

We remember those who left us in the recent past

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We begin with a quote from John Waller (2002): “No scientist is an island. Instead, most are members of tightly linked networks of highly specialized researchers who depend on others’ expertise, advice and experience for their own ideas to make any progress at all. As well as involving conflict and controversy, good science is necessarily collaborative and cooperative.” It is this obvious thought, as well as the fact that the progress in our field would depend on what we have already learnt from others, that is behind this brief presentation.

Here, we remember briefly, with just a few words, a few scientists who left us during 2016–2018. Our list is incomplete. In alphabetical order, those mentioned below are: Jalal Aliyev (Azerbaijan National Academy of Science, Azerbaijan), Klaus Apel (ETH, Zurich, Switzerland), Thomas (Tom) T. Bannister (University of Rochester, Rochester, NY, USA), Christoph Beck (Albert-Ludwigs University, Freiburg, Germany), Frederick (Fred) L. Crane (Purdue University, West Lafayette, Indiana, USA), George Feher (University of California at San Diego, CA, USA), Ulrich Heber (University of Wurzburg, Germany), Andre T. Jagendorf (Cornell University, Ithaca, NY, USA), Otto Kandler (Ludwig Maximilian University, Munich, Germany), Vyacheslav (Slava) Klimov (Institute of Photosynthesis, Pushchino, Russia), David (Dave) Krogmann (Purdue University, West Lafayette, IN, USA), Shmuel Malkin (Weizmann Institute of Science, Rehovot, Israel), Shigetoh Miyachi (University of Tokyo, Tokyo, Japan), Joseph Neumann (Telaviv University, Tel Aviv, Israel), Itzhak Ohad

(Hebrew University, Jerusalem, Israel), John M. Olson (Odense University, Denmark), Cyrille Sironval (University of Liège, Liège, Wallonia, Belgium), Krishna K. Tewari (University of California Irvine, CA, USA), Achim Trebst (University of Bochum, Bochum, Germany), William (Bill) Vidaver (Simon Fraser University, Vancouver Canada), Diter von Wettstein (Washington State University, Seattle, WA, USA), Thomas J. Wydrzynski (Australian National University, Canberra, Australia). We miss them all, and hope to continue to learn from their lives and research.

A brief note on each of the above-mentioned scientists follows, along with a reference, when available.

Jalal Aliyev (1928–2016)

Jalal was a pioneer of photosynthesis research, photorespiration and all aspects of plant productivity in Azerbaijan. There, he gave new directions in many areas including molecular biology, plant biotechnology, computational biology and bioinformatics, as applied to crop productivity in Azerbaijan. He was a great human being, and was much loved and respected by his students and staff. For further information on his life and research, see Huseynova et al. (2016).

Klaus Apel (1942–2017)

Klaus was a pioneer in plant research with unlimited passion and drive for developing new models and tools.

Based on presentation at the First European Congress on Photosynthesis Research (ePS1) held in Uppsala, Sweden, June 25–28, 2018.

He made seminal contributions in the area of chloroplast biogenesis, which included: Role of singlet oxygen in plant stress responses and its importance in retrograde signaling, insight in the interactions between the nucleus and the chloroplast and in the regulation of the biosynthesis of chlorophylls. For further information on his life and research, see Rochaix et al. (2018).

Tom Bannister (1930–2018)

Tom was a wonderful teacher, researcher and a mentor of many students in Biology. His earliest work dealt with excitation energy transfer within phycobilisomes, and light-induced reduction of chlorophyll in solutions. He was an authority on relating chlorophyll a fluorescence with photosynthesis, and on models for estimating rates of primary production in natural bodies of water. It is important to mention that he was, in addition to being a scientist, a wonderful dancer, and had a great sense of humor. For further information on his life and research, see Laws et al. (2018).

Christoph Beck (1941–2017)

Christoph did important research on the biology of the green alga *Chlamydomonas reinhardtii*. His research focussed on the following topics: sexual differentiation (including the role of phototropin and photoperception), the role of chlorophyll precursors in the light induction of nuclear heat-shock genes, and on the role of heme, derived from plastid, as a regulator of nuclear gene expression. For further information on his life and research, see Schroda and Grossman (2017).

Fred Crane (1925–2016)

Fred was an authority on mitochondrial and chloroplast biochemistry, and plasma membrane redox chemistry. He, with a few others, discovered coenzyme (Co) Q10 in beef heart mitochondria. He was the first to document the functional role of CoQ10 in mitochondrial electron transport. Further, he discovered many aspects of quinones in chloroplasts and named them plastoquinones. For further information on his life and research, see Dilley (2017).

George Feher (1924–2017)

George was an inventor and a major discoverer of many aspects of bacterial photosynthesis. He invented ENDOR (Electron Nuclear Double Resonance) spectroscopy. He was an authority on basic mechanisms of proton and electron transfer in biology. He and his research

group determined (1) the bacterial reaction center (bRC) subunit structure and its primary sequence; (2) electronic structure of donors and acceptors of bRC, using Electronic Paramagnetic Resonance and ENDOR; (3) crystal structure of bacterial RC complex with cytochrome c2. For further information on his life and research, see Okamura et al. (2018).

Ulrich Heber (1930–2016)

Ulrich was a pioneer, one of the topmost authorities on biochemistry of photosynthesis, particularly of metabolism and its regulation, and of responses of plants to the environment, particularly of freezing stress. He studied forest decline in great depth. For further information on his life and research, see Dietz et al. (2018).

Andre Jagendorf (1926–2017)

Andre was an outstanding unique scientist, he was a pioneer of plant biochemistry. He was brilliant and, a non-conformist, and had he devised ingenious experiments. He made ground-breaking discoveries on several enzymes involved in electron and proton flow in chloroplasts; his research showed that ATP could be produced in chloroplasts in darkness by protons accumulated within the thylakoid, supporting Peter Mitchell's chemiosmotic hypothesis. For further information on his life and research, see Govindjee (2017).

Otto Kandler (1920–2017)

Otto was unique, eminent and a respected researcher and teacher, who had a rare vibrancy and style. He was the discoverer of photophosphorylation in vivo. Furthermore, he was a major contributor to the concept of three forms of life: Archaea, Bacteria and Eukarya. For further information on his life and research, see Govindjee and Tanner (2018).

Dave Krogmann (1931–2016)

Dave was a great scientist, a mentor and an outstanding teacher, who had a remarkable impact on anyone who came in contact with him. He was a pillar of photosynthesis research in United States; he was an international authority on electron transfer intermediates in oxygenic photosynthesis, particularly the soluble cytochromes. The photosynthetic system of his choice was cyanobacteria, and one of his major discoveries was the Orange Carotenoid Protein in these microorganisms. For further information on his life and research, see Brand et al. (2017).

Slava Klimov (1945–2017)

Slava was a pioneer of the mechanism of light energy conversion and water oxidation in photosynthesis, particularly on the unique participation of pheophytin and bicarbonate in Photosystem II. He was a scientist par excellence, a great human being, a wonderful friend, a great mentor and a Renaissance man, who loved to play music. For further information on his life and research, see Allakhverdiev et al. (2018).

Shmuel Malkin (1934–2017)

Shmuel was an expert on the dynamics of light harvesting and electron transport in oxygenic photosynthesis. He pioneered the use of *photoacoustics* to explore many aspects of photosynthesis. Shmuel was not only an accomplished scientist, but a gifted musician who touched the lives of many. He was a caring and thoughtful person, respected and much loved by everyone he met. For further information on his life and research, see Herbert et al. (2018).

Shigetoh Miyachi (1930–2016)

Shigetoh San discovered several things including: The existence of chlorophyll *d* in the cyanobacterium *Acaryochloris marina*, the blue-light-dependent beta carboxylation in the green alga *Chlorella*, and the structure and function of carbonic anhydrases involved in the carbon concentrating mechanism. Further information on his life and research is expected to be published in the future.

Joseph Neumann (1930–2017)

Joseph was not only a biochemist of the highest order, but also a great philosopher, who discussed '*Life and Consciousness of Life*'. He has provided us with detailed mechanistic information on the electron and proton flow and ATP synthesis in chloroplasts, specifically on the relation of light-induced pH changes to phosphorylation. For further information on his life and research, see Nelson (2017).

Itzhak Ohad (1930–2016)

Itzhak was a world-renowned authority on chloroplast biogenesis and morphology, photosystem II function, especially photoinhibition, and D1 protein turnover cycle, as well as structure and function of light harvesting complexes. He clearly was a pioneer of electron microscopy in Israel. Above all, Itzhak was a wonderful

teacher at all levels, and he always provided a spark in any discussion anywhere. For further information on his life and research, see Adir et al. (2017).

John Olson (1929–2017)

John is the discoverer of the FMO (Fenna-Mathews-Olson) protein, while he was at Brookhaven National Lab. FMO was the first chlorophyll-containing protein isolated and the first to have its structure determined. He was an expert on the antenna and the reaction center complexes of green bacteria. John is best known for his ideas on the origin and evolution of photosynthesis. For further information on his life and research, see Blankenship et al. (2018).

Cyrille Sironval (1922–2017)

Cyrille was an extraordinary teacher and plant biology researcher of his time. He is the one who provided the formal representation of light-induced etioplast photo-transformation as a succession of states. He also developed the idea of growing plants under repeated flashes of light ('flashed leaves') and provided evidence for photoactivation of photosystem II in continuous light. In addition, he related chlorophyll accumulation to photoperiodism, and chloroplast development to chlorophyll biosynthesis in light. Further, he established the need of a photoenzyme for the photoreduction of protochlorophyllide, and provided detailed information on protochlorophyllide-chlorophyllide cycle in vivo, its kinetics and excitation energy transfer processes in it. Further information on his life and research is expected to be published in the future.

Krishna Tewari (1937–2017)

Krishna was a great scientist who was always full of life, fun, laughter and generosity. He was the first to demonstrate that, in plants, extra-chromosomal genetic determinants lie within an organelle and have distinct characteristics from the nuclear genomic material. He proved that chloroplast DNA from higher plants is in closed circular form and does not contain histones. Furthermore, he made fundamental contributions to the understanding of gene expression and replication in chloroplasts. In addition, Krishna was the founding director of the International Centre for Genetic Engineering and Biotechnology (ICGEB) in New Delhi, India. Further information on his life and research is expected to be published in the future.

Achim Trebst (1929–2017)

Achim dedicated his life to *Biochemistry of Photosynthesis*, with more than five decades of discoveries. To list just a few: Separation of Light and Dark phases in photosynthesis; the elucidation of the electron transport pathway in photosynthesis into individual steps by the use of inhibitors, artificial electron acceptors and donors; the identification of the 3-D structure of photosystem II and its degradation; and, lastly, he explained how singlet oxygen is formed by chloroplasts. For further information on his life and research, see several articles in *Photosynthesis Research* (Volume 100, pp. 113–127, 2009), and Bothe et al. (2018).

Bill Vidaver (1921–2017)

Bill was an innovator, an enthusiastic scientist, an inspiring teacher and a wonderful friend to many. He invented a high pressure cuvette and perfected the bare platinum electrode measurement for oxygen. He had even a patent for a portable chlorophyll fluorometer, which was adapted later for trees. His main research was on high pressure and oxygen effects on photosynthesis and chlorophyll fluorescence. For further information on his life and research, see Burr et al. (2018).

Diter von Wettstein (1929–2017)

Diter was a pioneer of chlorophyll biosynthesis as well as lipid biosynthesis. Further, he provided the earliest micrographs of developing chloroplasts. He was also the first one to provide real hints as to how the thylakoids form. On the practical side, he provided gluten-deficient wheat and better barley beer. For further information on his life and research, see Hooper (2017).

Tom Wydrzynski (1947–2018)

Tom exploited the use of many techniques in understanding the mechanism of photosystem II (Water-plastoquinone oxido-reductase); these included NMR, ESR, FTIR and mass spectrometry. He pioneered the thinking about water access to the Oxygen Evolving Complex. Last but not the least, he pioneered work on artificial photosynthesis, an area very important for developing clean fuels. He is remembered for his deep and innovative thinking and warm care he extended to his coworkers. For further information on his life and research, see Govindjee (2008), Conlan et al. (2018, in press), and Govindjee et al. (2018, in press).

Concluding remarks

We have not included here those who passed away in 2015. However, we refer here to the Tributes of just a selected few. We miss them all. (1) Yurina et al. (2017) on Navik Karapetyan (1936–2015; from Moscow, Russia), an important contributor to the regulation of photochemical processes in photosynthesis; (2) Govindjee and Pulles (2016) on Lou Duysens (1921–2015), a pioneer of biophysical aspects of photosynthesis, and discoverer of antagonistic effect of light I and light II on cytochrome *f*, among other things; (3) Buchanan et al. (2016) and Nonomura et al. (2016) on Andy Benson (1917–2015), co-discoverer of the Calvin-Benson cycle; and Govindjee and Frenkel (1919–2015) on Al Frenkel, discoverer of photophosphorylation in bacterial photosynthesis. One of us (Govindjee) has honored several photosynthesis researchers (see <http://www.life.illinois.edu/govindjee/honorsfrom.html>), including Andrew A. Benson (in 2010), and Alexander A. Krasnovsky (in 2013); in addition, Govindjee (2009) provides a list of others honored between 1988 and 2009.

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