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Andrey Kaulen

(1951-2000)

This special issue of *Biochemistry* (*Moscow*) is dedicated to the memory of Dr. Andrey Kaulen, late Head of the Department of Photobiochemistry, A. N. Belozersky Institute of Physico-Chemical Biology, Moscow State University.

Andrey Kaulen graduated from the Department of Biochemistry of Moscow State University in 1974 and then entered the Ph.D. program in that Department. Working in the Laboratory of Bioenergetics headed by Prof. V. P. Skulachev, he received his Ph.D. in Biochemistry in 1978 and his Doctor of Science degree in 1990. In 1993 A. D. Kaulen became the Head of the Laboratory of Photochemistry of Biomembranes and then Head of the Department of Photobiochemistry of A. N. Belozersky Institute of Physico-Chemical Biology.

Andrey Kaulen dedicated his scientific carrier to the elucidation of the mechanism of photoinduced proton transport by bacteriorhodopsin. This retinal-containing protein of halobacteria is the simplest biological transducer of solar energy, using light to establish a transmembrane gradient of proton electrochemical potential. Working with his senior colleagues Prof. V. P. Skulachev and Dr. L. A. Drachev and later leading his own laboratory, Andrey Kaulen carried out a number of outstanding studies. His research started in the framework of a joint project of the Academy of Sciences of the USSR and Moscow State University, "Rhodopsin", which was organized by Academicians Yu. A. Ovchinnikov and V. P. Skulachev in 1974. It was a very exciting time for bioenergeticists. P. Mitchell's chemiosmotic theory had received substantial experimental support [1]. D. Oesterhelt and W. Stoeckenius had just reported that the retinal-containing protein bacteriorhodopsin [2] plays an important role in light energy storage in halobacteria, working as a light-driven proton pump [3]. Studies of this new protein and this new type of transformation of solar energy began in several laboratories in the USA, Germany, the USSR, England, Japan, Hungary, Israel and other countries. Bacteriorhodopsin became the first membrane protein whose primary structure was solved [4]. The development of this new area of bioenergetics and photobiochemistry led to a series of exciting achievements; it resulted in the discovery and characterization of new members of a still growing family of retinal-containing proteins [5, 6]. International cooperation also resulted in the formation of a group of scientists who knew each other for more than a quarter of a century and regularly meet at Retinal Protein conferences. Andrey Kaulen was one of the youngest and most distinguished members of this club. He made outstanding contributions to the field of retinal proteins and particularly to the development of photoelectric studies and the elucidation of the mechanism of proton transfer by bacteriorhodopsin.

The discovery of bacteriorhodopsin function posed several questions that had to be solved. Is proton transport electrogenic? How can one follow the pathway and kinetics of proton movement in the bacteriorhodopsin molecule? What is the link between proton transport and the spectroscopically observed photocycle of bacteriorhodopsin? In a series of outstanding studies Andrey Kaulen and his colleagues in the Laboratory of Bioenergetics, Moscow State University [7-10] addressed these problems. Together with L. A. Drachev and V. P. Skulachev, Andrey Kaulen developed the original method for fast kinetic measurements of the photoinduced electric potential. This method was used to follow the photoelectric responses from a membrane containing bacteriorhodopsin. These studies provided experimental evidence for electrogenic proton transfer that included several phases, each correlated with the photocycle reactions [9]. This work opened a new approach in studies of the mechanism of proton transport by bacteriorhodopsin and other proteins. It provided the first information on the kinetics of photo-induced charge transfer in bacteriorhodopsin. This method was also very fruitful for studying photoelectric processes in visual rhodopsin [11]. For these studies Andrey Kaulen was awarded a highly prestigious award for young scientists in the USSR.

In subsequent studies Andey Kaulen and his colleagues found answers to many other important questions such as: how many protons are transported by bacteriorhodopsin per absorbed light quantum, which stages of the photocycle are accompanied by proton uptake and release, and what is the rate of proton release [12, 13]? The effects of proteolysis [14, 15], different retinal configurations [16], inhibitors [17], and mutations [18, 19] on electrogenic proton transfer were thoroughly investigated.

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As the Head of the laboratory of Photochemistry of Biomembranes Andrey Kaulen continued studies on bacteriorhodopsin. He paid special attention to the role of structural changes in the mechanism of proton uptake [20-22], the role of specific amino acid residues in proton transport [23], and the effect of membrane potential on the bacteriorhodopsin photocycle [24]. He was also interested in studies of the involvement of bacteriorhodopsin in phototaxis [25], photogeneration of electric potential in halorhodopsin [26], and electrogenesis in cytochrome *c* oxidase [27, 28]. Large parts of the results of these studies were summarized in his last review published in the a special issue of *Biochimica et Biophysica Acta* on bacteriorhodopsin [29].

It was always interesting to read papers written by Kaulen and his colleagues. Andrey always concentrated on central problems, trying to find original approaches for their solution. He never accepted common views without their critical evaluation. Thorough analysis of experimental data and their interpretations, and deep insight into the mechanisms of phenomena was very typical of him. This brilliant talent allowed Andrey Kaulen to carry out fundamental work in the best traditions of the Moscow school of bioenergetics and biophysics.

Personal interaction with Andrey was always very interesting and rewarding. We met at the famous Bioenergetics seminars in Belozersky Institute of Moscow State University, in his Laboratory, at Retinal Protein conferences on Lake Baikal, in Kyoto, in Israel, at Awaji Island in Japan. In these meetings I found that he was not only a bright and devoted scientist, but also a nice cheerful man, who could be sometimes ironic, sometimes shy, but always a pleasant person.

It is tragic that the life of this brilliant and energetic scientist was lost to a deadly disease at such a young age. Andrey was less than 49 years old, full of plans and projects. The present issue is a tribute to Andrey Kaulen, the thankful acknowledgement of his contribution to science and to the good memories that he left to his colleagues, students, and teachers.

The reviews, mini-reviews, and experimental papers of this issue represent recent advances in studies on bacteriorhodopsin and other retinal-containing proteins. They highlight structural and spectral studies allowing us to discuss the mechanism of proton transport at the molecular and atomic levels and the mechanism of the ultra fast primary processes of light energy conversion in rhodopsin and bacteriorhodopsin. Several papers deal with description and comparison of processes in bacteriorhodopsin, rhodopsin, phoborhodopsin, and the rhodopsin of unicellular algae, and the development of new approaches in studies of retinal proteins. Papers were written by distinguished experts working in this field. They readily accepted invitation to take part in the issue dedicated to Andrey Kaulen and I am very grateful to them for their contributions.

Also I would like to thank all the reviewers for their expertise and useful advice. I am very grateful to Drs. L. A. Drachev, T. G. Ebrey, E. S. Imasheva, V. P. Skulachev, and V. P. Shinkarev for their help during preparation of this issue.

Sergei Balashov, Guest Editor

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