



Special issue in honor of Prof. H.K. Lichtenthaler

In honor of Hartmut Karl Lichtenthaler

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Abstract

We honor here Hartmut Karl Lichtenthaler, a pioneer of plant physiology, plant biochemistry, plant biophysics, plant molecular biology, and stress physiology. His contributions to the ingenious use of chlorophyll *a* fluorescence imaging in understanding the physiological processes in leaves stand out. We wish him many happy and productive years of research and educating others.

Keywords: chlorophyll fluorescence imaging; Eugene Rabinowitch; isoprenoid biosynthesis; Melvin Calvin; phylloquinone; Robert Emerson.

I express my heartfelt greetings, and best wishes, for many happy and productive years to my dear friend Hartmut Lichtenthaler at the University of Karlsruhe, Germany, whom I consider as my younger brother. A quick look at the 'photosynthesis literature', tells us that the name Hartmut Lichtenthaler is not only synonymous with the discovery of phylloquinone in Photosystem I, but brings, before our eyes, the images of osmophilic plastoglobules (see Lichtenthaler 2013, for a review), and the intricate differences in ultrastructure, pigment composition and photosynthetic rates of 'sun chloroplasts' vs. 'shade chloroplasts' from sun and shade leaves (see a review by Lichtenthaler and Babani 2004), as well as the processes that led to the forest decline (see Sharkey and Govindjee 2016). In addition, Hartmut is well known for detecting and establishing, in close cooperation with the chemist Michel Rohmer, the non-mevalonate desoxyxylulose-phosphate (DOXP)/methylerythritol phosphate (MEP) pathway of isoprenoid biosynthesis in chloroplasts, which is responsible for the biosynthesis of carotenoids, plastoquinone-9, phylloquinone, isoprene, and phytol, that are essential components of the photosynthetic apparatus (Lichtenthaler *et al.* 1997, Lichtenthaler 1999).

Furthermore, and closer to my heart is Hartmut's authoritative research on the use of 'chlorophyll (Chl) *a* fluorescence' (Govindjee *et al.* 1986, Lichtenthaler 1988, Papageorgiou and Govindjee 2004) in studying the effects

of stress on plants (see Lichtenthaler and Rinderle 1988, Lichtenthaler *et al.* 1998). In fact, Hartmut is the top authority on the use of Chl fluorescence in plants under stress (see his own account: Lichtenthaler 2020).

Moreover, Hartmut is the pioneer of imaging the red and far-red Chl *a* fluorescence of whole leaves (Lang *et al.* 1994, Lichtenthaler and Miehé 1997, Buschmann and Lichtenthaler 1998) and in the application of Chl fluorescence imaging (at the maximum F_m , and the steady-state F_s after 5 min of saturating light) in order to simultaneously determine, in a nondestructive way, the individual photosynthetic activity of several thousand or ten thousand leaf pixels and the gradients in photosynthetic rates over the leaf surface (Lichtenthaler and Babani 2000, Lichtenthaler *et al.* 2000, 2007, 2013). No one can match the description of research what Hartmut has done better than what he himself has written in an outstanding review (see Lichtenthaler 2015). To show my connection with Hartmut's Chl *a* fluorescence imaging, I refer the readers to my efforts, with the late Robert (Bob) Clegg (1945–2012) on the imaging of lifetime of Chl *a* fluorescence (see *e.g.*,

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*Wikipedia: https://en.wikipedia.org/wiki/Hartmut_K._Lichtenthaler; biography: <https://peoplepill.com/people/hartmut-k-lichtenthaler/>; curriculum vitae: <https://www.botanik.kit.edu/molbio/1008.php>; scientific publications: <https://www.botanik.kit.edu/molbio/1003.php>.

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Holub *et al.* 2000, 2007).

Hartmut continues to amaze me with not only his research, but his contributions to writing tributes remembering the discoverers of the photosynthetic carbon fixation cycle (see Lichtenthaler *et al.* 2015, Buchanan *et al.* 2016, for Andrew A. Benson; and Govindjee *et al.* 2020 for Melvin Calvin). On top of all this, he has provided for the future generation, English translation of Robert Emerson's 1927 PhD thesis (Emerson 1927), in German, under Otto H. Warburg (see Lichtenthaler and Björn 2020, for a prelude, see Govindjee 2020).

I end this article on Hartmut Lichtenthaler's outstanding and exciting contributions to photosynthesis by showing a photograph of two of us (Fig. 1) paying homage to two pioneers of the past: Robert Emerson (1903–1959; Govindjee 2020), and Eugene Rabinowitch (1901–1973; Govindjee *et al.* 2019).



Fig. 1. A photograph of Hartmut Lichtenthaler (*left*) and the author Govindjee (*right*), who have continuously exploited the use of Chl *a* fluorescence in understanding photosynthesis and the life of plants. They are shown here at the historical plaque, which honors two pioneers of photosynthesis research – Robert Emerson and Eugene Rabinowitch – who had their laboratories in the Natural History Building (in the background), in Urbana, Illinois, USA. This photo was taken in May 2005 during the 'International Symposium on Chloroplast Engineering', held at the University of Illinois at Urbana-Champaign. Source: Rajni Govindjee.

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