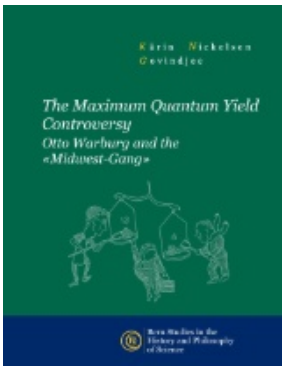

The Maximum Quantum Yield Controversy

Otto Warburg and the "Midwest-Gang"

Available at http://www.bod.de/index.php?id=1132&objk_id=560914

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Whoever turns to the history of photosynthesis research in the twentieth century is soon confronted with the fact that one of its most exciting periods, the years from 1920 to 1960, was in large part overshadowed by a bitter controversy in which many of the leading scientists in the field were involved. It centered on the question, how efficient the process of photosynthesis was. This book attempts a reconstruction of the course of the controversy, based on previously unknown archival sources, and analyzes the arguments brought forward by the two parties.

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Some of the comments on the book are:

Howard Gest (USA) :

This small book details the history of an important chapter in photosynthesis research, decades of attempts to determine the minimum quantum requirement of oxygenic photosynthesis. Numerous scientists were involved, eventually resulting in two "camps" reporting discordant results. The leading figures of the opposing groups were Robert Emerson at the University of Illinois (Urbana) and Otto Warburg in Germany. Nickelsen and Govindjee (a former student of Emerson) are to be complimented for their excellent documentation of the quantum requirement problem, profiles of the many scientists involved and description of an extraordinary meeting** in Urbana on December 18, 1948 in which the protagonists came face-to-face. There was no resolution of the controversy at the meeting, and it continued on for many years. As the decades

passed and many new discoveries on photosynthetic mechanisms were made, interest in the "exact" minimum quantum requirement faded. It is important to note that practically all of the investigators involved used the unicellular green alga *Chlorella pyrenoidosa* as the experimental system. Equally important is the fact that the major combatants, except for Warburg, had backgrounds mainly in the physical sciences. Unlike microbiologists, they were obviously unaware of the great differences in the metabolic and other properties of cultures of unicellular microbes that depend on many factors: age of the cells, the exact chemical composition of the growth medium, and the physical growth conditions. No wonder their results differed from day-to-day and laboratory-to-laboratory! Nobel Laureate Warburg was a biochemist of great distinction, and had made important discoveries on enzyme catalysis and intermediary electron carriers, but very rarely worked with microbial cells. ***This book is an important contribution to the history of photosynthesis research and also gives insights into personal and philosophical aspects of research on complex subjects.***

**According to Albert Frenkel the 1948 meeting in Urbana "was civilized, and without the nasty quality that the controversy would later acquire." As stated in a footnote on page 52 in the book, I had attended the meeting and clearly remember Warburg's opening remarks, translated by Victor Schocken as he spoke. Warburg said that the crux of the disagreement was that American scientists simply did not know how to measure light intensity accurately, whereas he (Warburg) knew how because his famous father, Emil Warburg, taught him. Farrington Daniels immediately challenged this insult in gentlemanly fashion. Warburg's arrogance was a key factor in prolonging an extraordinary expenditure of effort and research funds by a large number of dedicated scientists. Eventually there was a general consensus that Emerson was right and Warburg wrong about the maximum efficiency of photosynthesis in Chlorella.

Ekkehard Höxtermann (Germany) :

"Many thanks for your interesting [book]! I cannot improve it; it is systematic, compact, exciting, quite well balanced between individual/special positions and general conclusions, history of science and contemporary history etc. I learned a lot, especially on Warburg's stay in the United States"

Colin Wraight (USA) :

"Thanks for sending this [book]. I had intended to look over it as requested but when I opened it to find that it is over 100 pages long, I had second thoughts. However, despite myself I started skimming it and was soon quite engrossed. It is a compelling story and very well done. I found myself desperately wanting to be told the answer, i.e., why Warburg got the numbers he did, even though that is not really known. However, I think a degree of satisfaction is provided in the *Emerson Strikes Back* chapter, and by the *Concluding Remarks* solidifying the possibility/likelihood of serious issues of integrity.

Lars Olof Björn (Sweden) wrote :

"I have now read through your manuscript "The maximum quantum yield controversy". This is great! Important not only for the field of photosynthesis, but for showing how science can go wrong. A bit reminiscent of the religious wars that have been so destructive for humanity."

Govindjee, one of authors, adds his personal comments: History was made on the campus of the University of Illinois at Urbana-Champaign (UIUC), Illinois, when the 1931 Nobel laureate Otto Warburg had arrived on this campus in 1948;his photo was published on the cover of "Science"(that we have included in the book). Warburg was assigned to Robert Emerson's Lab in the basement of the Natural History Building on the campus. The historical story, covered in this book, is between the 1931 Nobel laureate Otto Warburg (Germany) and the *Mid-west Gang* that includes Robert Emerson, Warburg's own doctoral student; and later Professor at the UIUC; Eugene Rabinowitch, also a professor at the UIUC; James Franck (1926 Nobel laureate) from the University of Chicago, Illinois; Hans Gaffron (another pioneer of Photosynthesis Research, also from the University of Chicago); and the Wisconsin Photochemist Farrington Daniels and several others.

I love the cartoon, we used, in the Introduction to the book; it shows the "fair-minded" Mid-West Gang member Eugene Rabinowitch (later co-inventor of the *Doomesday clock* on the cover of the "*Bulletin of Atomic Scientists*") attempting to bring balance between Warburg (who believed that plants and algae needed a minimum of 4 photons to evolve one O_2 molecule) and Emerson (who had measured a minimum value of 8-12 photons to evolve one O_2 molecule). The book has several interesting photos including a unique photo of Warburg sitting under a tree with several others; the quotes from several Archives included in this small little book are unique in many ways.