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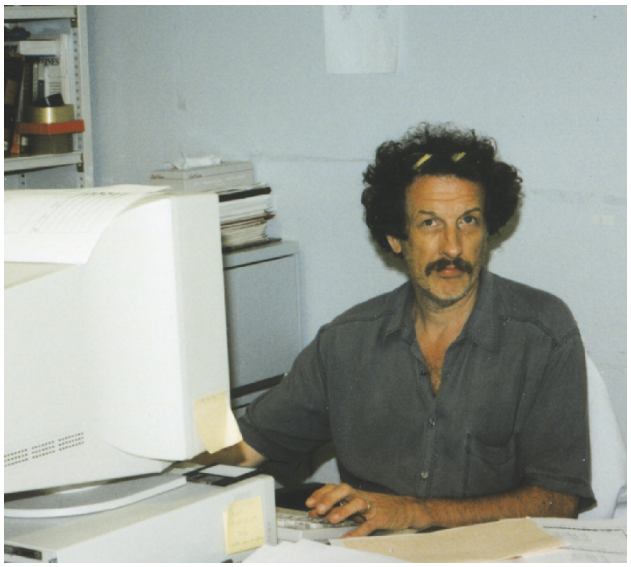
MEMOIR



Colin Wraight in his laboratory at the University of Illinois at Urbana-Champaign, mid 1970. Courtesy of Mary Wraight. Source: Maróti and Govindjee (2015), with permission.

Colin A. Wraight

November 27, 1945 – July 10, 2014

We present here a Memoir of Colin Allen Wraight (1945–2014), a central figure in photosynthetic electron transfer research, particularly in photosynthetic bacteria, who died of leukemia, in Urbana, Illinois, on July 10, 2014. Born in London, England, on November 27, 1945, he had only recently retired from his position as a Professor in Biochemistry, Biophysics & Quantitative Biology, and Plant Biology at the University of Illinois at Urbana-Champaign (UIUC). Wraight was known especially for his pioneering studies on electron and proton transfer in the photochemical reaction center, and for his careful quantitation of the remarkable quantum efficiency of this device in photosynthetic bacteria. A detailed Tribute is being published simultaneously in *Photosynthesis Research*, another Springer journal (Govindjee *et al*. 2015); this Memoir is based on the first part of that Tribute.

Colin Wraight completed both his undergraduate and graduate degrees at the University of Bristol (1964–1971), the latter in the laboratory of Antony (Tony) R. Crofts. He was the first (along with J. Baz Jackson) of Tony's graduate students. Those were heady days, at the height of the great Chemiosmotic Wars, and the Crofts lab was on the frontlines. Colin did some beautiful work including determining the dependence of (chlorophyll) fluorescence quenching (Wraight and Crofts 1970) on the chloroplast ΔpH, and building an intimidating phosphoroscope with which he established the dependence of delayed light emission (DLE) from chlorophyll (Wraight and Crofts 1971) on both components of the proton motive force (ΔpH and Δψ). These results emphasized the vectorial nature of the initial photochemical reactions as Peter Mitchell had proposed. (We all know that Mitchell, in 1978, received the Nobel Prize in Chemistry for his hypothesis of chemiosmosis.) Bristol was not far from Glynn House in Bodmin, and interactions with Peter Mitchell were a regular occurrence. Colin's PhD examiner was Robert (Robin) Hill, and the 'examination' included Robin's demonstration of a "glow of light" from a chlorophyll solution in a darkened fume hood.

Colin spent a postdoctoral year in Louis (Lou) N. M. Duysen's laboratory at the State University in Leiden (1971–1972), following up his work on DLE (Wraight *et al*. 1972). He then moved to Roderick (Rod) K. Clayton's lab at Cornell University, in Ithaca, NY, for another stint as a postdoc (1972–1974). In Rod's lab he forswore chloroplasts to concentrate on photosynthetic bacteria, a decision he rarely revisited. In Ithaca he made one especially important (and well-cited) measurement (Wraight and Clayton 1974): that the absolute quantum efficiency of the photochemical reaction center of what is now known as *Rhodobacter sphaeroides* was 1.02 ± 0.04. And what a number that is: it is as close to a perfect as Nature could ever have. [*See* an outstanding Tribute by Wraight (2014), on the life of Rod Clayton.]

Colin had a brief sojourn on the faculty at the University of California (UC), Santa Barbara, and in 1975 he moved to the University of Illinois at Urbana-Champaign (UIUC), IL. He joined the faculty as an Assistant Professor in the Departments of Plant Biology, and of Physiology and Biophysics. In 1999 he moved to the Department of Biochemistry, which was his permanent home until the end. Perhaps not serendipitously, Tony Crofts had moved to the UIUC in 1978,

and the two resumed collegial (and occasionally experimental) interactions that led to a very important and highly cited review (Crofts and Wraight 1983), and several insightful papers (*see e.g*., Shinkarev *et al*. 2001). In addition, Colin collaborated with one of us (Govindjee), and showed the relation of membrane potential ($\Delta\psi$) to DLE (Jursinic *et al*. 1978); and then the complete absence of the role of bicarbonate in electron and proton transfer in photosynthetic bacteria in contrast to that in oxygenic photosynthesis (*see e.g*., Wang *et al*. 1992).

In Rod Clayton's lab Colin had begun to get seriously interested in the quinones of the primary and secondary acceptors of the photochemical reaction center, and these became a major focus of his research. Early work identified the two-electron gate of Q_B (Wraight 1977), and demonstrated once and for all that protonation was associated with electron transfer to this species (Wraight 1979). This work continued throughout his career, probing the redox potential dependence of protonation (Maróti and Wraight 1997), crucial amino acids in the binding domain (Takahashi and Wraight 1990, 1996; Maróti *et al*. 2015), and the effect of replacing the native ubiquinone with a variety of others (Wraight *et al*. 2008).

Most recently Colin and his group focused on the role of methoxy substituents on ubiquinone function (Taguchi *et al*. 2013). It is one of nature's imponderable questions (at least with our present state of knowledge) as to why ubiquinone is so ubiquitous (hence its name), yet not present in the chloroplasts of cells that have ubiquinone in their mitochondria, but the 2,3-dimethoxy motif likely plays a role, and this work is the first clear experimental evidence addressing the question. Undoubtedly it will carry on, but it will be less fun in Colin's absence.

Colin was a gregarious companion, and an outstanding teacher, but his science often tended to be solitary and deep. He was renowned for his incisive analyses, which included how herbicides function in plants and bacteria (Wraight 1981), how protons are transferred in bioenergetics proteins (Wraight 2006), and on models for oxygen evolution in plants (Shinkarev and Wraight 1993, Shinkarev *et al*. 1997). More importantly, his penetrating intelligence made him the perfect companion at conferences, where his evident pleasure in learning made it a delight to join him in puzzling out what experiments might be most useful. He will be greatly missed.

Colin was widely admired beyond his science for his wit, engaging sense of humor and love of life. Some who knew Colin have contributed personal and scientific remembrances that are included in the detailed Tribute to Colin (Govindjee *et al*. 2015), as are many photographs featuring Colin at different times in both his personal and professional life.

Colin's awards and honors have included: William Garner Prize for Chemistry, University of Bristol (1966); Plenary Session Speaker, 8th International Congress on Photosynthesis Research, Providence, RI (1987); Chairman and Organizer (elected), Gordon Research Conference on "Physico-chemical Aspects of Photosynthesis", Plymouth NH (Summer) (1988); Fellow of the John Simon Guggenheim Memorial Foundation (1988–1989); Associate of the Center for Advanced Studies, University of Illinois (1988–1989); Fulbright Scholar (1995); and Chairman and Organizer (elected), Gordon Research Conference on "Protons & Membrane Reactions", San Buenaventura, CA (Winter) (2003).

We end this memoir by naming some of those who had the privilege of having worked in his laboratory or were trained by him. In alphabetical order, they are: Jiliang Gao; Oleksandr Kokhan; Jonathon W. Larson; Peter Maroti; Erik Martin; James (Jim) C. McComb; Robert (Bob) E. Overfield; David (Dave) R**.** Paterson; Vladimir (Vlad) Shinkarev; Robert (Bob) J. Shopes; Randall (Randy) R. Stein; Chang (Charles) Sun; Alexander (Alex) Taguchi; Eiji Takahashi; Ahmet S. Vakkasoglu; and Xutong Wang, among others.

Colin is survived by his wife Mary, three children Lydia, Sebastian, and Tristan, and a grandchild Felix Colin.

A more complete version of a Tribute that includes reminiscences from students and colleagues, and several photographs since his youth to his adult life, is available in Govindjee *et al*. (2015). We also refer the readers to Maróti and Govindjee (2015) to read about the details of Wraight's thoughts in the form of one of his last lectures and a poster in the area of Biological Energy Conversion.

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