



HISTORY & BIOGRAPHY

A tribute to Ion C. Baianu (18 August 1947–10 February 2013): his 1982–1984 contributions to oxygenic photosynthesis

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Abstract

Here we present the 1982–1984 collaborative research of Ion C. Baianu (18 August 1947–10 February 2013) with one of the authors (Govindjee) at the University of Illinois at Urbana-Champaign on the role of chloride in Photosystem II. Then, we provide a brief presentation of his general academic and research legacy.

Keywords: $^{35}\text{Cl}^-$ Nuclear Magnetic Resonance; chloride in Photosystem II; food chemistry research; Ion C. Baianu; oxygenic photosynthesis; University of Illinois at Urbana-Champaign.

Collaborative research on oxygenic photosynthesis

During 1982–1984, Govindjee and Christa Critchley, then a research associate in Govindjee's laboratory, worked closely with Dr. Ion C. Baianu (1947–2013) on the "Role of chloride in Photosystem II" by using Nuclear Magnetic Resonance (NMR). For Christa Critchley's contributions, see Govindjee (2024).

Govindjee met Ion C. Baianu in 1982 in Herbert (Herb) S. Gutowsky's laboratory in the Department of Chemistry at the University of Illinois at Urbana-Champaign (UIUC); for Gutowsky's life and discoveries, see Jonas and Slichter (2006). Below, we summarize all that was found then – thanks to the knowledge and the contributions of Ion C. Baianu – yes, sometimes one of the authors (GG) and Ion even worked together overnight! In addition, we include here what the other author (AS) remembers about the life and work of Ion Baianu.

The very first paper with Ion C. Baianu (see Critchley *et al.* 1982) led the authors to conclude that the thylakoids of salt-tolerant higher plants needed greater than 250 mM (up to 3 M) chloride (Cl^-) ions for maximum photosynthetic oxygen (O_2) evolution, as well as for the maximum

variable chlorophyll (Chl) *a* fluorescence. However, when chloride was given as CaCl_2 , instead of MgCl_2 or KCl or NaCl , higher rates of oxygen evolution were observed – suggesting that Ca^{2+} also plays an important role on the electron-donor side of PSII; the pH dependence was quite different in the presence and absence of high salt concentrations. Further, this pH dependence matched that of $^{35}\text{Cl}^-$ NMR line broadening – an area where Ion Baianu was the expert; although EDTA (ethylene diamine tetra acetic acid) did not affect it, heat treatment abolished it. Further, only anions – with similar radii (*e.g.*, Br^-) were effective in replacing Cl^- ; on the other hand, small anions, such as F^- and OH^- , were inhibitory; and larger ions had no effect.

Together with Ion C. Baianu, a model was proposed in which chloride was suggested to facilitate PSII electron transport by reversible ionic binding to the oxygen-evolving side of PSII; this research was also presented at an international conference (see Govindjee *et al.* 1983).

The second paper (Baianu *et al.* 1984), on the above topic, was a major one and was published in the *Proceedings of the U.S. National Academy of Sciences*; an overview of this research was also presented at

Highlights

- Ion C. Baianu established the role of chloride in photosynthesis through Cl^- -NMR
- He made key contributions in physical chemistry of food processes
- He was an authority on chemical engineering and modeling of biological systems

Received 23 August 2026

Accepted 27 August 2026

Published online 2 September 2026

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Acknowledgement: We thank Dr. Robert E. Blankenship for reading and improving this tribute before its publication.

Conflict of interest: The authors declare that they have no conflict of interest.



Fig. 1. A 1997 photograph of I.C. Baianu at the University of Illinois at Urbana-Champaign – near a plaque recognizing Herbert S. Gutowsky for his discoveries on Nuclear Magnetic Resonance – slightly modified from Fig. 4 in Brown and Glazebrook (2013); reproduced with permission.

a conference (see Coleman *et al.* 1984). Baianu *et al.* (1984) had investigated the role of chloride in photosynthetic O_2 evolution by monitoring the chloride (Cl^-) NMR linewidth under a variety of conditions in aqueous suspensions of chloroplasts, from several halophytes (e.g., *Avicennia germinans*, *Avicennia marina*, and *Aster tripolium*), as well as from spinach (*Spinacea oleracea*). Although the line broadening showed weak, ionic binding of chloride to thylakoids, the bound Cl^- exchanged rapidly ($>>10^4 s^{-1}$) with the free Cl^- in solution; this binding was shown to be necessary for O_2 evolution to occur. Further, the Michaelis-Menten constants, obtained from the Cl^- dependence of the O_2 evolution rates, were shown to be 15–70 mM for the halophytes, compared with 0.6 mM for spinach. Data showed two types of Cl^- binding sites in the halophytes, of which the stronger one, at lower $[Cl^-]$, was suggested to be the “activator” for O_2 evolution. The essential role of chloride ions on the electron-donor side of PSII was established and, thus, Ion C. Baianu’s contributions are important for photosynthesis research.

We now provide a brief presentation on Ion C. Baianu, including an overview of his outstanding research in chemistry and related topics (see also Brown and Glazebrook 2013).

Academic and research legacy of Ion C. Baianu

We begin this section with a photograph of Ion Baianu on the campus of the University of Illinois at Urbana-Champaign (see Fig. 1).

Ion C. Baianu was born on 18 August 1947, in Romania, to Constantine and Simona Baianu. He graduated in 1968 as a biophysicist from the Faculty of Physics, University of Bucharest. After graduation, Ion C. Baianu started working as an Assistant in the Department of Biophysics of the Faculty of Physics, where he gave seminars on

Biophysical Techniques. One of us (A. Stirbet) was a student in Biophysics at that time in Romania and was impressed by Ion’s knowledge of spectroscopic methods, such as Electron Paramagnetic Resonance (EPR), Nuclear Magnetic Resonance (NMR), and Raman spectroscopy.

In 1971, Ion C. Baianu had the opportunity to go to the University of London (Queen Elizabeth College, QEC), in the UK, to obtain a doctoral degree in Biophysics with Professor Ronald Edgar Burge (1932–2022), a Fellow of the Institute of Physics (Baianu 1974). After that, Ion C. Baianu remained in the UK and worked first as a Research Fellow in Cambridge from 1974 to 1977, during 1977 and 1978 as an Independent Researcher at the Cavendish Laboratory in the Department of Physics at Cambridge, UK, and then in industry. The research at the Cavendish Laboratory included: electron microscopy, NMR of proteins (see e.g., Baianu *et al.* 1978), X-ray and neutron scattering, spin-wave excitations, quantum computation, membranes, and complex systems.

Ion C. Baianu left the UK in 1980 to work at the University of Illinois at Urbana-Champaign (UIUC) in the USA as a Postdoctoral Fellow until 1982. His research focused on physical chemistry, fluorescence, NMR of proteins, membranes, and photosynthesis (see above for Collaborative research on oxygenic photosynthesis).

During 1983–1987, Ion C. Baianu was an Assistant Professor of Food Chemistry in the Department of Food Science, as well as a Senior Research Associate in the School of Chemistry, with Professor H.S. Gutowsky (a member of the U.S. National Academy of Sciences). From 1987, Ion Baianu served as an Associate Professor until 1994, when he became a full Professor in the Department of Food Science and Human Nutrition at the UIUC, being also an Affiliate Professor of Nuclear Engineering at the same place. His research dealing with the physical chemistry of foods included, e.g., structure–function relationships using NMR, NIRS (near-infrared spectroscopy), the soybean composition database (Baianu *et al.* 2011), chemical imaging, molecular modeling of proteins, and the use of immobilized enzymes. During his work at the University of Illinois at Urbana-Champaign, Ion C. Baianu published over 400 research articles, and edited more than 50 volumes of reference texts, including, e.g., the multi-volume Physical Chemistry of Food Processes.

In addition to the above, Ion C. Baianu had a great passion for mathematics and its different applications in biology from a young age, being fascinated by Robert Rosen’s work on categories in biology (see Rosen 1958, Baianu and Marinescu 1968, 1974). During his lifetime, Ion Baianu published a great number of papers in mathematical biology on diverse topics (e.g., Baianu 1986, Baianu *et al.* 2006; for further information, see Brown and Glazebrook 2013).

On 10 February 2013, sadly, for all of us, Ion C. Baianu passed away unexpectedly when he was only 65 years old, leaving behind his wife Kimiko, his son Stephen, and two daughters, Antonia and Christina. His numerous professional achievements will be remembered by all of us.

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