

A tribute to Achim Trebst, a friend

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Abstract I honor here a friend, Achim Trebst, on his 80th birthday on June 9, 2009. I have known his outstanding research, on the biochemistry of photosynthesis, for years. My brief tribute, which includes personal, scientific and a cultural component, is followed by excellent tributes by Volker ter Meulen and Rudolf K. Thauer, by Heinrich Strotmann, and by Walter Oettmeier (this issue).

Keywords Sanskrit verses honoring Achim Trebst · Photosystem II reaction center · Chemical tools · Herbicides · Bicarbonate

A tribute

Looking for academic personal connections with Achim, I am reminded of the fact that he had once worked in the laboratory of the Nobel laureate Otto Warburg, and I had worked with Robert Emerson who had obtained his PhD in Warburg's laboratory. This connection may look tenuous to most, but I feel a special linkage with Achim through it.

I begin this tribute with a Sanskrit verse, composed by Hans Henrich Hock, that captures my thoughts for honoring Achim (see Fig. 1 below); he is the mentor in this verse.

I have known and admired Achim's extensive work by reading many of his thorough and outstanding papers, reviews, and chapters in books. I have enjoyed them all.

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जीवन्त्योषधयो यथा भानुशक्तिप्रचोदनात् ।
तच्छास्त्रशिक्षकं वयं सखायं पूजयामहे ॥

Wie die Pflanzen von dem Antrieb der
Sonnenstrahlen leben,
Den Mentor in dieser Wissenschaft, den Freund
verehren wir.

How the plants live from the impetus of the
sun's rays,
The mentor in this science, the friend, him we
honor.

Fig. 1 The top section shows the Sanskrit verse; it is followed by its German translation, and then its English translation. Composed and translated by Hans Henrich Hock

I have never worked with him, but we have visited each other in our laboratories and in our homes in Urbana, and Bochum, respectively. What impressed me most about him are: his modesty, his gentleness, and his thoughtfulness. He is a very pleasant scholar, and has been always highly considerate of others around him. His interest in Science is very engaging even after years of his formal retirement. Figure 2 shows his picture taken by me on November 14, 2006 at the University of Bochum. It captures his intense interest in the Photosystem II structure displayed by Eckhard Hofmann on his computer. I remember that on that day I was attempting to convince Achim that bicarbonate (carbonate) plays an important role on the electron acceptor side of PSII. He provided much insight into my understanding of the electron acceptor side of PSII, particularly how and where the herbicides bind, and how they function.



Fig. 2 A 2006 photograph of Achim Trebst with Eckhard Hofmann, at the University of Bochum. Photo by Govindjee

Achim is known for his outstanding contributions, with his many coworkers (see e.g., Volker ter Meulen and Rudolf K. Thauer, Heinrich Strotmann, and Walter Oettmeier, this issue), in many areas of biochemistry of photosynthesis. These include his pioneering work on the functional ‘autonomy’ of the chloroplast system, on the mechanistic understanding of the electron flow by the use of DBMIB (2,5-dibromo-3-methyl-6-isopropyl-*p*-benzoquinone; see Trebst et al. 1970), on the vectorial electron flow that had direct bearing on the chemiosmotic theory given by the Nobel laureate Peter Mitchell; on the relationship between mitochondrial cytochrome *b/c*₁ and the chloroplast cytochrome *b₆/f* complex, and on the protective function of tocopherols. I refrain from discussing these areas further because others more competent than I are qualified to talk about them.

Achim’s major contribution to the photosynthetic community has been that he really provided them the chemical tools for the functional and structural localization of carriers and energy conservation sites. Among his many early publications, which had profound influence on my thinking and on my own research, I mention some of them here (see Trebst 1974, 1980, 1986, 1987; and Trebst and Draber 1986). These were concerned with the action of externally added chemicals, including various herbicides. Achim’s original research was responsible for our ability to do ‘*biochemical surgery*’ of the path of electron transport leading us to suggest that a major binding site of bicarbonate is at the *Q_A – Q_B* side of Photosystem II, close to where herbicides bind (Khanna et al. 1977, 1981; also see a review by Van Rensen et al. 1999).

Achim was among the first to discuss the idea of similarity of the reaction centers of Photosystem II and that of the purple photosynthetic bacteria (Trebst 1986, 1987). This gave impetus to several laboratories, including that of Tony Crofts and my own, for the homology modeling of Photosystem II (Crofts et al. 1987; Bowyer et al. 1990; Xiong et al. 1996, 1998), using results from the exciting data of the Nobel laureates Hartmut Michel, Johann Deisenhofer, Robert Huber and their coworkers on the reaction center of the purple bacteria (see e.g., Deisenhofer et al. 1984, 1985).

Epilogue

In the tradition of the Indian culture, I end this tribute, to honor and congratulate Achim, with two additional Sanskrit verses, composed by Rajeshwari Pandharipande, both meant for Achim.

The first one relates to Achim’s insight as a scientist (Fig. 3) and the second one wishes him an everlasting life (Fig. 4).

My tribute will remain incomplete without a picture of two of us (see Fig. 5, courtesy of Rolf Thauer). Further, my distinguished colleagues Lars Björn (Sweden), George Papageorgiou (Greece) and Ondrej Prásil (Czech Republic) honor Achim by dedicating two of their recent papers (see Björn and Govindjee 2009; Kana et al. 2009).

सूर्यसलिलसंयोगात् वनस्पतिः वनायते ।

निरीक्षणपरीक्षणसंयोगात् अभिनिवेशः ज्ञानायते ॥

Durch die Verbindung von Sonne und Wasser
wächst der Baum zum Wald,
(So wie) durch Beobachtung und Analyse die
Einsicht (des Wissenschaftlers) zur Kenntnis
wächst.

With the confluence of the sun and the water,
the plant grows into a forest
(Just as) the insight (of a scientist) grows into
knowledge through observation and
analysis.

Fig. 3 The top portion shows the 2nd Sanskrit verse for Achim; it was composed by Rajeshwari Pandharipande; below it is the German translation by Hans Henrich Hock, followed by its English translation by Rajeshwari

ज्योतिर्जलसंयोगः सम्यक् भवतु सर्वदा ।
भवान् अभिसंस्कृतशास्त्रज्ञः जीवतु सर्वदा ॥
Möge die Verbindung von Licht und Wasser
ewig existieren.
Mögen Sie, der hochvollendete
Wissenschaftler, ewig leben!
May there always be the appropriate confluence
of the light and the water !
May you, the accomplished scientist, live for
ever!

Fig. 4 The top portion shows the 3rd Sanskrit verse for Achim; it was composed by Rajeshwari Pandharipande; below it is the German translation by Hans Henrich Hock, followed by its English translation by Rajeshwari

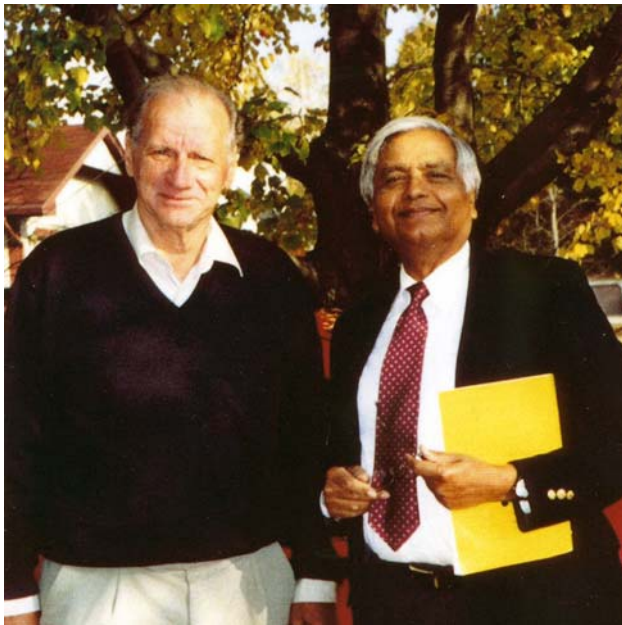


Fig. 5 A 2006 photograph of Achim Trebst and Govindjee. Courtesy of Rolf Thauer

Acknowledgment I am highly thankful to Hans Henrich Hock for the 1st Sanskrit verse (Fig. 1) and to Rajeshwari Pandharipande for the 2nd (Fig. 3) and the 3rd (Fig. 4) Sanskrit verses. I also thank Rolf Thauer for Fig. 5, and Tony Crofts for reading and approving this Tribute for publication in Photosynthesis Research.

References

- Björn LO, Govindjee (2009) The evolution of photosynthesis and chloroplasts. Dedicated to Achim Trebst at his 80th birthday on June 9, 2009. *Curr Sci* 96:1466–1474
- Bowyer J, Hilton M, Whitelegge J, Jewess P, Camilleri P, Crofts A, Robinson H (1990) Molecular modelling studies on the binding of phenylurea inhibitors to the D1 protein of Photosystem II. *Z Naturforsch* 45c:379–387
- Crofts AR, Robinson HH, Andrews K, Van Doren S, Berry E (1987) Catalytic sites for reduction and oxidation of quinones. In: Papa S, Chance B, Ernster L (eds) *Cytochrome systems: molecular biology, bioenergetics*. Plenum Publishers, New York, pp 617–624
- Deisenhofer J, Epp O, Miki K, Huber R, Michel H (1984) X-ray structure analysis of a membrane protein complex: electron density map at 3 Å resolution of the chromophores of the photosynthetic reaction center from *Rhodospseudomonas viridis*. *J Mol Biol* 180:385–398
- Deisenhofer J, Epp O, Miki K, Huber R, Michel H (1985) Structure of the protein subunits in the photosynthetic reaction centre of *Rhodospseudomonas viridis* at 3 Å resolution. *Nature* 318:618–624
- Kana R, Prášil O, Komárek O, Papageorgiou GC, Govindjee (2009) Spectral characteristic of fluorescence induction in a model cyanobacterium, *Synechococcus sp.* (PCC 7942). Dedicated to Achim Trebst at his 80th birthday on June 9, 2009. *Biochim Biophys Acta*. doi:10.1016/j.bbabi.2009.04.013
- Khanna R, Govindjee, Wydrzynski T (1977) Site of bicarbonate effect in Hill reaction: evidence from the use of artificial electron acceptors and donors. *Biochim Biophys Acta* 462:208–214
- Khanna R, Pfister K, Keresztes A, Van Rensen JJS, Govindjee (1981) Evidence for a close spatial location of the binding sites of CO₂ and for the photosystem II inhibitors. *Biochim Biophys Acta* 634:105–116
- Trebst A (1974) Energy conservation in photosynthetic electron transport of chloroplasts. *Annu Rev Plant Physiol* 25:423–458
- Trebst A (1980) Inhibitors in electron flow: tools for the functional and structural localization of carriers and energy conservation sites. *Methods Enzymol* 69:675–715
- Trebst A (1986) The topology of the plastoquinone and herbicide binding peptides of photosystem II—a model. *Z Naturforsch* 41c:240–245
- Trebst A (1987) The three-dimensional structure of the herbicide binding niches on the reaction center polypeptides of Photosystem II. *Z Naturforsch* 42c:742–750
- Trebst A, Draber W (1986) Inhibitors of PSII and the topology of the herbicide Q_B binding polypeptide in the thylakoid membrane. *Photosynth Res* 10:381–392
- Trebst A, Hart E, Draber W (1970) On a new inhibitor of photosynthetic electron transport. *Z Naturforsch* 25b:1157–1159
- Van Rensen JJS, Xu C, Govindjee (1999) Role of bicarbonate in Photosystem II, the water-plastoquinone oxidoreductase of plant photosynthesis. *Physiol Planta* 105:585–592
- Xiong J, Subramaniam S, Govindjee (1996) Modeling of the D1/D2 proteins and cofactors of the photosystem II reaction center: Implications for herbicide and bicarbonate binding. *Protein Sci* 5:2054–2073
- Xiong J, Subramaniam S, Govindjee (1998) A knowledge-based three dimensional model of the Photosystem II reaction center of *Chlamydomonas reinhardtii*. *Photosynth Res* 56:229–254