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NEWS REPORT

Honoring Jean-David Rochaix

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Abstract We honor Jean-David Rochaix, an outstanding scholar of chloroplast biogenesis and photosynthesis, who received the prestigious Lifetime Achievement Award of the International Society of Photosynthesis Research at its 17th International Photosynthesis Congress held in Maastricht, The Netherlands (August 5–12, 2016). With this award he joins other major discoverers in the field of photosynthesis: Pierre Joliot (of France, 2013); Ulrich W. Heber* (of Germany, 2010) and Kenneth Sauer (of USA, 2010); Jan M. Anderson* (of Australia, 2007); and Horst T. Witt* (of Germany, 2004). See "Appendix 1" for the list of those who have received the ISPR Communication, Innovation, Calvin–Benson, and Hill awards.

Keywords Photosynthesis · Chloroplast · Biogenesis · Chlamydomonas · State transitions

*Ulrich Wolfgang Heber (October 25, 1930–June 12, 2016); Joan (Jan) Mary Anderson (13 May 13, 1932–August 28, 2015); Horst Tobias Witt (March 1, 1922–May 14, 2007).

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Jean-David Rochaix and his contributions

A visit to Rochaix's web site (http://www.molbio.unige.ch/eng/research_groups/rochaix/lab) reminds us that "a unique feature of plant and algal cells is that they contain three distinct genetic systems located in the nucleus, chloroplast and mitochondria. These systems contain their own genome and protein- synthesizing machineries." Jean-David Rochaix has intensively investigated the molecular interactions between the chloroplast and nucleo-cytosolic systems that are critical for the assembly and function of the photosynthetic apparatus. He has also studied the remarkable ability of photosynthetic organisms to adapt to changes in both light quality and quantity, and in particular the dynamic acclimation processes that occur in the thylakoid membranes.

Figure 1 shows a photograph of Jean-David Rochaix (in the center), together with the authors (Govindjee, on the left, and Kevin Redding, on the right) at the International Congress in Maastricht, The Netherlands.

When the officers of ISPR (Richard Cogdell, President; John Golbeck, Treasurer; and Kevin Redding, Secretary, one of the authors) announced the award to Rochaix, at the International Congress in Maastricht, The Netherlands, they quoted from the many people who had nominated him to the chair of the selection committee (A. William Rutherford, Past President of ISPR).

Excerpts from the nominators

- The brilliant scientific career of Jean-David Rochaix and his numerous contributions to the field of photosynthesis clearly testify to his scientific qualities.

Fig. 1 A photograph of Jean-David Rochaix with Govindjee (on the *left*) and Kevin Redding (on the *right*), at the 17th International Photosynthesis Congress, in Maastricht, The Netherlands. Two additional photographs of Jean-David Rochaix, while attending a 2013 international conference, is shown in the Supplementary Material

- Jean-David started by pioneering chloroplast gene identification and chloroplast gene transformation, then he firmly set the ground for our current understanding of chloroplast biogenesis with the identification of nuclear control on chloroplast gene expression.
- More recently, he advanced the field of functional regulation of photosynthesis and set a new stage for the mechanism of *state transitions*, with his most elegant identification of the major kinases involved, both in algae and plants.
- Looking back on his 40 years of photosynthesis-related discoveries, it is evident that Jean-David Rochaix is a visionary scientist, with his consistent identification of some of the major challenges in the field, as they appeared over time.
- Some of his most striking qualities are his broad vision of the most pertinent scientific questions, his fine intuition of how to approach them, his high standard of quality in obtaining and interpreting data, and his communicative enthusiasm for the pursuit of science.

A brief biography

Jean-David's father Michel Rochaix was an agronomist and had directed an agronomy research center near Geneva, Switzerland. His mother, Simone Rochaix, was a nurse. He has an older brother, François Rochaix, and a younger sister, Laurence Rochaix. Jean-David studied Physics at the University of Lausanne and obtained his PhD in Biophysics from Harvard University under the supervision of Paul Levine in 1972. After post-doctoral work in the laboratory of Joseph Gall at Yale University, he joined the Department of Molecular Biology of the University of Geneva as "Chargé de recherches" in 1974 and was nominated to be a professor there in 1981. He was Chairman of the Department of Molecular Biology from 1991 to 1994 and then again from 1998 to 2001.

Jean-David has been married to Giustina Danisi Rochaix for ~40 years, and has two sons, Marcel (28 years old) and André (25 years old).

Research

Jean-David Rochaix's research interests have been in the area of biogenesis and regulation of the photosynthetic apparatus of the unicellular green alga *Chlamydomonas reinhardtii,* as well as the model plant *Arabidopsis thaliana*. He has used molecular-genetic approaches to study chloroplast gene expression and the interactions between the plastid and nuclear genetic systems. His laboratory has developed new tools for chloroplast genetic engineering, with which they have studied the biogenesis and regulation of many proteins involved in photosynthesis. Jean-David has also been interested in the molecular mechanisms underlying acclimation of photosynthetic organisms to changing environmental conditions. These studies led to the discovery of the Stt7/STN7 protein kinase in the chloroplast. This enzyme acts as a redox sensor and is involved in *state transitions* and retrograde signaling. More recently his research group has developed a repressible chloroplast gene expression system, which has led to the discovery of novel plastid signaling pathways and to the elucidation of the function of essential plastid genes. He is currently working in Beijing as a Visiting Professor at the Photosynthesis Research Center of the Chinese Academy of Sciences on signaling in plants and algae.

Prof. Rochaix has extensively published (over 250 papers, reviews and book chapters) in top journals, and book series, including (just a random sampling): *Advances in Photosynthesis and Respiration Including Bioenergy and Related Processes*; *Annual Review of Cell Biology*; *Biochimica et Biophysica Acta; Cell; EMBO* (European Molecular Biology Organization) *Journal*; *FEBS* (Federation of European Biochemical Society) *Letters*; *Gene*; *Journal of Biological Chemistry*; *Journal of Molecular Biology*; *Nature*; *Nucleic Acids Research*; *Photosynthesis Research*; *Plant Cell*; *Plant Physiology*; *Proceedings of the National Academy of Sciences*, *USA*; and *Science*.

With some thought, we have selected ten papers from Jean-David Rochaix's research group that we consider

representative of his ingenuity and rigor. (We know full well that others might have selected different papers, indicative of the depth and breadth of his research.) Our selection is: (1) Cyclization of chloroplast DNA fragments of *Chlamydomonas reinhardtii* (Rochaix 1972); (2) On herbicide resistance and cross-resistance: changes in photosystem II (Erickson et al. 1985); (3) On mutations at a particular nuclear locus of *Chlamydomonas reinhardtii* specifically affecting the stability of a specific chloroplast transcript encoding the D2 protein of photosystem II (Kuchka et al. 1989); (4) On the requirement of a small chloroplast RNA for trans-splicing in *Chlamydomonas reinhardtii* (Goldschmidt-Clermont et al. 1991); (5) On the role of chloroplast protein kinase Stt7 in the phosphorylation of light-harvesting complex II and in the so-called *state transition* in Chlamydomonas (Depège et al. 2003); this was followed by a fool-proof evidence that state transitions and light adaptation require chloroplast thylakoid protein kinase STN7 (Bellafiore et al. 2005). (6) On the FLP (Flu-Like Protein) acting as regulator of chlorophyll synthesis in response to light and plastid signals in *Chlamydomonas* (Falciatore et al. 2005). (7) On the discovery of a novel factor (*ATAB 2*) in the signaling pathway of light-controlled synthesis of photosystem proteins (Barneche et al. 2006). (8) On the conditional repression of essential chloroplast genes that revealed new signaling pathways and regulatory feedback loops in *Chlamydomonas* (Ramundo et al. 2013). (9) On the conditional depletion of a chloroplast protease activating nuclear genes involved in autophagy and other processes (Ramundo et al. 2014). (10) A serine protease, labeled as DEG9, was shown to modulate cytokinin and light signaling by affecting the level of another regulator (Chi et al. 2016).

Govindjee thanks Jean-David Rochaix for writing excellent chapters in the Series (that he and Tom Sharkey have been editing) on Advances in Photosynthesis and Respiration (see e.g., Rochaix 2006a, b); for editing and for producing a wonderful book on the molecular biology of *Chlamydomonas* (Rochaix et al. 1998). And, last, but not the least, is Jean-David's elegant and excellent collaboration in the search for the binding site of bicarbonate on the electron acceptor site of Photosystem II (Shevela et al. 2012) through the use of site-directed mutants of *Chlamydomonas* (Govindjee et al. 1991). Kevin Redding thanks Jean-David for his generosity in encouraging him to publish several papers independently while he worked with him as a postdoctoral fellow; among the several papers that they published together, we specifically mention Redding et al. (1999), which proved the indispensability of photosystem I in photosynthesis and in the life of oxygenic photosynthetic organisms. For a list of key research collaborators of Rochaix, see Appendix 2.

Fig. 2 Jean-David Rochaix (JDR) with students from the Photosynthesis Research Center in Beijing in 2014. From *left* to *right*: Flora Song, Peiqiang Peng, JDR, Baoye He, Hailong Guo, and Lei Zhao

Fig. 3 Excursion with students from the Pohang University of Science and Technology in South Korea in 2015

Committees and awards

Rochaix was elected as a member of EMBO (in 1981) and of Academia Europea (in 2002). He was Chairman of the EMBO Young Investigator Program (2000–2004), member of the EMBO Council (1994–1999) and of the Council of Scientists of the Human Frontier Science Program Organization (2006–2010) and President of the Biology Platform of the Swiss Academy of Sciences (2007–2012). He has received many awards, including the Prize of the University of Lausanne (1968); Friedrich Miescher Prize (1980); Gilbert Morgan Smith Medal (US National Academy of Sciences) (1991), and now the 2016 Lifetime achievement award of the ISPR.

However, it must be said that Jean-David's lifetime of scientific achievement is far from over, as evidenced by photographs in Figs. 2 and 3 showing him sharing his knowledge in his typical unassuming way with students in China and Korea, respectively. We wish him all the best in his future research and communication of science.

Acknowledgments We thank A. William (Bill) Rutherford for providing us the necessary information on behalf of the International Society of Photosynthesis Research (ISPR) regarding Jean-David Rochaix. We are grateful to Steven (Steve) C. Huber, and John Golbeck for reading and approving the publication of this Tribute. We also thank Rahul Ukey, of UIUC, for his help in editing the photograph shown in Fig. 1.

Appendix 1: The other ISPR awardees (2004–2016)

Prepared from information on the ISPR web site (http://www.photosynthesisresearch.org/page-1853064).

International Society of Photosynthesis Research (ISPR) Prize Winners, excluding student awards, are listed below.

Lifetime achievement award

2016: Jean-David Rochaix (Switzerland); 2013: Pierre Joliot (France); 2010: Ulrich Heber (Germany) and Kenneth Sauer (USA); 2007: Jan Anderson (Australia); 2004: Horst Witt (Germany).

Communications award

2016: James Barber (UK); 2013: Robert Blankenship (USA); 2010: Oliver Morton (UK); 2007: Govindjee (USA); 2004: David Walker (UK).

Innovation prize

2016: David Kramer (USA); 2013: Stephen Long (USA); 2010: Agu Laisk and Vello Oja (Estonia); 2007: Ulrich Schreiber (Germany).

Melvin Calvin-Andrew Benson award

2016: Andrew Leaky (USA); 2013: Xinguang Zhu (China); 2010: Carl Bernacchi(USA); 2007: Julian Hibberd (UK); 2004: Klaas van Wijk (USA).

Robin Hill award

2016: Nicholas Cox (Australia); 2013: Min Chen (Australia); 2010: Tomas Morosinotto (Italy); 2007: Warwick Hillier (Australia) and Junko Yano (USA); 2004: Kevin Redding (USA).

Appendix 2: Key collaborators of Jean-David Rochaix

An alphabetical list of key collaborators of Jean-David over the years have been (for ease in searching names, we have bolded the alphabets of the last names, only at their first appearance):

Bruno **A**mati, Andrea Auchincloss, Frédy **B**arneche, Roberto Bassi, Stéphane Bellafiore, Pierre Bennoun, Eric Boudreau, Mauro **C**eol, Yves Choquet, Michèle Crévecoeur, David **D**auvillée, Anil Day, Robert Debuchy, Christian Delessert, Nathalie Depège, Emine Dinc, Michel Dron, Franz Dürrenberger, Oliver **E**benhöh, Lutz Eichacker, Jeanne Erickson, Angela **F**alciatore, Nicolas Fischer, Mark Fleischmann, Lars Gunnar Franzén,

Geoffrey Fucile, Vera **G**öhre, Michel Goldschmidt-Clermont, Augustin Guardiola, Mounia **H**eddad, Muriel Herz, Michael Hippler, Bruce **K**ohorn, Michael Kuchka, Pierre Künstner, Fabrice **L**aroche, Linnka Levebvre-Legendre, Stéphane Lemaire, Sylvain Lemeille, Stéphane Lobréaux, Vanya Loroch, Pia **M**alnoe, Yves Marco, Stephen Mayfield, Livia Merendino, Stéphane Miras, Caroline Monod, Helle **N**aver, Jörg Nickelsen, Karl **P**erron, Saul Purton, Michèle **R**ahire, Silvia Ramundo, Stéphane Ravanel, Kevin Redding, Christian Rivier, Norbert Rolland, Michel **S**chneider, Alexey Shapiguzov, Su-Yin Soen, Robert Spreitzer, Otello Stampacchia, Raymond Surzycki, Stefan Surzycki, Yuichiro **T**akahashi, Fabian **V**aistij, Jean-Marie Vallet, Jeannette van Dillewijn, Donald **W**eeks, Adrian Willig, Veronika Winter, Jean-Luc **Z**anasco, and William Zerges.

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Chi W, Li J, He B, Chai X, Xu X, Sun X, Jiang J, Feng P, Zuo J, Lin R, Rochaix JD, Zhang L (2016) DEG9, a serine protease, modulates cytokinin and light signaling by regulating the level of Aeabidopsis response regulator 4. Proc Natl Acad Sci USA 113(25):E3568–E3576. doi:10.1073/pnas.1601724113

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Erickson JM, Rahire M, Mets L, Rochaix J-D (1985) Herbicide resistance and cross-resistance: changes at three distinct sites in the herbicide-binding protein of photosystem II. Science 228:204–207

Falciatore A, Merendino L, Barneche F, Ceol M, Meskauskiene R, Apel K, Rochaix JD (2005) The FLP proteins act as regulators of chlorophyll synthesis in response to light and plastid signals in *Chlamydomonas*. Genes Dev 19:176–187

Goldschmidt-Clermont M, Choquet Y, Girard-Bascou J, Michel F, Schirmer-Rahire M, Rochaix J-D (1991) A small chloroplast RNA may be required for trans-splicing in *Chlamydomonas reinhardtii*. Cell 65:135–143

Govindjee, Schwarz B, Rochaix JD, Strasser RJ (1991) The herbicide-resistant D1 mutant L275F of *Chlamydomonas reinhardtii* fails to show the bicarbonate/reversible formate effect on chlorophyll a fluorescence transients. Photosynth Res 27:199–208

Kuchka MR, Goldschmidt-Clermont M, van Dillewijn J, Rochaix JD (1989) Mutations at the nuclear NAC2 locus of *C. reinhardtii* specifically affect the stability of the chloroplast psbD transcript encoding polypeptide D2 of photosystem II. Cell 58:869–876

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