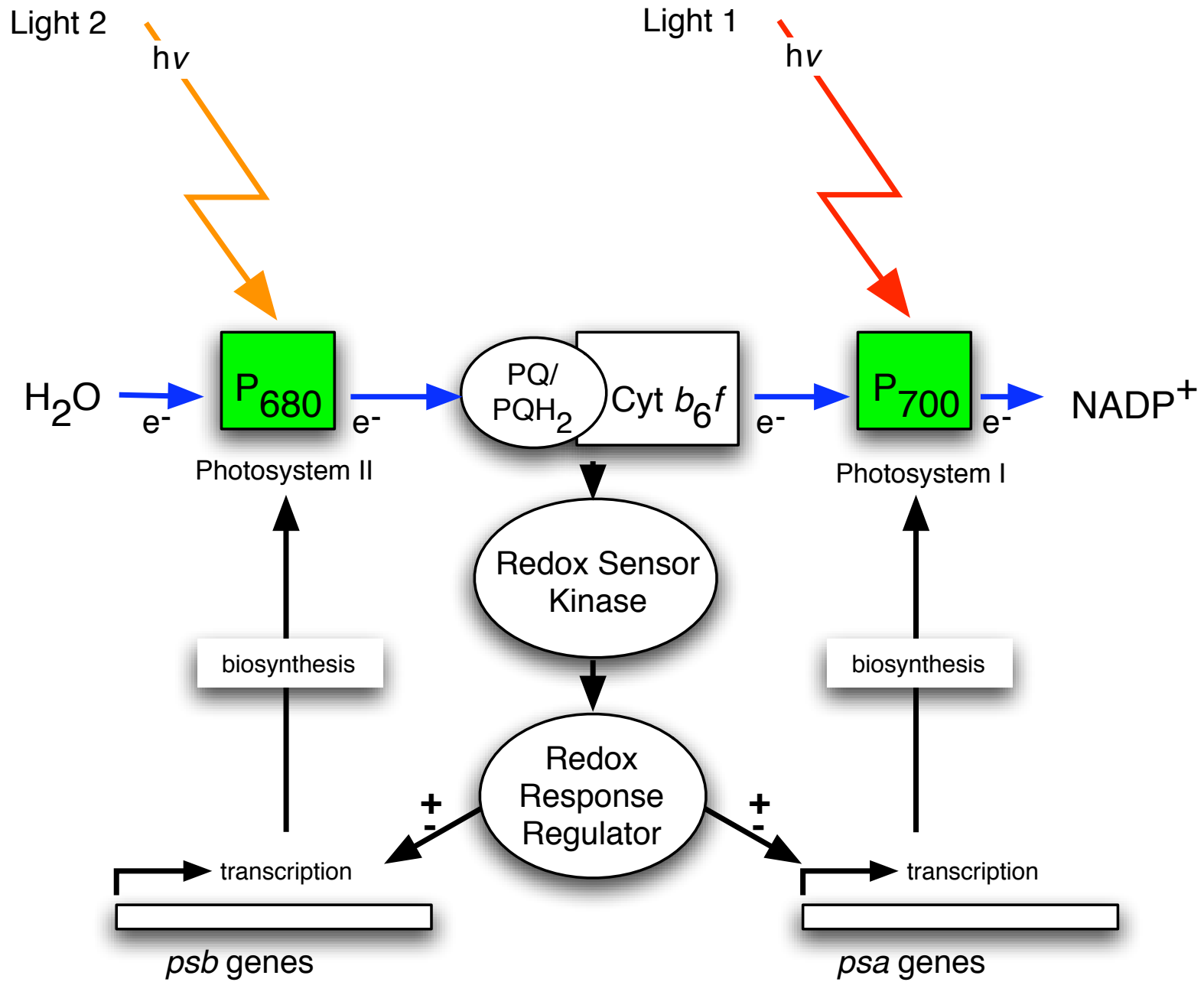
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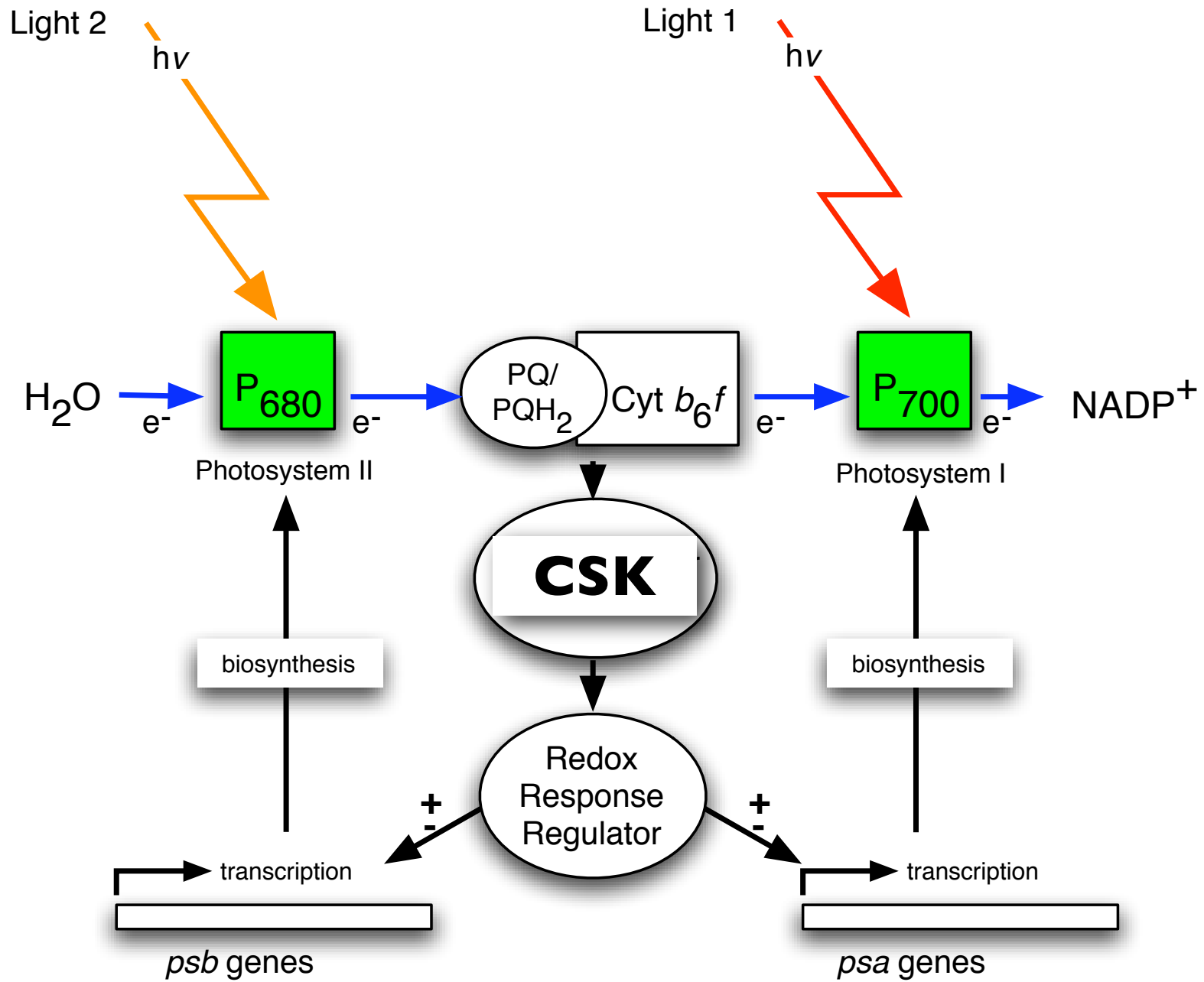
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Lecture 6

Mitochondria, ageing, and sex – energy versus fidelity

