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LETTER TO THE EDITOR

The energy flux theory celebrates 40 years: toward a systems biology concept?

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In 2018, the theory of energy fluxes in biomembranes (TEFB) developed by Professor Dr. Reto Jörg Strasser (one of the most influential leaders in the deep understanding and application of chlorophyll *a* fluorescence) celebrated its 40th anniversary (Strasser 1978). We are aware of the significant contributions and influences that Professor Cyrille Sironval and Professor Warren Butler had on the development of the Strasser's TEFB (Butler 1978, Butler and Strasser 1977, Strasser and Butler 1977, Brouers and Sironval 1978; Sironval and Strasser 1981; Strasser and Sironval 1972; Sironval *et al*. 1984).

Chlorophyll *a* fluorescence signals are exploited by an increasing community of users. It has evolved a growing interest in the last years (*e.g*., an average of 10750 articles per year during the last 18 years; a search by year made on *Google Scholar* using "chlorophyll+fluorescence" as keywords shows more than 204,260 connected results from 2000 to 2018, *see* Fig. 1S, *supplement*), a remarkable interest already reported in details by Ripoll *et al*. (2016).

Conceptual models are essential for understanding complex phenomena in nature. Thus, they are meaningful only if they can be experimentally validated; during the last decades the TEFB has provided a linkage of theoretical and experimental energetic behavior of biomembranes. The TEFB has enabled Prof. Strasser to establish the theoretical background and experimental framework for developing sophisticated fluorescence analysis methods like the JIP-test, an interpretation of fast fluorescence induction kinetics (fast Kautsky's curves) (Tsimilli-Michael and Strasser 2013). However, biological systems showing emergent properties (nonlinear interactions among the network of their components) (Mazzocchi 2008, Lüttge 2013, Sheth and Thaker 2014, Souza and Lüttge 2015), suggest that living organisms should not be considered as a simply conglomeration of elements, but as a complex system that has integration and organization of its parts (Amzallag 2001, Souza *et al*. 2016).

We look forward to further developments of the TEFB toward its integration into a general Systems Biology theory, by assuming dynamic models and connectance/complexity among their parts in a network, so that it could be applied to deepen into the study of photosynthetic energy fluxes (per cross section and per reaction center). Indeed, this letter honors the magnificent research work that Professor Dr. Reto Jörg Strasser and his collaborators at the Bioenergetics Laboratory of the University of Geneva in Switzerland have contributed.

This photograph of Prof. Strasser, measuring fluorescence with a *PEA* instrument in his Laboratory of Bioenergetics at the Station de Botanique in Jussy, Geneva, Switzerland, was taken in 2000 by his PhD student Ronald Maldonado Rodriguez..

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