G. J. Kelly · E. Latzko

Thirty Years of Photosynthesis

1974–2004

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With 61 Figures and 2 Tables

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Dr. Grahame J. Kelly
Queensland University of Technology
Faculty of Science
School of Life Sciences
GPO Box 2434
Brisbane Qld 4001
Australia

Prof. Dr. Erwin Latzko
Kirchbergstr. 21
85402 Kranzberg
Germany

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Foreword

"The path of carbon in photosynthesis" for Progress in Botany: 50 years of Calvin-Benson cycle – 30 years of Kelly-Latzko reviews

While writing this Foreword and trying to focus my thoughts on the biochemistry of photosynthesis, a handsome slim hardcover booklet of 104 pages bound in dark blue linen is in front of me on my desk:

"The Path of Carbon in Photosynthesis"
J. A. Bassham and M. Calvin, 1957

I acquired it in the month of my oral Ph.D.-exams, April 1960, to get prepared with the Nobel-laureate's text. In 2004 in his last swan-song review for Progress in Botany Grahame J. Kelly celebrated "The Calvin cycle's golden jubilee" in an overview of 50 years of carbon flowing for the progress in botany. He had met Erwin Latzko in 1970 in another then foremost and now historic place of the biochemistry of photosynthesis, the laboratory of Martin Gibbs at Brandeis University, Massachusetts. Four years later Latzko and Kelly (1974) published their first joint review on photosynthetic carbon metabolism, starting off a long flow of articles on the flow of carbon in the series Progress in Botany. Most faithfully they produced regular accounts of the progress in Progress in Botany every second year, and when Erwin Latzko decided to retire after the 1996 review Grahame Kelly carried on alone.

Most of the reviews are headed by quotations and mottos alluding to both the author's sympathetic sense of humour and their deep concern for the issue of photosynthesis harvesting the sun, and in this vein the quotation in the 1992 review (Kelly and Latzko, 1992) best suits as a representative example:

> *"The first man I saw was of a meagre aspect, with sooty hands and face, his hair and beard long, ragged and singed in several places. His clothes, shirt and skin were all of the same colour. He had been eight years upon a project for extracting sunbeams out of cucumbers, which were to be put into vials hermetically sealed, and let out to warm the air in raw inclement summers. He told me, he did not doubt in eight years more, that he should be able to supply the Governor's garden with sunshine at a reasonable rate …"*
> Jonathan Swift in *Gulliver's Travels*, ca. 1727.

With the 2004 review Grahame Kelly now also decided to retire. He does it at the climax of the golden jubilee of the Calvin cycle, and this now certainly ends an era of photosynthesis reviewing. Reviews in the future will have a different touch, in as much as progress advances into the molecular realm: "*The transformation of a pig with a spinach gene has now been described*" (Saeki et al. 2004; see notes added in proof to the vol. 64, 2002-review in Progress in Botany, in this volume).

Looking forward to this book presenting the 16 reviews of 30 years of photosynthesis in Progress in Botany has a historical twist as the book demonstrates the development of the field over the decades. Nevertheless, it is more than looking back. It presents the reader with an up-to-date account of the state of the field. Hence we owe thanks to Grahame Kelly and Springer-Verlag for presenting the entire collection of the 16 reviews in this volume. It will be stimulating reading for all interested in the biochemistry of photosynthesis. Great thanks are also due to Ursula Gramm for her continuous great care over very many years in general for Progress in Botany at Springer Verlag in Heidelberg and particularly for her care for the present book.

Grahame Kelly has meticulously re-read all the reviews again to develop updating comments from the perspective of 2005. These are added at the ends of the individual reviews compiled in this volume. It is noteworthy that astonishingly little needed to be said which underlines the evergreen liveliness of each individual review.

I wish this book about the path and metabolism of carbon in photosynthesis smooth paths and a metabolic generation of new approaches, ideas and insights in the community interested in the biochemistry of photosynthesis.

Darmstadt, in August 2005 Ulrich Lüttge

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Preface

My interest in photosynthesis began, I suspect, at an early age. As a child brought up in the small Australian town of Kempsey, one of my enjoyments was to create a vegetable garden behind the family house, and sell produce to my parents at 50 % of the prevailing market value. This involved weighing the produce, and I began to wonder how my garden plants could accumulate such weight. This curiosity, combined with an excessive fear of being asked to study the French language upon entering high school (perhaps I foresaw that it was to be Germany, not France, where I was to spend six years of my academic life), dictated that I enter the "B" class which was free of foreign languages but included "agriculture". I continued into "Agricultural Science" at the University of Sydney where, I can still recall, John F Turner attended to my childhood query by describing the famous willow-twig experiment of Van Helmont (who obviously asked similar questions as a child) and, more importantly, by outlining the Benson-Calvin cycle of photosynthetic CO_2 fixation. The biochemistry of plant growth became my passion, and subsequently coaxed me into Turner's laboratory in Sydney, followed by Martin Gibbs' laboratory in Waltham and Erwin Latzko's laboratories in Weihenstephan and Münster.

The above brief personal history is pertinent because this entire book is, in essence, an historical account. Erwin Latzko and I embarked on the production of this chronicle in 1974, although at the time we neither planned nor anticipated that it would continue uninterrupted for three decades. But it did, thus this resultant collection is unique: it offers the opportunity to read the 30-year history of a particular topic in photosynthetic carbon metabolism (e.g. the history of Rubisco, or the history of chloroplast starch synthesis and degradation) written "as it took place". Nothing was written in the context of later discoveries, because these were unknown at the time of writing! Readers can comfortably follow a topic by jumping from one review to the next, reading the appropriate section in each review as they proceed. An additional bonus is that, in our contortive efforts to make subsections of photosynthesis crystal-clear to all plant scientists, even anatomists and taxonomists, we re-

drew many metabolic pathways (some old, some new) such that all inputs and outputs were balanced. Twenty-three of these are distributed through the 16 reviews. For example, in Figure 2 of the 1980 review one can clearly see the successful photosynthetic generation of sucrose by a leaf simultaneously photorespiring 37 % of its fixed CO_2, a situation that is close to natural for most plants. Textbooks always show pathways, but seldom attend to such metabolic accountancy.

The collection of reviews acquired, along the way, a multifaceted character. Examples include: (1) the often overlooked menagerie of marine microalgae that perform close to half of Earth's CO_2 fixation was given prominence in 1984 after I was introduced to these colourful photosynthesizers by Shirley Jeffrey of the CSIRO Marine Laboratories in Hobart; (2) recognition of the emerging link between photosynthesis research and sociopolitical issues was made in 1990 after my brief visit to "Die Grünen" in Bonn; and (3) the inevitable claim that new molecular biotechnologies might be put to use to boost photosynthesis and increase humanity's food supply was critically questioned in 1994, 1998 (with inspiration from a little of the philosophy of David Walker) and 2002.

This history of photosynthetic carbon metabolism is not solely a production from Erwin Latzko and me. We recognise the thousands (literally) of curious researchers who have, over the years, slowly but surely untwined the intricacies of the biochemistry within the great variety of photosynthetic cells that exist in an equal variety of sunlit niches on Earth. This book is the story of their work. Having been drafted by us, we are then grateful to the editors (Hubert Ziegler; Ulrich Lüttge) who have polished what we have written, and to the capable staff at Springer-Verlag, most recently Dieter Czeschlik and Ursula Gramm (who, by the way, makes delicious coffee) for ensuring that it became available as printed pages for the readers. Finally, we hail the eternal bright support of our colleagues, friends and families over the years. As writer of this Preface, I particularly express my gratitude for the endurance of my long-time co-author Erwin Latzko and his delightful wife Sylvia, and for the patience of my beautiful wife Chusi and three charming daughters Madeleine (born in Freising during preparation of the 1978 review), Vivienne (born in Münster during preparation of the 1980 review), and Genevieve (born in Wollongong during submission of the 1984 review). Their patience has been rewarded by Springer-Verlag's decision to publish this unusual book which, we trust, will delight the minds of those 21st-century young scientists who become struck with a passion for contemplating the biochemistry of plant growth.

Grahame J Kelly

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